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Abstract

Effectiveness and cost-effectiveness of acute hospital-based spinal cord injuries services: systematic review

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Objectives: To examine four key areas: (1) the effectiveness and cost-effectiveness of spinal fixation surgery, (2) the consequences of immediate versus delayed referral to a spinal injuries unit (SIU), (3) the number of people with a new spinal cord injury (SCI) who are discharged from hospital without ever being transferred to an SIU, and (4) the effectiveness and cost-effectiveness of steroids for people with SCI.
Data sources: Searches were carried out on several databases and also on the Internet. Specialist SCI and spinal injury related websites were searched, specifically the Spinal Injuries Association, the British Association of Spinal Cord Injury Specialists and the National Spinal Cord Injury Association.
Review methods: Three separate search strategies were devised to find studies relating to the four key areas. Two reviewers independently screened all study citations for inclusion. The lists of all retrieved studies were scanned for additional studies. Quality of studies was assessed and data were extracted by one reviewer then checked by the second. Data from included studies were summarised within each key area. For dichotomous data, relative risks were calculated with 95% confidence intervals. Pooled relative risks were calculated as appropriate. For continuous data, mean differences with 95% confidence intervals were calculated and, if data were pooled, weighted mean differences were calculated. Searches were carried out to identify economic evaluations, details of these together with a critical appraisal of quality are presented in structured tables. Quality was assessed using a checklist supplemented with additional comments on the adequacy of methodology where appropriate.
Results: For spinal fixation versus no fixation, 68 retrospective observational studies were found that suggested some benefits of fixation surgery. Only four studies were found on fixation surgery in SIUs compared with non-SIU hospitals and no significant differences were seen. All 28 studies concerning delayed referral to a SIU were retrospective observational studies. In most, study details were poorly reported and there was doubt over the comparability of groups at baseline and on confounding factors. Times of referral and transfer were not reported separately. Evidence suggested an effect in favour of the SIU group for neurological improvement. No relevant published studies of any design were found regarding how many people with a new SCI are discharged from hospital without ever being transferred to an SIU. Two systematic reviews were found that assessed the effectiveness of steroids. No studies were identified that considered both costs and the impact on patient outcomes of a given intervention.
Conclusions: Although there was evidence to suggest some benefits of fixation surgery and also a benefit of immediate referral to SIUs compared with delayed or no referral, owing to the limitations of the data these should be interpreted with caution. Not enough data were found to assess whether surgery is more beneficial when carried out in SIUs and further research is required in this area. Well-designed prospective observational studies with appropriately matched controls are needed. High-dose methylprednisolone steroid therapy may be effective in promoting some degree of neurological recovery if given within 8 hours of injury. There is a need for more randomised controlled trials (RCTs) of pharmacological therapy for acute SCI. No published studies of any design were found to answer the question of how many people with acute SCI are discharged from hospital without ever being transferred to an SIU. Primary research involving audit of selected hospital records should be commissioned and published. The search strategy did not identify any full economic evaluations. Future research should include full economic evaluations, possibly alongside a large RCT, which fully consider the costs and consequences of implementing interventions.

Contents

Glossary and list of abbreviations

Glossary

Activities of daily living A measure of the functional abilities of a person with SCI, for example ability to dress, wash and so on.

ASIA score A measure of function after spinal cord injury modified from the Frankel classification.

Brown–Sequard syndrome An incomplete spinal cord injury; there is loss of pain, temperature and other sensation on the opposite side of the lesion and spastic paralysis on the same side as the lesion.

Cauda equina The roots of the upper sacral nerve that extend beyond the termination of the spinal cord at the first lumbar vertebra in the form of a bundle of filaments.

Central cord syndrome Affects the cervical region of the spine and results from focused damage to the corticospinal tracts.

Cervical vertebra Any of the seven vertebrae of the neck.

Complete injury A total paralysis and loss of sensation below the level of spinal cord injury.

Conus medullaris A tapering lower part of the spinal cord at the level of the first lumbar segment.

Corticospinal tracts The nerve fibres that carry signals from motor control areas of the brain to the spinal cord.

Frankel classification A measure of function after spinal cord injury.

Halo orthosis A metal ring and supporting frame placed around the head and attached to a body jacket or vest in order to immobilise the upper body and cervical spine.

Heterotopic ossification The formation of new bone deposits in the connective tissue that surrounds major joints.

Incomplete injury Some movement and/or feeling remains below the level of spinal cord injury; movement and feeling may improve over time.

Ischaemia Localised reduction of blood volume in tissue due to the obstruction of the inflow of arterial blood.

Lesion An injury or wound.

Lipid peroxidation Oxygen free radicals are thought to attack the nerve cell membranes, further degrading the nerve tissue of the spinal cord.

Lumbar vertebra Any of the five vertebrae situated between the thoracic vertebrae and the sacrum.

Oedema An abnormal excess accumulation of fluid in connective tissue.

Paraplegia Injury in the spinal cord in the thoracic, lumbar or sacral segments, including the cauda equina and conus medullaris.

Pressure sore (also skin sore or decubitus ulcer) A breakdown in the skin due to pressure that results in tissue death and sometimes infection.

Sacral vertebrae Any of the five fused vertebrae that make up the sacrum

Sacrum The part of the spinal column that is directly connected with or forms a part of the pelvis.

Secondary injury The biochemical and physiological changes that occur in the spinal cord following trauma. These changes are thought to involve oedema, ischaemia and lipid peroxidation.

continued

Glossary *continued*

Spinal cord injury An insult to the spinal cord resulting in a change, either temporary or permanent, in its normal motor, sensory or autonomic function.

Spinal injury unit A specialised centre in which experienced staff treat only people with SCIs.

Spinal shock A state of transient physiological (rather than anatomical) reflex depression of cord function below the level of injury with associated loss of all sensorimotor functions.

Syringomyelia A chronic progressive disease of the spinal cord associated with sensory disturbances, muscle atrophy and spasticity.

Tetraplegia Injury to the spinal cord in the cervical region with associated loss of muscle strength in all four extremities.

Thoracic vertebra Any of the 12 vertebrae dorsal to the thoracic region and characterised by articulation with the ribs.

Thoracolumbar Of, relating to, arising in or involving the thoracic and lumbar regions.

Thoracotomy Surgical opening of the chest cavity.

Vertebra Any of the bony or cartilaginous segments that make up the spinal column.

List of abbreviations

BASCIS	British Association of Spinal Cord Injury Specialists
CI	confidence interval
CSF	cerebrospinal fluid
CT	computed tomography
DVT	deep vein thrombosis
GI	gastrointestinal
ICU	intensive care unit
ITU	intensive therapy unit
MRI	magnetic resonance imaging
MRSA	methicillin-resistant *Staphylococcus aureus*
NASCIS	National Acute Spinal Cord Injury Study
NSIC	National Spinal Injuries Centre
RCT	randomised controlled trial
RR	relative risk
SCI	spinal cord injury
SIA	Spinal Injuries Association
SIU	spinal injury unit
SLI	severe ligamentous injury
SR	systematic review
SVBI	severe vertebral body injuries
UTI	urinary tract infection

All abbreviations that have been used in this report are listed here unless the abbreviation is well known (e.g. NHS), or it has been used only once, or it is a non-standard abbreviation used only in figures/tables/appendices in which case the abbreviation is defined in the figure legend or at the end of the table.

Executive summary

Objectives

The review aims to examine the following four questions:

1. the effectiveness and cost-effectiveness of spinal fixation surgery
2. immediate versus delayed referral to a spinal injuries unit (SIU)
3. how many people with a new spinal cord injury (SCI) are discharged from hospital without ever being transferred to an SIU
4. the effectiveness and cost-effectiveness of steroids for people with SCI.

Methods

Search strategy

Three separate search strategies were devised to find studies about:

- spinal fixation surgery
- referral, transfer and discharge of spinal cord injured patients
- steroid use for people with SCI.

Inclusion and exclusion criteria

Participants

People of any age with a complete or partial interruption of spinal cord function resulting from trauma.

Interventions

Q1 – surgical spinal fixation compared with any other treatment
Q2 – immediate versus delayed referral to SIU
Q3 – transferral to SIU, non-transferral to SIU
Q4 – steroids versus any other intervention.

Outcomes

All reported clinical outcomes were recorded. Outcomes such as radiological evaluation were given less emphasis.

Study design

Q1a – controlled studies
Q1b – controlled studies
Q2 – controlled studies or large case series
Q3 – any published data
Q4 – randomised controlled trials (RCTs) and systematic reviews.

Two reviewers independently screened all study citations for inclusion. The reference lists of all retrieved studies were scanned for additional studies. Excluded studies are reported.

Data extraction and quality assessment strategy

Quality of studies was assessed, according to criteria set out in NHSCRD's Report 4, and data were extracted by one reviewer and checked by the second. Quality scores were not assigned to studies, but the results of quality assessment are discussed in the text.

Methods of analysis/synthesis

Data from included studies were summarised within each research question category. For dichotomous data, relative risks were calculated with 95% confidence intervals. Pooled relative risks were calculated as appropriate. For continuous data, mean differences with 95% confidence intervals were calculated and, if data were pooled, weighted mean differences were calculated. Statistical heterogeneity was assessed. Where pooling was not sensible, data were summarised narratively, giving prominence to studies with the least biased designs.

Methods for assessing cost-effectiveness

For each of the study questions described above, searches were carried out to identify economic evaluations. Details of each published economic evaluation, together with a critical appraisal of its quality are presented in structured tables. Quality was assessed using a checklist updated from that developed by Drummond and co-workers. This checklist has been supplemented with additional comments on the adequacy of methodology where this is appropriate.

Results

Question 1a. Spinal fixation versus no fixation

Sixty-eight studies were found: many were poorly reported or of poor validity. Most were

retrospective observational studies and many included people with spinal injury but without SCI. The decision on whether to operate often depended on the severity of the injury. In many studies, results of surgery with and without fixation were reported together. Heterogeneity was seen in many results which did not seem to be explained by severity of injury, types of surgery performed, country of study, year of publication or sample size.

It is unclear whether fixation surgery is associated with neurological improvement. Neurological deterioration did not differ between groups. There was significantly less mortality in the fixation group. Fixation surgery was more likely to be associated with device failure (which is not surprising) and wound infection, and less likely to be associated with instability of the spine. Data on urinary status and length of stay were equivocal. Fixation was associated with increased functional ability (to walk), shorter time to mobilisation and possibly increased independence in daily living activities.

It is unclear whether early fixation is more likely to lead to neurological improvement, shorter duration of hospitalisation or improved urinary status than late fixation.

Question 1b. Fixation surgery in spinal injury units (SIUs) compared with non-SIU hospitals

Only four studies were found. No significant differences were seen.

Question 2. Delayed referral to a SIU

All 28 studies were retrospective observational studies. In most, study details were poorly reported and there was doubt over the comparability of groups at baseline and on confounding factors. Times of referral and transfer were not reported separately.

Evidence suggested an effect in favour of the SIU group for neurological improvement. No differences were seen between early and late referrals. There was no difference in functional outcome between groups. Data on death rates in early versus late referrals and SIU versus non-SIU groups were equivocal.

Rates of most complications did not differ significantly between the two groups. The SIU group were less likely to develop pressure sores. One study showed that patients undergoing early referral experienced fewer overall complications than late referrals. Patients in the early referral group had a lower risk of developing pressure sores; this effect may have been time dependent. Delayed referral patients were more likely to experience a wide variety of complications.

Data from one study showed that patients treated in SIUs were less likely to need assistance with many activities of daily living. The study also found that patients in the SIU cohort spent more hours out of the house per week and were more likely to be in paid employment.

Patients receiving treatment in SIUs were more likely to have experienced shorter lengths of stay in hospital. Evidence suggested that patients undergoing early referral experienced shorter acute hospitalisation times.

Question 3. How many people with a new SCI are discharged from hospital without ever being transferred to an SIU?

No relevant published studies of any design were found. Primary research should be commissioned and published.

Question 4. Steroids

The evidence suggested that treatment with high-dose methylprednisolone within 8 hours of injury resulted in greater motor function recovery (of around four points, measured by standard clinical examination) compared with placebo. However, the practical relevance of this improvement was not stated. No effect was seen when all patients treated with methylprednisolone within 24 hours were compared with those treated with placebo. Greater pinprick sensation was shown in all patients in the methylprednisolone group at 6 months but this beneficial effect was not evident at 1 year. Comparison of a 10-day regimen of high-dose with low-dose methylprednisolone found no differences between groups except that wound infection was higher in the high-dose group.

Economics

No studies were identified that considered both costs and the impact on patient outcomes of a given intervention. We were therefore unable to present any useful cost information which may have helped to improve the decision-making process.

Conclusions

Only retrospective observational studies were found which assessed spinal fixation surgery or

delayed referral to SIUs. In most studies there was doubt over the comparability of groups, at baseline and on confounding factors. Although there was evidence to suggest some benefits of fixation surgery and also a benefit of immediate referral to SIUs compared with delayed or no referral, owing to the limitations of the data these should be interpreted with caution.

In general, there was little investigation of the implications of the interventions from the point of view of the patients, relatives or partners. Primary qualitative research should be carried out among users to understand what outcomes are important, and patients should be involved in study design.

Data on effectiveness of spinal fixation surgery is high in quantity but low in quality. Spinal fixation does not appear to offer advantages in terms of neurological improvement, length of hospital stay or urinary status. Spinal fixation patients experienced less mortality, spinal instability or psychological problems. They were more likely to be mobile in a shorter time and independent in activities of daily living than non-fixation groups. They were more likely to experience wound infection, device failure and loss of spine flexibility. Not enough data were found to assess whether surgery is most beneficial when carried out in SIUs. Further research of higher quality is required in this area.

Patients undergoing immediate referral to SIUs may experience better outcomes than patients whose referral is delayed, or who are treated elsewhere. Owing to the questionable comparability of groups in the majority of studies, the evidence to support this conclusion is weak. Well-designed prospective observational studies with appropriately matched controls are needed.

High-dose methylprednisolone steroid therapy may be effective in promoting some degree of neurological recovery if given within 8 hours of injury. There is a need for more RCTs of pharmacological therapy for acute SCI.

We found no published studies of any design which would help to answer the question of how many people with acute SCI are discharged from hospital without ever being transferred to an SIU. Primary research involving audit of selected hospital records or a search of national hospital activity data should be commissioned and published.

The search strategy did not identify any full economic evaluations, that is, no study considered the costs as well as the impact on patient outcomes of a given intervention. Future research should include full economic evaluations, possibly alongside a large RCT, which fully consider the costs and consequences of implementing interventions.

Chapter 1

Aim of the review

At present there is no evidence-based service specification on which to commission and develop spinal cord injuries services, as these have so far not been comprehensively reviewed by any one Health Authority or Region. There is currently a lack of agreement on the ranges of services purchased by existing consortia. Specialist spinal cord services are perceived to be expensive and there are a limited number of providers of acute spinal injury surgery and rehabilitation.[1] The purpose of this review is ultimately to agree a multi-regional approach (between South East, London, Eastern and South West Regions) to specialist spinal cord injuries acute services.

The review aims to answer the following four questions in relation to people with a complete or partial interruption of spinal cord function resulting from trauma:

1. The effectiveness and cost-effectiveness of spinal fixation
   (a) Is there a difference in functional outcome (mobility, activities of daily living, disability/handicap/impairment[2]), cost and length of stay between those who have had a spinal fixation and those who have not?
   (b) Is there a difference in the outcomes of fixation surgery in spinal injury units (SIUs) compared with fixation surgery in non-SIU hospitals?
2. Consequences of delayed referral to a spinal injuries unit: does immediate referral to an SIU result in a better outcome than delayed referral?
3. How many people with a new spinal cord injury (SCI) are discharged from hospital without ever being transferred to a SIU?
4. The effectiveness and cost-effectiveness of steroids for people with SCI: do patients given steroids have a better outcome than patients not given steroids?

Chapter 2
Background

Description of underlying health problem

It is estimated that between 500 and 700 people sustain a traumatic SCI in the UK each year.[3] SCI can occur at any age, the effects are usually permanent and currently there is no cure.[1] The modal age of an SCI is 19 years and most people with SCI then live a relatively normal lifespan, so lifetime cost of care may be high. The most common mechanism of injury within the UK population is a sudden unexpected impact or deceleration (e.g. road accidents, domestic falls). Further neurological deterioration, resulting from lesion extension after the initial injury, can occur naturally in about 5% of cases,[1] and complications associated with the systemic effects of SCI can lead to respiratory compromise. Significant delays and complications [sometimes leading to admission to an intensive therapy unit (ITU)] can also arise as a result of inappropriate or poorly informed management.

Immediate care

The first 24 hours following injury constitute 'immediate care'. It is during this time that the majority of complications can occur.[1] Decisions made at the scene of the injury can have a profound impact on the outcome for and ongoing management of individual patients so care pathways are crucial. It has been suggested[4] that SIUs may influence the pre-transfer care of people with SCI by liaising closely with colleagues in general hospital units, and by providing advice and information.

Methicillin-resistant *Staphylococcus aureus* (MRSA) infection is perceived as a complication associated with a delay in transfer beyond 24 hours [National Spinal Injuries Centre (NSIC)] to 4 days (Salisbury District Hospital) (Ward T, personal communication, 2001; Gardner B, personal communication, 2001).

Current service provision

SIUs

In the UK and the Republic of Ireland there are 12 SIUs which provide comprehensive acute, rehabilitation and continuing care facilities and services. In the South West, South East, London and Eastern Regions there are three SIUs: Salisbury District Hospital, Royal National Orthopaedic Hospital and the NSIC, Stoke Mandeville.

The British Association of Spinal Cord Injury Specialists (BASCIS) has arrived at the following Clinical Service Specification of a Modern Spinal Cord Injury Centre or SIU (Gardner B, personal communication, 2001):

1. Cooperation in the efficient retrieval and early admission of acute spinal cord injured patients for specialised care. This requires liaison with the Ambulance Service and with all Accident and Emergency and Acute Trauma/Orthopaedic Units in the region. It includes the provision of guidelines for acute care and transportation.
2. Admission system. The service must have the support of a fully equipped Accident and Emergency Centre and Trauma Service to deal with the admission of patients both directly from the local accident scene and those who have been transferred from other hospitals.
3. Accurate and rapid diagnosis of the spinal lesion using modern diagnostic aids. The service must have access to facilities for full diagnostic investigation including plain X-ray, computed tomography (CT) and magnetic resonance imaging (MRI) scans on a 24-hour basis with other modalities such as neurophysiological assessment being available as appropriate.
4. Specialist management in the acute phase. With the aim of optimising recovery and minimising complications, the service must have available the support of Orthopaedic Surgery, Neurosurgery, General Surgery and Anaesthetics. The Centre must have the capability of managing multiple injuries and patients requiring ventilatory support.
5. Physical and psychological rehabilitation to enable patients to reach their full potential for independent living. The service must have dedicated Physiotherapy and Occupational Therapy staff with on demand services from

Speech Therapy and Dietetics. The team will include Clinical Psychology. Psychiatric Services will be available on demand.
6. Discharge of patients to appropriately modified domestic or residential facilities. The service must have close links with the Social Services and other community providers. It must have the facilities to visit and educate relatives, carers and health care professionals, both in the hospital and in the community.
7. Advice and guidance towards further education or gainful employment.
8. Provision of after care which encompasses Hospital Outreach Services. After care for spinal cord injured patients necessitates lifetime surveillance. The Centre must provide community liaison services with open access for consultation by patients, general practitioners and community nursing staff.
9. Clinical audit of the process and outcomes of care for acute spinal cord injured patients.
10. Readmission of spinal cord injured patients for: the treatment of life-threatening complications such as respiratory failure, septicaemia, widespread tissue necrosis with toxaemia due to pressure sores and intractable autonomic dysreflexia; urological surgery, for example for the treatment of renal and vesical calculi, bladder outlet obstruction and for major bladder and urethral reconstruction; major surgery such as thoracotomy for phrenic nerve implant insertion and spinal canal exploration for the treatment of syringomyelia or for intra-spinal somatic and autonomic nerve implants; other medical complications related to SCI.

Some perceived benefits of SIU care to patients include familiarity of staff with spinal problems and therefore ease of admittance of patients for short stays without major changes in their routine; availability of peer psychological support and formal psychological support staff; advice on a wide range of personal issues; availability of advice and support on the necessary rehabilitation and supportive equipment.

Description of interventions

Immediate referral to an SIU

The Spinal Injuries Association (SIA) and BASCIS both recommend that transfer to a specialist SIU should be made as soon as possible after diagnosis of the SCI.[5–8] In the majority of cases referral of SCI patients to a local SIU takes place within a few weeks or months of injury. Accepted delays in transfer can be due to availability of spinal or ITU beds or physiological status; transfer may also be delayed due to distance or mode of transport, or where patients present with significant accompanying trauma or respiratory compromise. However, a potentially significant number of people with SCI do not have the opportunity to access this system (13% in a survey by the SIA[3]) and are managed in a non-specialist environment (commonly orthopaedic, neurosurgical or general rehabilitation areas).

If the trend of referring hospitals is to refer ventilated and high-level tetraplegics for care in specialist spinal injuries centres and to keep those with paraplegia for local treatment, this inevitably increases the complexity and dependency within the SIUs, leading to longer stays with more complex discharges, and alters the status of the Spinal Injuries Centres towards high-dependency units rather than restorative rehabilitation. However, if the reverse is true and multiply injured patients are more likely to be treated in a general hospital and transferred late, the SIUs will be dealing with less severe cases.

Spinal fixation surgery

If the spine is unstable following injury, surgical fusion and bracing may be necessary, in some cases consisting of posterior decompression and fusion with a bone graft and hardware consisting of wires or rods. Different techniques are used for cervical spine surgery and for thoracolumbar spine surgery. Actual procedures may vary between surgeons (for example, surgeons in an SIU may be more likely to use bone grafts). Surgical reduction and stabilisation of the spine at the immediate/early stage are done to prevent secondary SCI, but can cause further oedema at the lesion site with a resulting extension of ischaemia. The risk potential for deep vein thrombosis (DVT) following SCI is reported to increase significantly following spinal surgery. Transient or permanent neurological deterioration has followed early surgical intervention to the upper-mid cervical spine in patients with tetraplegia. This can result in the need for mechanical ventilation even if the patient was self-ventilating before the surgical intervention. Some procedures for surgical fixation of the thoracic spine may involve a thoracotomy, necessitating a period of postoperative, mechanical ventilation.

Steroids

It has been suggested that high-dose methylprednisolone may help reduce the effects of spinal cord oedema after trauma if given within

the first 8 hours after injury.[9] The potential for this treatment to influence the process of lesion formation could mean a significant improvement in rehabilitation outcomes and quality of life after injury; however, the treatment is not without risk.

A Cochrane review[10] has found that methylprednisolone improves neurological outcome up to 1 year post-injury, compared with placebo, naloxone or tirilazad mesylate. However, another systematic review found no evidence of benefit.[11] Neither review found trials of any other steroids in SCI patients. The recommended dosage of methylprednisolone is 30 mg kg^{-1} intravenously over 15 minutes initially within 8 hours of injury, then 5.4 mg kg^{-1} every hour for 23 hours.

It has been reported that a new class of steroids known as 21-aminosteroids (which include tirilizad mesylate) have shown promising results;[12] however, in one trial which compared tirilizad and methylprednisolone, no differences were found.[13]

Chapter 3
Methods

Methods for reviewing effectiveness

Search strategy

Three separate search strategies were devised to find studies about:

- spinal fixation surgery
- referral, transfer and discharge of spinal cord injured patients
- steroid use for people with SCI.

An initial decision was made by the review team to exclude search terms for 'spinal cord diseases' and limit the searches to 'traumatic spinal cord injury'. It was also agreed to exclude more general terms for 'spinal injury'. The use of broader terms for 'spinal injury' and 'spinal cord diseases' would have ensured a sensitive response, but would have produced an unmanageable set of results.

It was also felt that any attempt to use specific search terms for 'spinal injury units' would have been detrimental, and would have resulted in relevant records being missed.

The first search strategy was devised to find papers about spinal fixation surgery for spinal cord injuries. This strategy combined terms for 'spinal cord injury' with terms for 'fixation' and 'fusion'. The strategy also used specific search terms for 'spinal cord surgery', but not broader search terms for 'spinal surgery' in order to narrow the search. This strategy was used to identify literature for questions 1a and 1b.

The second search strategy was used to find papers dealing with the referral, transfer and discharge of spinal cord injured patients. This strategy used a combination of search terms for 'referral', 'transfer' and 'discharge' with search terms for 'spinal cord injury'. This search strategy was used to identify literature for questions 2 and 3.

The third search strategy aimed to find studies looking at steroid use in SCI. This strategy combined search terms for 'steroids' with terms for 'spinal cord injury'. The search strategy was designed to find systematic reviews, randomised controlled trials (RCTs) and cost effectiveness studies and therefore used relevant methodological filters.

The following databases were searched:

- Allied and Complementary Medicine (AMED)
- Cochrane Controlled Trials Register (CCTR)
- Cumulative Index to Nursing and Allied Health Literature (CINAHL)
- Database of Abstracts of Reviews of Effectiveness (DARE)
- EMBASE
- Health Economic Evaluations Databases (HEED)
- Health Management Information Consortium (HMIC)
- MEDLINE
- National Research Register (NRR)
- NHS Economic Evaluation Database (NHS EED).

Searches were also carried out on the Internet using OMNI (http://omni.ac.uk), Copernic (http://www.copernic.com/), Alta Vista (http://www.altavista.com/) and Google (http://www.google.com/). Specialist SCI and spinal injury related websites were searched, specifically Spinal Injuries Association (http://www.spinal.co.uk/), the British Association of Spinal Cord Injury Specialists (http://www.bascis.pwp.blueyonder.co.uk/) and the National Spinal Cord Injury Association (http://www.spinalcord.org/).

The three search strategies used in MEDLINE are listed in Appendix 1. The MEDLINE search strategies were then translated and adapted as appropriate for each database searched. The dates and results of searches from other databases follow immediately after the MEDLINE strategies.

The search results from all databases were downloaded and imported into Endnote (ISI ReSearchSoft, USA) reference management software and duplicate records were deleted.The search results from the Internet were saved as HTML files.

Inclusion and exclusion criteria

Participants

People of any age with a complete or partial interruption of spinal cord function resulting from trauma.

Interventions

Q1 – Surgical spinal fixation compared with any other treatment. Spinal fixation surgery may or may not include bone grafting. Different surgical devices are available for fixation of the spine (e.g. Harrington rods). Separate comparisons will be made for different types of surgery and/or different instrumentations, if appropriate.
Q2 – Immediate (as defined by relevant studies) versus delayed referral to SIU.
Q3 – Transferral to SIU, non-transferral to SIU.
Q4 – Steroids versus any other intervention.

Outcomes

Q1a – Neurological improvement, functional ability/mobility, activities of daily living, duration of hospital stay (length of stay may not be the most appropriate measure, as it may be determined more by difficulties with accommodation and care packages than as a consequence of spinal fixation) and associated costs, time to mobilisation, psychological and social outcomes (including employment), revisions/removals, infections (especially MRSA), incidence of secondary complications (such as pressure sores), other adverse events, death.
Q1b – Neurological improvement, functional outcomes, length of hospital stay, time to mobilisation, complications, revisions/removals, infections (especially MRSA), psychological and social outcomes (including employment), incidence of secondary complications (such as pressure sores), other adverse events, death.
Q2 – Neurological improvement, complications, time spent on ITUs, time to start of rehabilitation and associated costs, psychological and social outcomes (including employment), incidence of secondary complications (such as pressure sores), other adverse events, death.
Q3 – Discharge from hospital, death.
Q4 – Mobility, activities of daily living (related to level of injury) and associated costs, psychological and social outcomes (including employment), adverse events (e.g. avascular necrosis of bone), death.

Study design

Q1a – Controlled studies, including prospective or retrospective cohort studies.
Q1b – Controlled studies (comparing an SIU with a non-SIU centre)
Q2 – Controlled studies or large case series
Q3 – Any published data
Q4 – Randomised controlled trials (RCTs) and systematic reviews.

Two reviewers independently screened all study citations for inclusion. Any discrepancies were resolved by discussion with reference to the original papers and, if necessary, a third reviewer was involved. The reference lists of all retrieved studies were also scanned for additional studies. Excluded studies and reasons for exclusion are reported in Appendix 6.

Data extraction strategy

Data were extracted on to forms developed for different study designs on a Microsoft Access database. One reviewer extracted the data and a second checked the forms. Any disagreements were resolved by discussion or, when necessary, with reference to the Reviews Manager.

Quality assessment strategy

Quality of studies was assessed according to criteria set out in NHSCRD's Report 4.[14] Quality assessment was carried out by one reviewer, transferred on to forms on the Microsoft Access database and checked by the second. Any disagreements were resolved by discussion or, when necessary, with reference to the Reviews Manager. Quality scores were not assigned to studies, but the results of quality assessment are discussed in the text.

Methods of analysis/synthesis

Data from included studies were summarised within each research question category. Heterogeneity in study design and participants, and also incomplete data in many of the studies, were expected to preclude a formal meta-analysis for all except question 4. However, after data extraction it was seen that it was possible to undertake meta-analysis for questions 1 and 2. For dichotomous data, relative risks were calculated with 95% confidence intervals, using the fixed effects model. Pooled relative risks were calculated as appropriate. For continuous data, mean differences with 95% confidence intervals were calculated and if data were pooled weighted mean differences were calculated. Statistical heterogeneity was assessed using the chi-squared test, with $p < 0.10$ indicating significant heterogeneity. For the other questions data were summarised narratively, giving prominence to data from studies with the least biased designs.

Methods for assessing cost-effectiveness

For each of the study questions described above, searches were carried out to identify any economic evaluations performed. Details of each published economic evaluation, if found, together with a critical appraisal of its quality, are presented in structured tables. Quality was assessed using a checklist updated from that developed by Drummond and co-workers.[828] This checklist has been supplemented with additional comments on the adequacy of methodology where this is appropriate. The checklist reflects the criteria for economic evaluation detailed in the methodological guidance developed by the National Institute for Clinical Excellence.[829]

Part of the assessment process involved the location of each study in the appropriate quadrant location of the cost-effectiveness plane (shown in *Figure 1*). This indicates the direction of the differential costs and effects of the alternative treatment options considered, but does not address the uncertainty surrounding these estimates. Where appropriate and where the data presented permitted, indications of the uncertainty underlying these estimates were assessed and an appropriate statistic such as confidence intervals around costs and effects or the incremental cost-effectiveness ratio, or cost-effectiveness acceptability curves was presented. It was not feasible to model the costs and effectiveness of specialist spinal units compared with other (non-specialist) units by obtaining cost data from these centres and estimating the cost per case in specialist versus non-specialist centres.

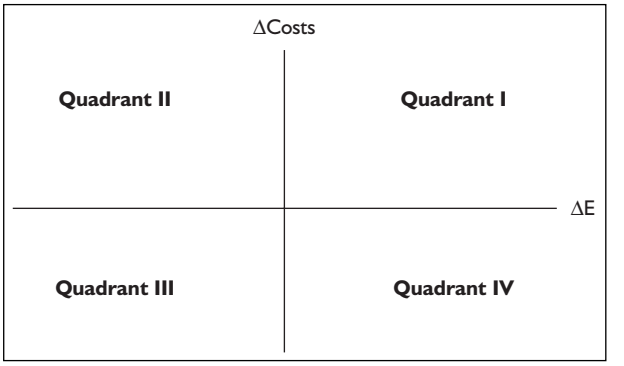

FIGURE 1 *Cost-effectiveness plane. Quadrant I: intervention increases costs and effectiveness. Incremental analysis required to assess cost-effectiveness compared with other interventions. Quadrant II: intervention is dominant as it increases costs and reduces effectiveness. Quadrant III: intervention reduces costs and effectiveness. Incremental analysis required. Quadrant IV: intervention is dominant as costs are reduced and effectiveness increased*

Chapter 4
Results

Results of literature search

Of the 7383 records found, 883 were ordered as full papers for assessment. After screening, 121 studies were included (134 publications). Details of included studies can be found under each individual question heading.

Excluded studies

A total of 732 publications were excluded from the review once the full paper had been screened. Details of excluded studies and reasons for their exclusion can be found in Appendix 6.

Studies awaiting assessment

At the time of writing this report, 17 publications were still awaiting assessment. Nine had been ordered but full papers had not been obtainable.[17–25] Eight were awaiting translation: one in Czech,[26] one in Danish,[27] one in Hungarian[28] and five in Japanese.[29–33] Bibliographic details of studies awaiting assessment can be found in Appendix 8.

Effectiveness

The effectiveness and cost-effectiveness of spinal fixation

Sixty-eight studies relating to this question were found. All contained some data relevant to question 1a and four were also relevant to question 1b.

Validity

All included studies were controlled studies, that is, they included a control group who did not receive surgical fixation. However, the *a priori* design of all these studies was not as controlled studies. Most of them were retrospective case series of people with SCI attending a particular unit. Some of the cases were treated surgically and some were not. Often, the decision on whether to treat surgically or not was made based on the severity of the patient's injuries (more severe injuries led to non-operative treatment in some units and to operative treatment in others). In these instances, we cannot say that the groups are comparable in terms of injury severity, prognostic or confounding factors. Sometimes, earlier patients in a case series were treated non-operatively because techniques for surgical fixation were not yet available. Later patients were treated with surgical fixation. In these instances, other aspects of care were likely to be different between the groups and so they are not comparable either. In some studies, few details of outcomes were reported. Some studies did not report results for surgical and non-surgical groups separately. In many studies, results of surgery with fixation and surgery without fixation were reported together and so the results of these studies relate to the effects of surgery, rather than fixation. In many studies, few details of baseline severity or patient demographics were reported so it was difficult to tell how comparable the treatment groups were.

Eight studies were published before 1980. We would expect surgical techniques to have improved in the past 20 years, so the relevance of these studies to today's practice is unclear.

Only two studies out of 68 stated that they made adjustment for confounding factors, although 11 out of 68 were assessed as being non-comparable for confounding factors and 32 were 'unclear'.

Question 1a. Is there a difference in functional outcome, cost and length of stay between those who have had a spinal fixation and those who have not?

Neurological improvement

Twenty-three studies[34–53,60,81] reported degree of neurological improvement using the Frankel or ASIA grade classification. The outcome was not reported consistently: some studies reported Frankel grades at baseline and at follow-up for individual patients, while some studies reported the number of people improving at least one Frankel grade, and some studies converted Frankel grade improvement to a percentage and gave an overall figure for the group. The fixation carried out used a mixture of anterior and posterior approaches in different studies. Nevertheless, at least some of the studies are similar enough for the results to be combined in a meta-analysis.

Daneyemez and co-workers[36] reported results in such a way that it is not clear how many people improved in each group. At the end of the study

there were 111/155 people without neurological deficit in the fixation group compared with 93 at the beginning of the study and 20/63 in the control group compared to 16 at the beginning of the study.

Jacobs and co-workers[45] assigned numbers to Frankel grades to calculate the percentage recovery. People treated surgically with Harrington rods improved by 53%, with Meurig–Williams plates by 50% and without fixation by 44%.

An and co-workers[57] did not report results clearly but reported that two of 13 patients who had neurological impairment in association with low lumbar burst fractures who were treated with Harrington rods had favourable outcomes, while the rest seemed to be treated by decompression surgery and also had favourable outcomes.

Pooled data from 21 studies on neurological improvement by the Frankel or ASIA grade classifications (*Table 1*) indicated a favourable result for spinal fixation surgery [relative risk (RR) 1.50, 95% confidence interval (CI) 1.37 to 1.60]. However, there is a high degree of heterogeneity in these results (chi-squared 54.29, $p < 0.0001$). Clinical heterogeneity exists in participants (level of SCI cervical or thoracolumbar, plus in some studies not all participants had SCI), intervention (in some studies, results for non-fixation surgery are reported together with results for fixation surgery, methods and instruments used in fixation surgery vary and treatment received by the control group also varies), setting (some in SIUs and some elsewhere), country of origin (Germany, Poland, USA and Saudi Arabia are some of the countries represented). The heterogeneity seen in the results could not be explained by any of these sources of clinical heterogeneity, or by year or study publication or by sample size. Studies which showed a positive effect for fixation surgery included studies from Poland, Germany, USA and Saudi Arabia. Participants had SCI at the cervical level in some studies and thoracolumbar level in others. Some studies included only people with SCI and some included people without SCI. Some used instrumentation for fixation and others did not.

A total of 24 studies[37,39,47,58–81] reported degree of neurological improvement using either another classification or the way neurological improvement was measured was unclear. Some of these other results have been displayed in a Forest plot (*Figure 2*) to get a feel for the direction of the treatment effect, with caveats as to the generalisability of the results.

Guthkelch and Fleischer[58] reported no difference in the eventual degree of return of neurological function between the two groups but did not present numerical data. Chen and co-workers[62] reported that removal of lesions due to traumatic central cord syndrome in the subacute period results in significant sensory and motor

TABLE 1 *Neurological improvement (Frankel/ASIA grades) with spinal fixation*

Study	Fixation *n/N*	No fixation *n/N*	RR (95% CI)
Arima, 1994[35]	1/10	0/3	1.09 (0.05 to 21.67)
Asazuma, 1996[34]	22/26	15/19	1.07 (0.81 to 1.42)
Bohlman, 1985[43]	8/41	9/154	3.34 (1.37 to 8.11)
Burke, 1976[60]	10/26	31/89	1.10 (0.63 to 1.94)
Donovan, 1987[44]	10/17	31/43	0.82 (0.53 to 1.27)
Donovan, 1992[37]	28/48	28/65	1.35 (0.94 to 1.96)
Fang, 1982[53]	7/18	7/11	0.61 (0.29 to 1.27)
Kiwerski, 1986[38]	333/548	241/632	1.59 (1.41 to 1.80)
Kiwerski, 1993[39]	88/203	10/70	3.03 (1.67 to 5.50)
Koivikko, 2000[46]	13/35	4/34	3.16 (1.14 to 8.72)
Koning, 1989[47]	17/29	15/47	1.84 (1.09 to 3.08)
Lifeso, 1985[48]	39/53	20/45	1.66 (1.15 to 2.38)
Lifeso, 2000[55]	13/29	2/21	4.71 (1.19 to 18.69)
Murphy, 1990[40]	16/58	10/44	1.21 (0.61 to 2.41)
Odendaal, 1991[49]	15/40	4/7	0.66 (0.31 to 1.40)
Ostl, 1989[50]	9/24	13/23	0.66 (0.35 to 1.24)
Prasad, 1995[41]	11/29	3/22	2.78 (0.88 to 8.79)
Vaccaro, 2001[56]	6/16	2/8	1.50 (0.39 to 5.83)
Willen, 1985[81]	11/26	9/24	1.13 (0.57 to 2.24)
Wilmot, 1986[42,51]	6/72	3/23	0.64 (0.17 to 2.35)
Young, 1978[52]	5/103	43/504	0.57 (0.23 to 1.40)

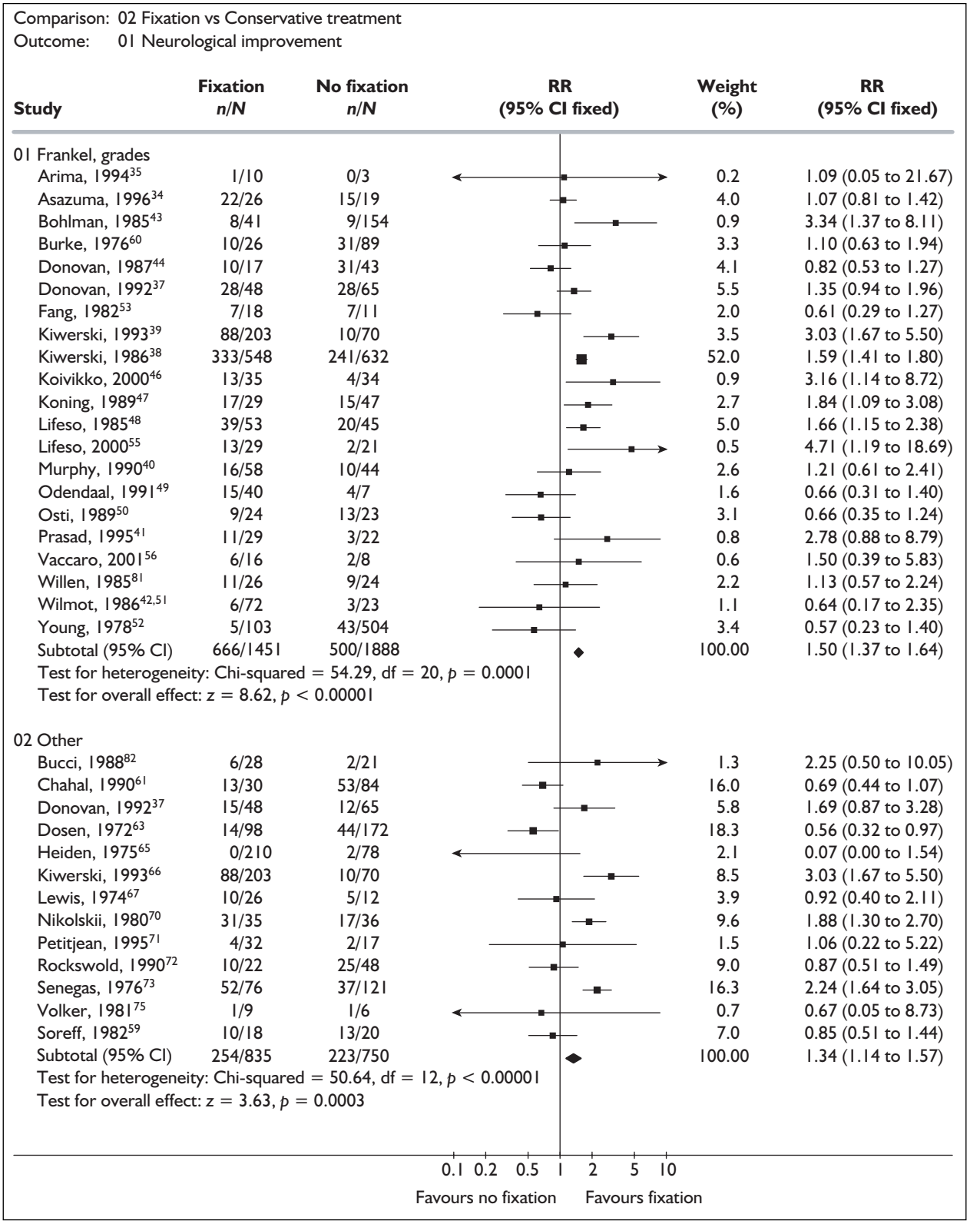

FIGURE 2 *Neurological improvement by spinal fixation*

improvement in short- and long-term follow-up. However, results were not presented in a way that a relative risk estimate could be calculated.

Duh and co-workers[64] presented neurological scores (*Figure 3*). All results for both early and late surgery and anterior and posterior approaches were found to favour fixation surgery over no surgery.

Lucas and Ducker[68] found that anterior fixation led to a significantly greater recovery rate than no fixation (0.18 compared with 0.08).

Meinecke[69] presented results in such a way that a relative risk estimate could not be calculated. They reported a functionally valuable neurological recovery of 19% versus 20% for fixation surgery in the complete paralysis group and 67% versus 58% in the partial paralysis group.

Waters and co-workers[76] presented ASIA change scores and concluded that motor recovery did not significantly differ between patients categorised in various surgical subgroups or between those having surgery and those treated non-operatively.

Comparison: 02 Fixation vs Conservative treatment
Outcome: 09 Neurological scores

Study	Fixation *n*	Fixation Mean (SD)	No fixation *n*	No fixation Mean (SD)	WMD (95% CI fixed)	Weight (%)	WMD (95% CI fixed)
01 Early anterior vs none: motor scores							
Duh, 1994[64]	23	42.40 (2.60)	189	20.3 (18.00)	–	7.4	22.10 (19.32 to 24.88)
02 Early anterior vs none: pinprick scores							
Duh, 1994[64]	23	63.90 (2.00)	189	51.3 (17.40)	–	8.4	12.60 (9.99 to 15.21)
03 Early anterior vs none: touch scores							
Duh, 1994[64]	23	65.50 (1.90)	189	53.00 (18.70)	–	7.4	11.60 (8.72 to 14.28)
04 Early posterior vs none: motor scores							
Duh, 1994[64]	99	35.90 (1.30)	169	20.30 (18.00)	–	8.6	15.60 (13.02 to 18.18)
05 Early posterior vs none: pinprick scores							
Duh, 1994[64]	99	60.90 (1.00)	189	51.30 (17.40)	–	9.2	9.60 (7.11 to 12.09)
06 Early posterior vs none: touch scores							
Duh, 1994[64]	99	62.80 (0.90)	189	53.00 (18.70)	–	8.0	9.80 (7.13 to 12.47)
07 Late anterior vs none: motor scores							
Duh, 1994[64]	37	37.00 (2.00)	189	20.30 (18.00)	–	8.2	16.70 (14.05 to 19.35)
08 Late anterior vs none: pinprick scores							
Duh, 1994[64]	37	62.10 (1.50)	189	51.30 (17.40)	–	9.0	10.80 (8.27 to 13.33)
09 Late anterior vs none: touch scores							
Duh, 1994[64]	37	62.00 (1.70)	189	53.00 (18.70)	–	7.7	9.00 (6.28 to 11.72)
10 Late posterior vs none: motor scores							
Duh, 1994[64]	147	30.90 (1.00)	189	20.30 (18.00)	–	8.7	10.60 (8.03 to 13.17)
11 Late posterior vs none: pinprick scores							
Duh, 1994[64]	147	59.40 (0.80)	189	51.30 (17.40)	–	9.3	8.10 (5.62 to 10.58)
12 Late posterior vs none: touch scores							
Duh, 1994[64]	147	60.20 (0.90)	189	53.00 (18.70)	–	8.0	7.20 (4.53 to 9.87)

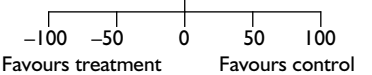

FIGURE 3 *Neurological improvement scores by spinal fixation*

Willen and co-workers[77] stated that no-one with complete SCI improved neurologically in any group. Scores are presented for incomplete SCI patients but without a measure of variance. The authors concluded that there was no difference between the three treatments after 2 years.

Yablon and co-workers[78] reported that 50% of the fixation group showed functional return of at least one nerve root while only 1/14 of the non-surgical group showed any recovery. The difference between groups was significant ($p < 0.01$).

Bucholz and Cheung[79] did not present any control group data but reported that 7/31 patients improved after fixation surgery.

Wilberger and co-workers[80] reported that neurological recovery was improved in patients undergoing surgery <25 hours or >200 hours after SCI, but the difference was not reported to be statistically significant.

Pooled data from 12 studies (*Table 2*) using measures of neurological improvement other than Frankel or ASIA grades also showed a favourable result for fixation surgery (RR 1.34, CI 1.14 to 1.57). Eight of the 12 studies showed no significant difference between groups, one showed a positive effect for conservative treatment and three showed a positive effect for fixation – one study was carried out in Russia using several different surgical techniques and was published in 1980. One was carried out in France published in 1976 using anterior fixation, plates and screws within 12 hours of injury and included only cervical fractures with SCIs. The other was carried out in Poland using an anterior approach and a bone graft or ceramic implant and published in 1993.

Neurological deterioration

Five studies reported this outcome (*Table 3*).[56,65,72,82,83] The pooled relative risk shows no statistically significant difference between fixation and non-fixation groups (pooled RR 0.84, 95% CI 0.37 to 1.888) and there is no significant heterogeneity in the result (*Figure 4*).

Mortality

Twenty-three studies[35,38,39,43,46–48,50,56,66–68,70,71,73,75,79,82,85–87,145] reported death as an outcome. The results have been pooled (*Table 4*, *Figure 5*), but with the caveat that, as mentioned above, the surgical and non-surgical groups may be dissimilar in terms of severity of injury, and mortality may be more likely in one group or the other simply because of this. At the protocol stage it was thought we would exclude patients who died within 48 hours, but the quality of the data in most of the studies was too poor to allow this.

TABLE 2 *Neurological improvement (other) by spinal fixation*

Study	Fixation *n*/*N*	No fixation *n*/*N*	RR (95% CI)
Chahal, 1990[61]	13/30	53/84	0.69 (0.44 to 1.07)
Donovan, 1992[37]	15/48	12/65	1.69 (0.87 to 3.28)
Dosen, 1972[63]	14/98	44/127	0.56 (0.32 to 0.97)
Heiden, 1975[65]	0/210	2/78	0.07 (0.00 to 1.54)
Kiwerski, 1993[39]	88/203	10/70	3.03 (1.67 to 5.50)
Lewis, 1974[67]	10/26	5/12	0.92 (0.40 to 2.11)
Nikolskii, 1980[70]	31/35	17/36	1.88 (1.30 to 2.70)
Petitjean, 1995[590]	4/32	2/17	1.06 (0.22 to 5.22)
Rockswold, 1990[72]	10/22	25/48	0.87 (0.51 to 1.49)
Senegas, 1976[73]	52/76	37/121	2.24 (1.64 to 3.05)
Sonntag, 1981[75]	1/9	1/6	0.67 (0.05 to 8.73)
Soreff, 1982[59]	10/18	13/20	0.85 (0.51 to 1.44)

TABLE 3 *Neurological deterioration by spinal fixation*

Study	Fixation *n*/*N*	No fixation *n*/*N*	RR (95% CI)
Bucci, 1988[82]	1/28	2/21	0.38 (0.04 to 3.87)
Heiden, 1975[65]	2/125	3/145	0.77 (0.13 to 4.55)
Marshall, 1987[83]	4/134	8/241	0.90 (0.28 to 2.93)
Rockswold, 1990[72]	1/22	1/48	2.18 (0.14 to 33.30)
Vaccaro, 2001[56]	1/16	0/4	0.88 (0.04 to 18.47)

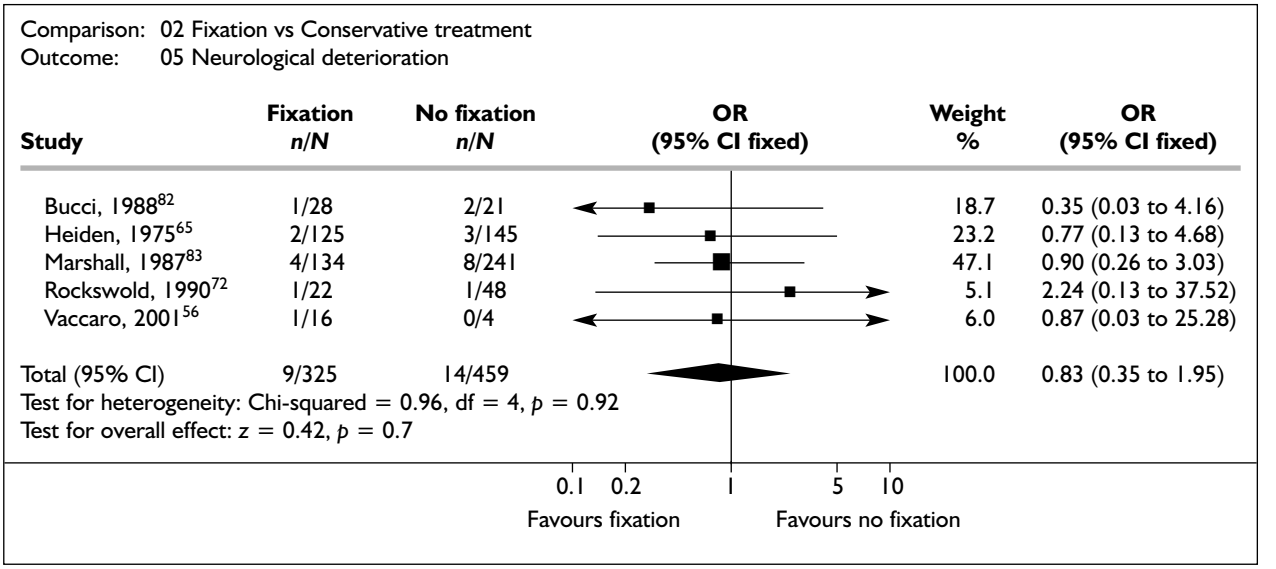

FIGURE 4 *Neurological deterioration by spinal fixation*

Pooled data from 20 studies showed a positive effect for fixation (pooled RR 0.47, 95% CI 0.40 to 0.55). Statistical heterogeneity was not noted in the result (chi-squared 26.14, $p = 0.13$) but visual inspection of the graph indicates that heterogeneity is present, probably for all the reasons mentioned in the neurological improvement section. In addition, the results may be confounded if the people who were most severely injured did not receive surgery for this reason.

Complications

Thirty-five studies[7,35,37,40–42,44–46,48–51,53,55,57,59,60,62,65,67,77,80–85,88–95,97,145] reported on complications following surgical and non-surgical treatment (*Table 5*, *Figure 6*). Complications reported included worsening, pneumonia, pressure sores, gastrointestinal bleeding, haemothorax, cystitis, dislodgement or loosening, failure to work, wound infection, further surgery, pain, callus formation, meningitis, spinal angulation, spinal stability, symptomatic deformity, ascending myelopathy,

TABLE 4 *Mortality by spinal fixation*

Study	Fixation *n/N*	No fixation *n/N*	RR (95% CI)
Arima, 1994[35]	2/10	0/3	1.82 (0.11 to 30.28)
Bohlman, 1985[43]	10/130	1/65	5.00 (0.65 to 38.22)
Bucci, 1988[82]	0/28	0/21	Not estimable
Bucholz, 1989[79]	0/15	4/93	0.65 (0.04 to 11.55)
Hamel, 1977[87]	8/30	10/30	0.80 (0.37 to 1.75)
Kiwerski, 1986[38]	45/548	136/632	0.38 (0.28 to 0.52)
Kiwerski, 1993[39]	20/203	17/70	0.41 (0.23 to 0.73)
Kiwerski, 1993[66]	83/963	160/798	0.43 (0.34 to 0.55)
Koivikko, 2000[46]	1/35	3/34	0.32 (0.04 to 2.96)
Koning, 1989[47]	5/29	7/47	1.16 (0.41 to 3.31)
Lemons, 1993[86]	2/26	0/38	7.22 (0.36 to 144.56)
Lewis, 1974[67]	11/62	7/27	0.68 (0.30 to 1.57)
Lifeso, 1985[48]	0/53	2/45	0.17 (0.01 to 3.46)
Nikolskii, 1980[70]	1/35	8/36	0.13 (0.02 to 0.98)
Ostl, 1989[50]	7/85	3/82	2.25 (0.60 to 8.41)
Petitjean, 1995[71]	1/32	2/17	0.27 (0.03 to 2.72)
Place, 1994[85]	0/65	1/48	0.25 (0.01 to 5.95)
Senegas, 1976[73]	18/76	61/121	0.47 (0.30 to 0.73)
Sonntag, 1981[75]	1/9	0/6	2.10 (0.10 to 44.41)
Tator, 1987[145]	7/116	14/92	0.40 (0.17 to 0.94)
Vaccaro, 2001[56]	5/16	5/8	0.50 (0.20 to 1.23)

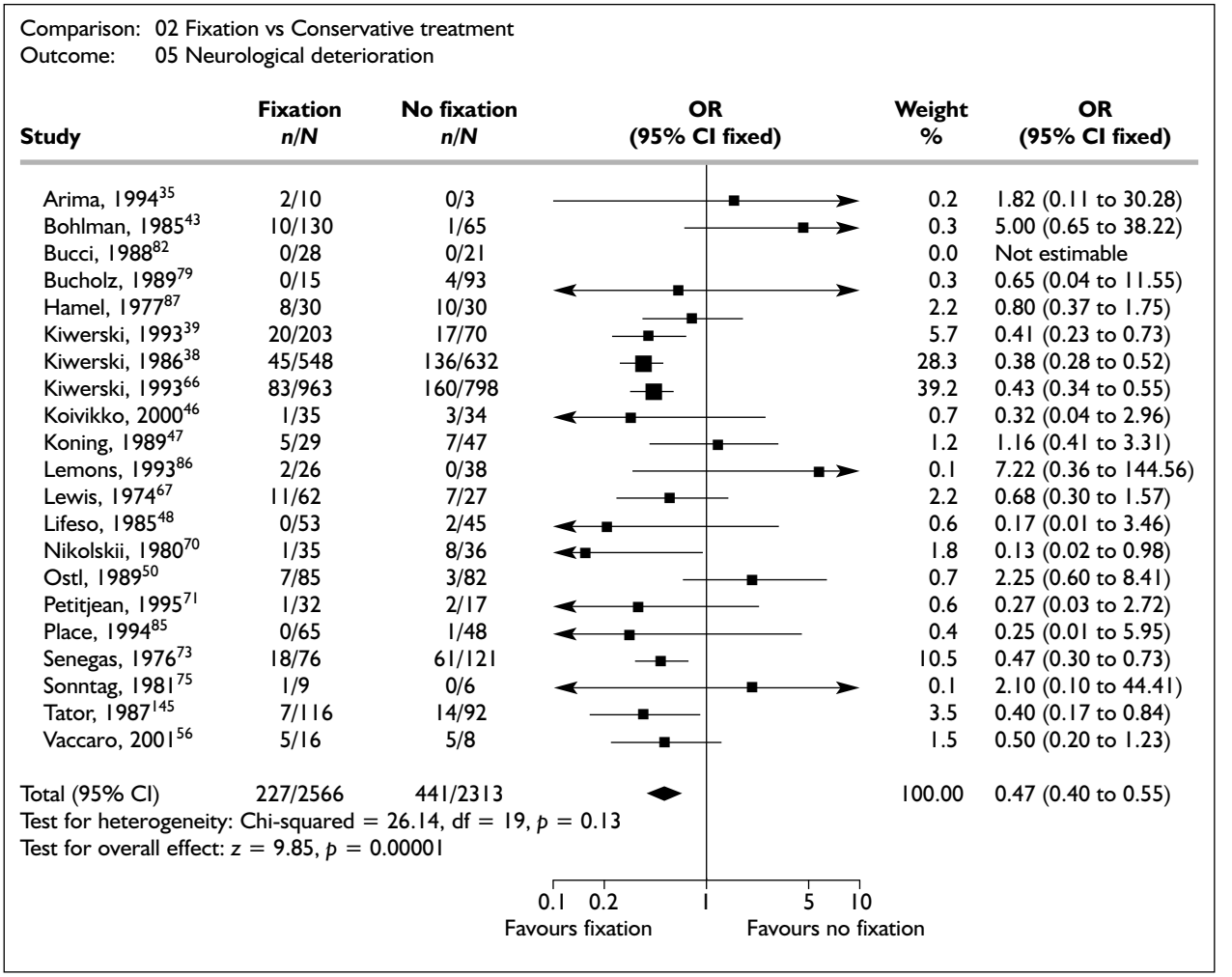

FIGURE 5 *Mortality by spinal fixation*

TABLE 5 *Complications with spinal fixation*

Complication	Study	Fixation *n/N*	No fixation *n/N*	Pooled RR (95% CI)
Pneumonia	Arima, 1994[35]	4/10	2/3	0.60 (0.31 to 1.15)
	Bucci, 1988[82]	1/28	3/21	
	Jacobs, 1980[45]	0/55	1/32	
	Wilmot, 1986[42]	2/65	1/23	
	Wilmot, 1986[51]	7/52	9/54	
Pressure sore	Arima, 1994[35]	1/10	1/11	1.37 (0.97 to 1.94)
	Fang, 1982[53]	8/18	5/54	
	Jacobs, 1980[45]	0/55	2/32	
	Koivikko, 2000[46]	5/35	3/34	
	Lifeso, 1985[48]	2/53	8/66	
	Ostl, 1989[50]	9/85	9/82	
	Soreff, 1982[59]	0/18	2/20	
	Tator, 1987[145]	19/116	10/92	
	Willen, 1983[77]	4/26	0/11	
	Wilmot, 1986[42]	1/65	0/23	
	Wilmot, 1986[51]	15/52	7/54	
Paralytic ileus	An, 1991[57]	3/21	0/6	2.23 (0.13 to 38.07)

continued

TABLE 5 *Complications with spinal fixation (continued)*

Complication	Study	Fixation *n/N*	No fixation *n/N*	Pooled RR (95% CI)
GI bleeding	Arima, 1994[35]	2/10	0/3	0.87 (0.46 to 1.65)
	Heiden, 1975[65]	5/125	5/145	
	Koivikko, 2000[46]	4/35	2/34	
	Tator, 1987[145]	6/116	9/92	
	Wilmot, 1986[51]	0/52	1/54	
Haemo/pneumothorax	Arima, 1994[35]	1/10	0/3	0.98 (0.29 to 3.29)
	Prasad, 1995[41]	2/29	0/22	
	Wilmot, 1986[42]	3/65	0/23	
	Wilmot, 1986[51]	0/52	3/54	
Treatment failure	An, 1991[57]	1/21	0/6	2.46 (1.84 to 3.29)
	Arima, 1994[35]	1/10	0/3	
	Bucci, 1988[82]	4/28	7/21	
	Carvell, 1994[7]	40/158	0/262	
	Chen, 1997[62]	2/28	0/86	
	Fang, 1982[53]	5/18	0/11	
	Gardner, 1988[88]	2/22	0/176	
	Heiden, 1975[65]	10/125	0/145	
	Jacobs, 1980[45]	1/55	0/32	
	Koivikko, 2000[46]	2/35	0/34	
	Lewis, 1974[67]	9/29	0/12	
	Lifeso, 1985[48]	2/53	0/66	
	Lifeso, 2000[55]	13/29	21/21	
	Lui, 1998[92]	1/18	0/10	
	Odendaal, 1991[49]	7/41	0/7	
	Ostl, 1989[50]	5/85	7/82	
	Willen, 1985[81]	5/26	0/24	
Requiring (further) surgery	Carvell, 1994[7]	23/158	31/262	1.35 (0.84 to 2.17)
	Chen, 1997[62]	2/28	0/86	
	Odendaal, 1991[49]	1/41	0/7	
Wound infection	An, 1991[57]	1/21	0/6	3.58 (1.80 to 7.10)
	Carvell, 1994[7]	4/158	0/262	
	Chen, 1997[62]	1/28	0/86	
	Gardner, 1988[88]	2/22	0/176	
	Heiden, 1975[65]	3/125	0/145	
	Jacobs, 1980[45]	1/55	0/32	
	Lifeso, 1985[48]	1/53	0/66	
	Lui, 1998[92]	2/18	2/10	
	Odendaal, 1991[49]	1/41	0/7	
	Ostl, 1989[50]	2/85	0/82	
	Place, 1994[85]	3/65	0/48	
	Prasad, 1995[41]	1/29	0/22	
	Wilmot, 1986[51]	2/52	0/54	
Symptomatic deformity	Donovan, 1987[44]	2/16	13/38	0.59 (0.32 to 1.07)
	Gardner, 1988[88]	3/22	10/176	
	Odendaal, 1991[49]	0/41	2/7	
	Willen, 1983[77]	6/23	4/9	
Pain at injury site	Chen, 1997[62]	1/28	0/86	0.90 (0.42 to 1.91)
	Gardner, 1988[88]	1/22	6/176	
	Koivikko, 2000[46]	1/35	1/34	
	Willen, 1985[81]	5/26	8/24	
Radicular pain	Gardner, 1988[88]	1/22	4/176	2.00 (0.23 to 17.10)
Sciatic pain	Soreff, 1982[59]	1/18	0/20	3.32 (0.14 to 76.60)
Symptomatic instability	Bucci, 1988[82]	2/28	8/21	0.22 (0.09 to 0.56)
	Donovan, 1987[44]	0/17	3/43	
	Donovan, 1992[37]	1/48	10/65	
	Gardner, 1988[88]	0/22	3/176	
	Osenbach, 1992[95]	0/59	4/122	

continued

TABLE 5 *Complications with spinal fixation (continued)*

Complication	Study	Fixation *n*/*N*	No fixation *n*/*N*	Pooled RR (95% CI)
Scoliosis	Place, 1994[85]	3/65	2/48	1.11 (0.19 to 6.37)
Lumbar charcot	Place, 1994[85]	1/65	0/48	2.23 (0.09 to 53.52)
Pulmonary embolism	An, 1991[57]	1/21	0/6	0.75 (0.39 to 1.43)
	Heiden, 1975[65]	5/125	7/145	
	Jacobs, 1980[45]	2/55	2/32	
	Koivikko, 2000[46]	0/35	2/34	
	Ostl, 1989[50]	1/85	1/82	
	Place, 1994[85]	2/65	0/48	
	Soreff, 1982[59]	0/18	1/20	
	Willen, 1983[77]	0/26	1/11	
	Wilmot, 1986[42]	5/65	1/23	
	Wilmot, 1986[51]	1/52	2/54	
CSF leak	Place, 1994[85]	1/65	0/48	2.23 (0.09 to 53.52)
Spasticity	Place, 1994[85]	1/65	0/48	2.23 (0.09 to 53.52)
Severe or chronic pain	Argenson, 1989[97]	13/24	12/38	1.39 (1.02 to 1.89)
	Burke, 1976[60]	8/26	2/89	
	Hardcastle, 1987[91]	5/46	3/41	
	Place, 1994[85]	1/65	3/48	
	Willen, 1983[77]	16/23	5/9	
	Willen, 1985[81]	11/26	14/24	
Cardiac complications	Koivikko, 2000[46]	4/35	2/34	1.90 (0.64 to 5.64)
	Lewis, 1974[67]	1/29	0/12	
	Wilmot, 1986[51]	4/52	2/54	
Asystolia	Soreff, 1982[59]	1/18	0/20	3.32 (0.14 to 76.60)
Lung abscess	Soreff, 1982[59]	1/18	0/20	3.32 (0.14 to 76.60)
Pseudarthrosis	Soreff, 1982[59]	1/18	0/20	3.32 (0.14 to 76.60)
DVT	An, 1991[57]	4/21	0/6	0.56 (0.28 to 1.09)
	Bucci, 1988[82]	2/28	0/21	
	Koivikko, 2000[46]	0/35	4/34	
	Lewis, 1974[67]	1/29	0/12	
	Ostl, 1989[50]	2/85	7/82	
	Soreff, 1982[59]	0/18	4/20	
	Willen, 1983[77]	6/26	2/11	
	Willen, 1985[81]	1/26	2/24	
UTI/urological complication	An, 1991[57]	2/21	0/6	1.01 (0.84 to 1.22)
	Arima, 1994[35]	1/10	0/3	
	Fang, 1982[53]	14/18	5/11	
	Koivikko, 2000[46]	8/35	7/34	
	Ostl, 1989[50]	13/85	18/82	
	Soreff, 1982[59]	0/18	2/20	
	Tator, 1987[145]	73/116	52/92	
	Willen, 1983[77]	15/26	8/11	
	Willen, 1985[81]	12/26	12/24	
Severe orthostatic reactions	Soreff, 1982[59]	0/18	2/20	0.22 (0.01 to 4.32)
Thrombophlebitis	Jacobs, 1980[45]	0/55	1/32	1.40 (0.82 to 2.41)
	Tator, 1987[145]	27/116	9/92	
	Wilmot, 1986[42]	11/65	1/23	
	Wilmot, 1986[51]	0/52	8/54	
Other respiratory complications	Bucci, 1988[82]	1/28	0/21	0.71 (0.49 to 1.03)
	Koivikko, 2000[46]	10/35	12/34	
	Tator, 1987[145]	23/116	30/92	
	Wilmot, 1986[42]	3/65	1/23	
	Wilmot, 1986[51]	3/52	3/54	
Bone displacement	Donovan, 1987[44]	7/17	19/43	0.93 (0.48 to 1.80)

continued

TABLE 5 *Complications with spinal fixation (continued)*

Complication	Study	Fixation *n/N*	No fixation *n/N*	Pooled RR (95% CI)
Reactive bone formation	Donovan, 1987[44]	9/13	36/43	0.60 (0.44 to 0.81)
	Donovan, 1992[37]	16/48	44/65	
Meningitis	Odendaal, 1991[49]	1/41	0/7	0.57 (0.03 to 12.81)
Horner's syndrome	Ostl, 1989[50]	6/85	0/82	12.55 (0.72 to 219.22)
Atelectasis	Wilmot, 1986[42]	12/52	7/54	1.78 (0.76 to 4.17)

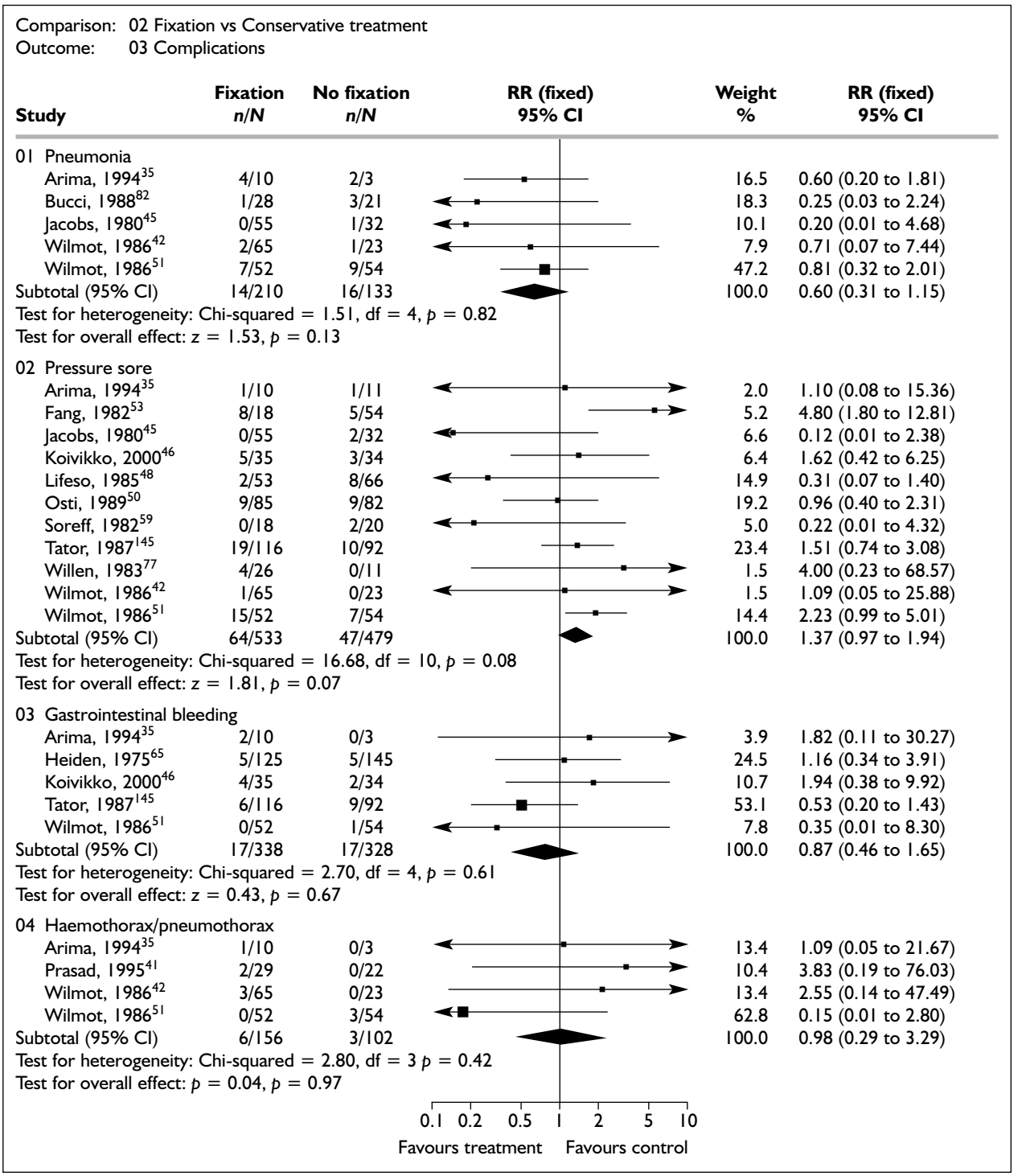

FIGURE 6 *Complications with spinal fixation*

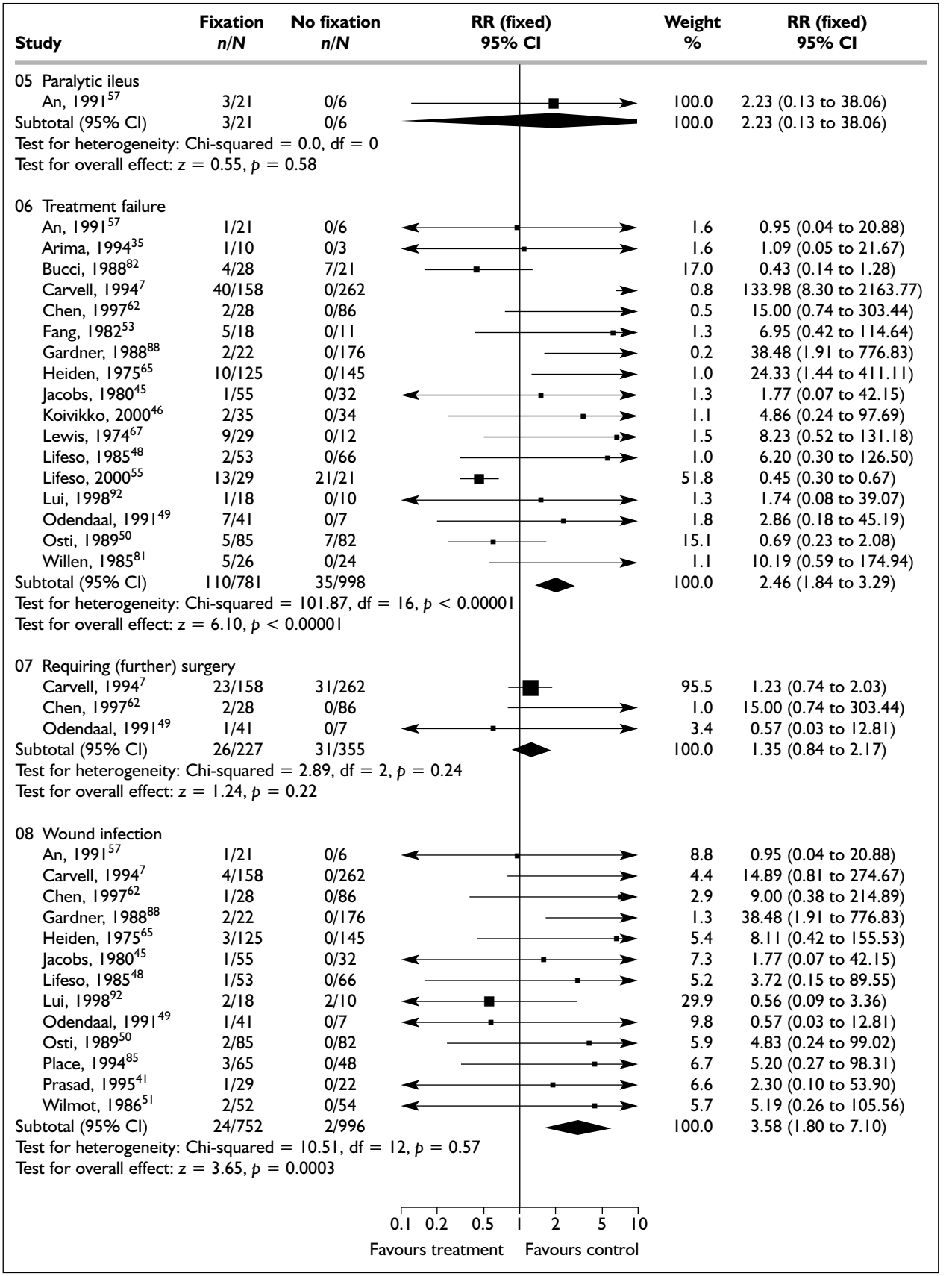

FIGURE 6 *Complications with spinal fixation (continued)*

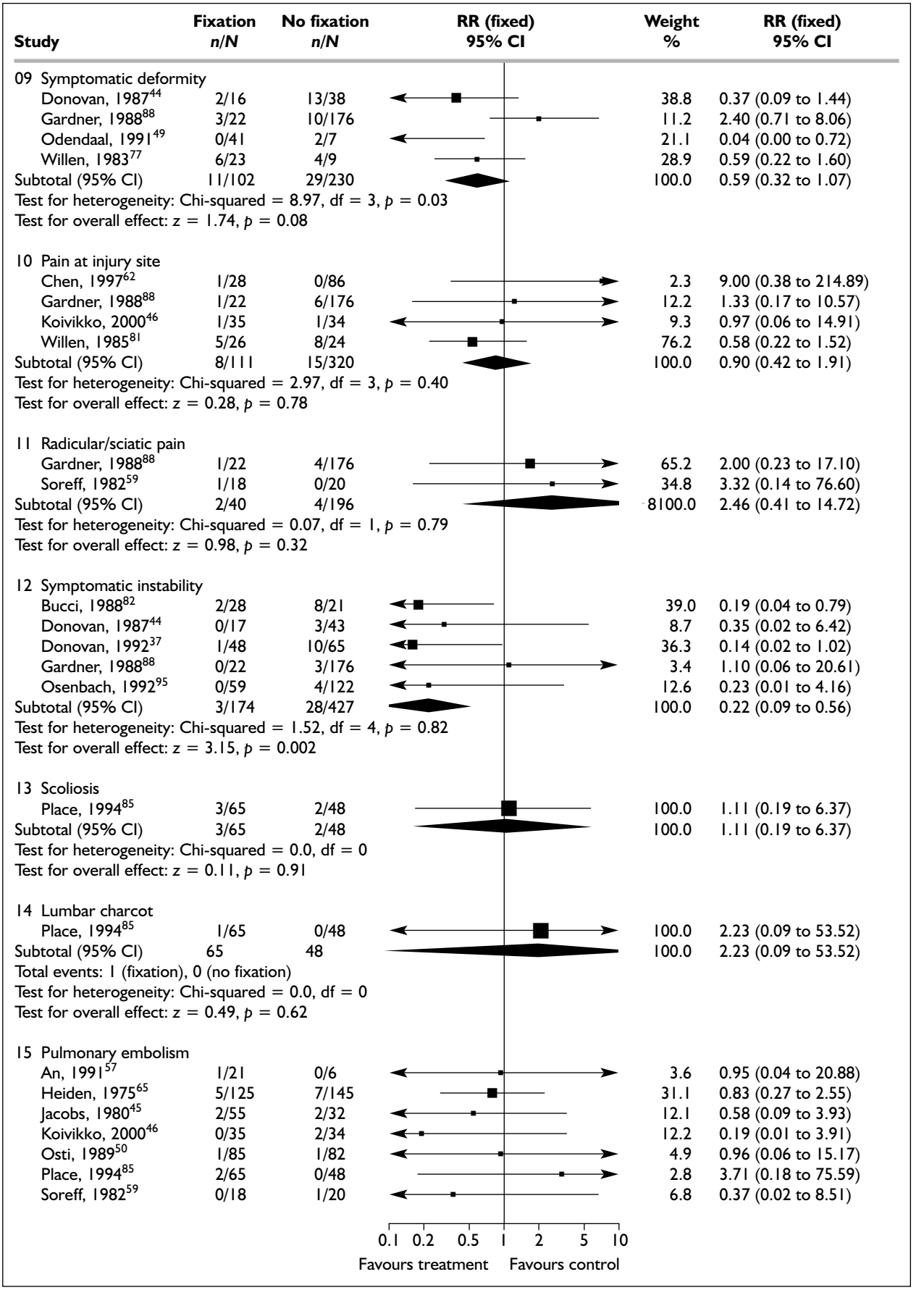

FIGURE 6 *Complications with spinal fixation (continued)*

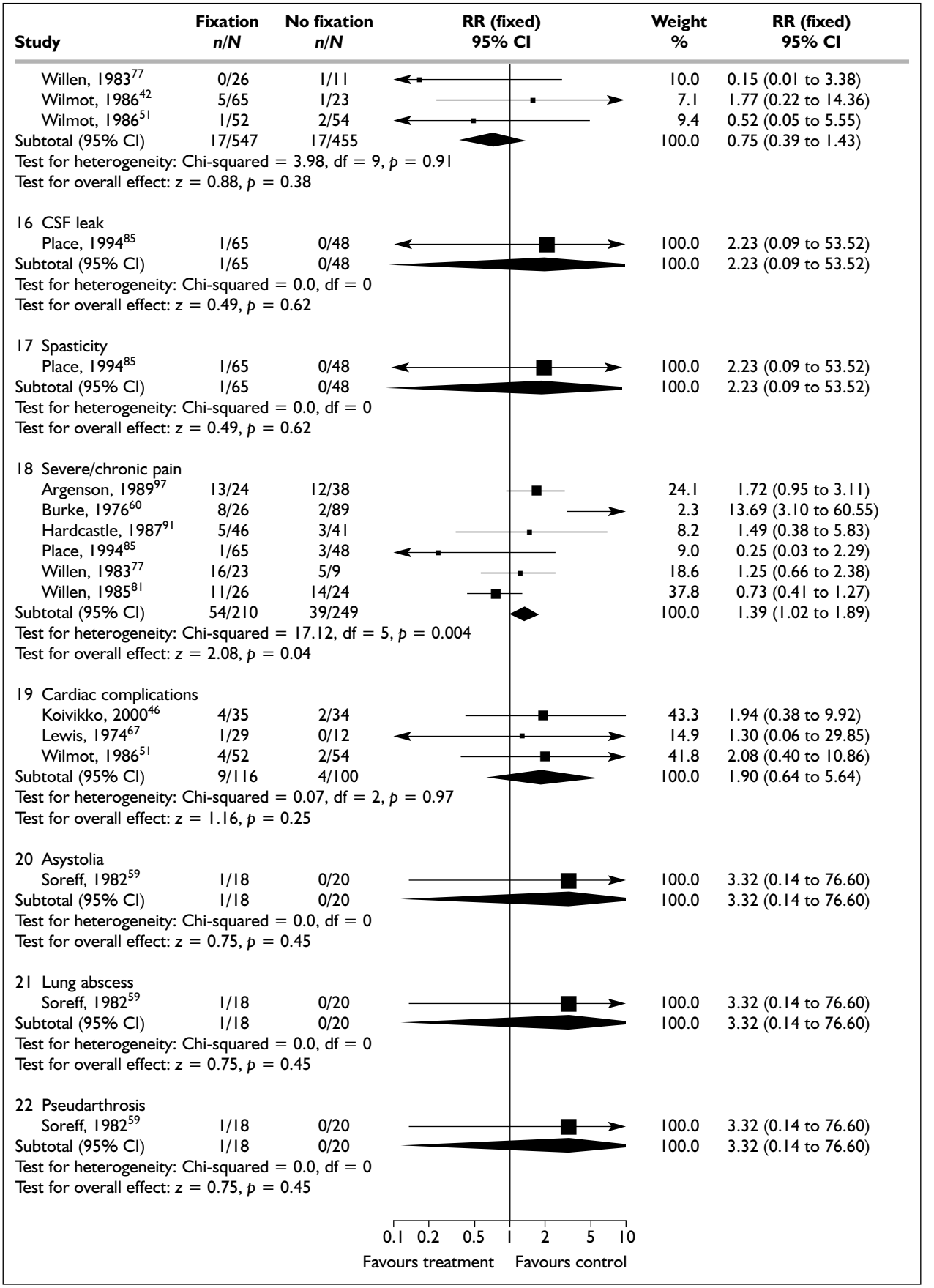

FIGURE 6 *Complications with spinal fixation (continued)*

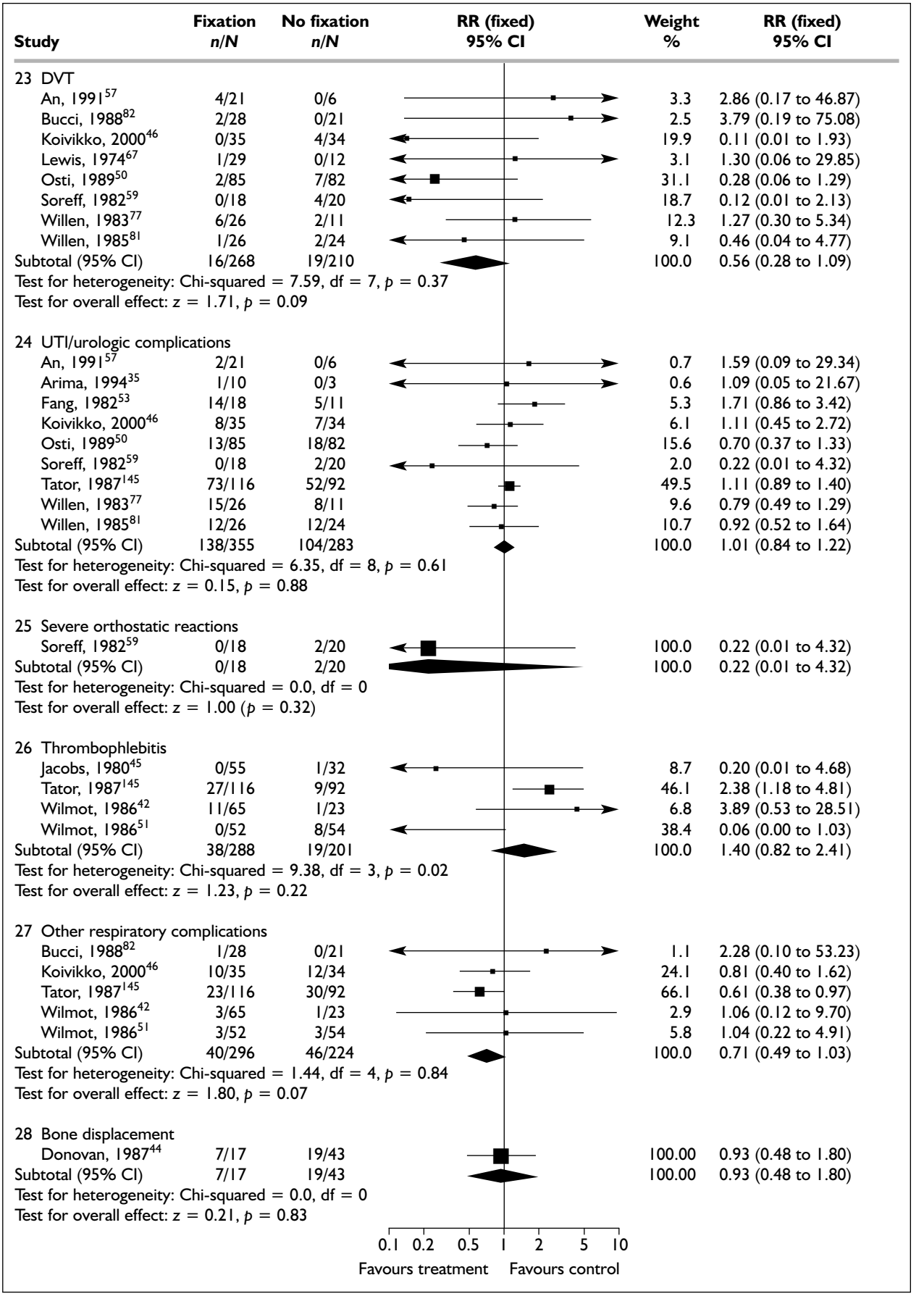

FIGURE 6 *Complications with spinal fixation (continued)*

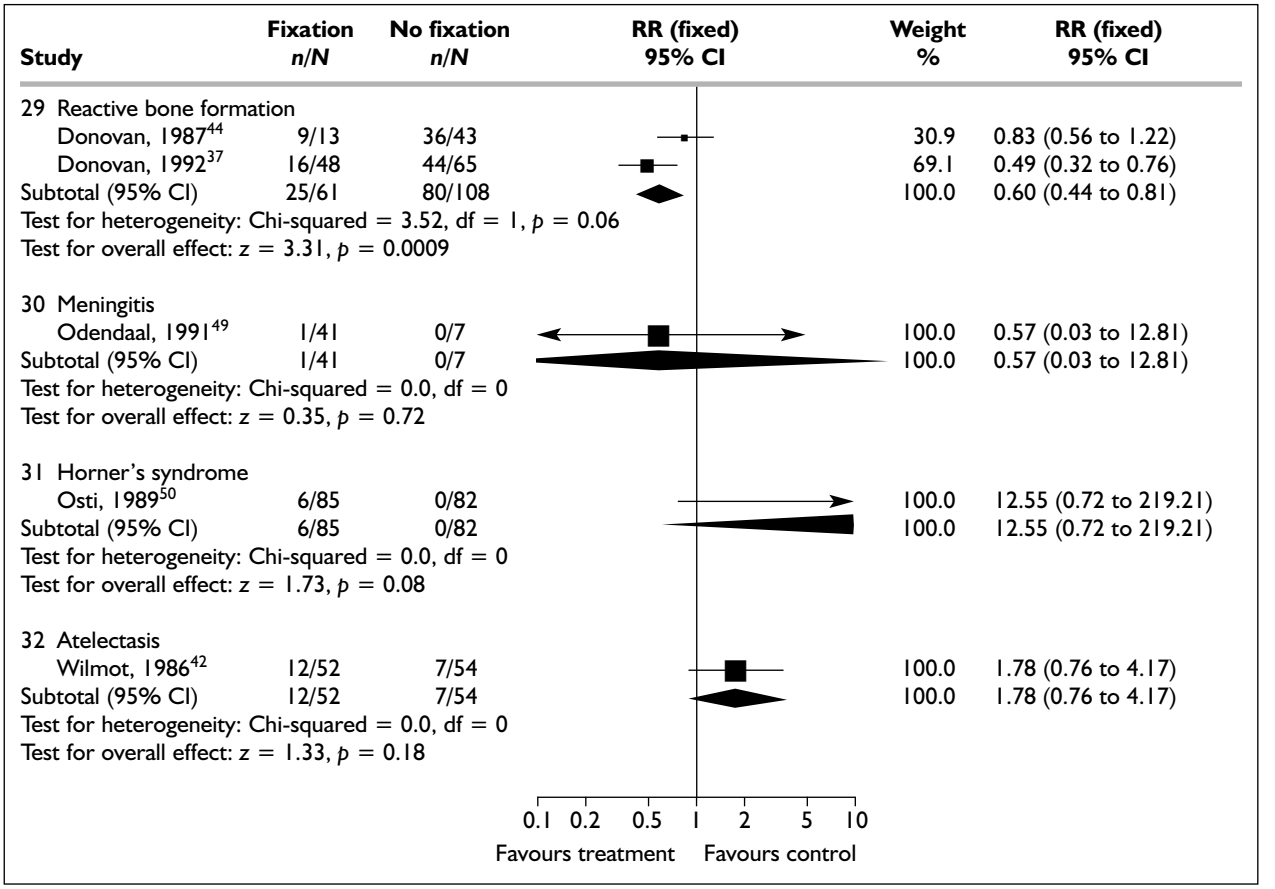

FIGURE 6 *Complications with spinal fixation (continued)*

need for removal, ossification, urinary tract infection (UTI)/urinary complications, pulmonary complications, wound healing, cerebrospinal fluid (CSF) leak, spasticity, cardiac complications and DVT/thrombophlebitis. Only one study reported on spasticity following surgery, although this was identified as a key outcome for the review by members of the expert advisory panel.

Five studies reported incidence of pneumonia – there was no significant difference between groups and no significant heterogeneity in this outcome. Eleven studies reported incidence of pressure sores. A borderline result was seen which was almost in favour of fixation (RR 1.37, 95% CI 0.97 to 1.94); however, there was significant heterogeneity in this result (chi-squared 16.68, $p = 0.082$). Incidence of gastrointestinal (GI) bleeding was reported by five studies, no significant difference was found between groups and there was no significant heterogeneity for this result. Four studies reported incidence of haemothorax or pneumothorax. There was no significant difference between groups and no significant heterogeneity in this result. Treatment failure was reported in 17 studies and was significantly more likely to occur in the fixation group (RR 2.46, 95% CI 1.84 to 3.29). This is not surprising as most studies reported on failure of fixation instrumentation. There was significant heterogeneity in this result (chi-squared 101.87, $p < 0.00001$). No difference and no significant heterogeneity was seen in need for further surgery reported in three studies.

Wound infection was significantly more likely to occur in the fixation group (13 studies, RR 3.58, 95% CI 1.80 to 7.10) but most studies reported this as surgical wound infection so this is not surprising. There was no significant heterogeneity in this result. Four studies found no significant difference between groups with regard to symptomatic deformity. There was significant heterogeneity in this result (chi-squared 8.97, $p = 0.03$).

No significant difference was seen between groups for pain at injury site in four studies. Radicular or sciatic pain were reported in one study each and no significant difference was seen between groups with regard to these outcomes.

Incidence of symptomatic instability reported in five studies favoured fixation (RR 0.22, 95% CI

0.09 to 0.56); no significant heterogeneity was seen in this result. Scoliosis and lumbar charcot were reported in one study and no significant difference was seen between groups. Pulmonary embolism was reported in 10 studies. No significant difference was seen between groups with regard to this outcome and no heterogeneity was seen in this result.

Reactive bone, or callus formation, reported in two studies, was more likely to occur in the non-surgical group (RR 0.60, 95% CI 0.44 to 0.81). However there was significant heterogeneity in this result (chi-squared 3.52, $p = 0.061$), with one study favouring fixation surgery and the other finding no difference between groups.

Incidences of CSF leak, spasticity, asystolia, lung abscess, pseudarthrosis, severe orthostatic reactions, bone displacement, meningitis, Horner's syndrome and atelectasis were all reported in one study each. No significant difference was seen between groups for any of these outcomes.

Severe or chronic pain was reported in six studies. A significant difference between groups was seen for this outcome in favour of non-fixation treatment (RR 1.39, 95% CI 1.02 to 1.89), but there was significant heterogeneity in this result (chi-squared 17.12, $p = 0.0043$).

Cardiac complications were reported in three studies. No significant difference was seen between groups for this outcome and there was no significant heterogeneity in this result.

Incidence of DVT was reported in eight studies. The result showed no significant difference between groups (RR 0.56, 95% CI 0.28 to 1.09). No significant heterogeneity was seen in this result.

Incidence of urological complications was reported in nine studies. No significant difference between groups and no significant heterogeneity were seen for this outcome.

Respiratory complications were reported by five studies. No significant difference between groups and no significant heterogeneity were seen for this outcome.

Thrombophlebitis was reported in four studies. No significant difference was seen between groups for this outcome. There was significant heterogeneity in this result (chi-squared 9.38, $p = 0.025$).

Length of hospitalisation

Sixteen studies[37,40–42,49–51,53,69,71,77,81,85,88,90,96] reported on the length of hospitalisation, either in acute care or rehabilitation, or both. This could be an important outcome as it relates to cost-effectiveness; however, as mentioned earlier in Chapter 3, the length of hospital stay may be more dependent on factors such as housing and level of support at home than on success or otherwise of surgical fixation. It may also relate to the level or complexity of the lesion. It was not possible to separate out this information from the included studies.

The results seem to be equivocal. Six studies report a shorter length of stay for surgery versus non-surgery. One reports a longer length of stay. Eight report no difference. In four it is unclear what the result is. The results are not well reported; in many studies measures of variance are missing, making it impossible to calculate the significance of the result.

Donovan and co-workers[37] reported mean length of stay for fixation and non-fixation groups but did not provide a measure of variance so mean differences with confidence intervals cannot be calculated. The fixation group had a mean length of stay of 42.9 days or weeks (not stated) compared with 47.9 days or weeks in the control group. Gardner and co-workers[88] also reported no measure of variance so further analysis is not possible. Mean time to discharge in the intervention group was 31 weeks compared with 29 weeks in the control group. Kiwerski and Ahmad[90] did not give mean values but presented some details of distribution of data for length of hospitalisation. Median length of hospitalisation in the fixation group was in the category 7–12 weeks and in the control group 4–5 months. Murphy and co-workers[40] reported mean days of hospitalisation but again with no measure of variance. Mean length of hospitalisation for the two fixation groups was 168.6 days for the early (2 weeks or less) fixation group and 197.1 days for the late group, compared with 189.4 days for the non-surgical group with unstable spines and 110.3 days for the non-surgical group with stable spines.

Place and co-workers[85] reported mean rehabilitation hospital stay (again with no measure of variance) to be 52.2 days in the fixation group, compared with 64 days in the non-surgical group and 64.2 days in the laminectomy group. The difference between the fixation and laminectomy group was reported to be significant ($p < 0.05$) but the difference between the fixation and the non-surgical group was not.

Prasad and co-workers[41] did not present numerical data but reported that operated cases had a shorter hospital stay and complications of mobilisation were limited compared with non-operated cases.

Wilmot and Hall[42,51] reported length of hospitalisation for both a group treated surgically at an SIU and one treated surgically elsewhere compared with a group treated non-surgically. Length of acute hospitalisation was significantly less in both surgical groups than in the non-surgical group [mean difference SIU group, –46.8 days (95% CI –75.4 to –18.2); mean difference non-SIU group, –36.6 days (95% CI –66.03 to –7.17)]. When lengths of acute and rehabilitation stay were combined, the difference between the SIU surgery group and the non-surgical group was not significant (mean difference –7.4 days, 95% CI –42.94 to 28.14 days), but the people treated surgically elsewhere had a considerably longer stay than those treated non-surgically (mean difference 43.1 days, 95% CI 1.89 to 84.31 days).

Ahn and co-workers[96] studied a variety of surgical procedures compared with no surgery and reported that bony fusion plus Harrington rod and the triple procedure were associated with the shortest hospital stays in both acute and rehabilitation facilities ($p < 0.05$). The mean acute hospital stay was 34.9 days with bony fusion plus Harrington rod and 37.5 days with triple procedure.

Meinecke[69] reported that in people with spondylodesis compared with those with conservative treatment, length of hospitalisation was 5 days less in those with tetraplegia and 34–57 days less for those with paraplegia.

Odendaal[49] reported a time to discharge of 12.6 weeks (range 2.1–39.3 weeks) in 41 people undergoing surgery compared with 15.0 weeks (range 9.9–19.9 weeks) in seven people undergoing postural reduction. The reduction in length of hospitalisation with surgery was reported to be not significant.

Ostl and co-workers[50] reported length of hospital stay for cervical spine injury patients (not all of whom had SCI). Those with complete SCI who had surgical fixation had an average stay of 225.1 days (range 180–325 days) compared with 194 days (range 120–260 days) for those who had no surgery. Those with incomplete SCI and fixation surgery had an average stay of 163 days (range 50–395 days) compared with 212 days (range 90–310 days) for those who had no surgery.

Petitjean and co-workers[71] compared a group who had early fixation surgery (within 24 hours of injury) with a group made up of those who had late surgery and those who had no surgery. The early surgery group stayed in intensive care for a mean 7.9 days (SD 8.9 days) compared with 16.2 days (SD 14 days) for the other group. The difference was found to be statistically significant in favour of early fixation surgery (mean difference –8.3 days, 95% CI –15.35 to –1.25 days).

Willen and co-workers[77] reported hospitalisation time for paraplegic patients with thoracolumbar fractures. One group received fusion with Harrington rods, one received laminectomy with or without fusion and one received no surgery. Mean hospitalisation time for the no-surgery group was 209 days (SD 87 days) compared with 146 days (SD 125 days) for the Harrington group and 244 days (SD 99 days) for the laminectomy group. The difference between the Harrington group and the no-surgery group was not significant (mean difference –54 days, 95% CI –141.44 to 33.44 days), nor was the difference between the laminectomy group and the no-surgery group (mean difference 35 days, 95% CI –38.03 to 108.03 days).

Fang and co-workers[53] reported mean number of days in hospital but gave no measure of variance. Those treated surgically were reported to spend on average 144 days in hospital compared with 114 days for those treated non-surgically.

Willen and co-workers[81] reported mean days in hospital for those with SCI treated surgically with Harrington rods compared with those treated conservatively. No significant difference was demonstrated between groups (mean difference –50 days, 95% CI –149.83 to 49.83 days).

Functional movement

This seems to refer to mobility (wheelchair, with crutches, etc.). Four studies[43,49,87,88] assessed this outcome (*Table 6*, *Figure 7*). Odendaal,[49] Gardner and co-workers[88] and Bohlman and co-workers[43] included only people with SCI. Hamel and co-workers[87] also included people with spinal injury without SCI. In Odendaal's study,[49] all the surgical group were treated with Harrington rods but a mixture of anterior and posterior approaches was used. In Hamel and co-workers' study,[87] all were treated with anterior fusion. In the other studies a mix of surgical approaches and techniques was used.

Gardner and co-workers[88] reported that in the surgery group, one of four people with complete cervical SCI and 4/11 people with complete thoracolumbar SCI developed functional

TABLE 6 *Functional ability (walking) with spinal fixation*

Study	Fixation *n/N*	No fixation *n/N*	RR (95% CI)
Bohlman, 1985[43]	11/130	1/65	5.50 (0.73 to 41.68)
Gardner, 1988[88]	5/15	8/83	3.46 (1.31 to 9.15)
Hamel, 1977[87]	16/30	7/30	2.29 (1.10 to 4.74)
Odendaal, 1991[49]	13/40	4/7	0.57 (0.26 to 1.24)

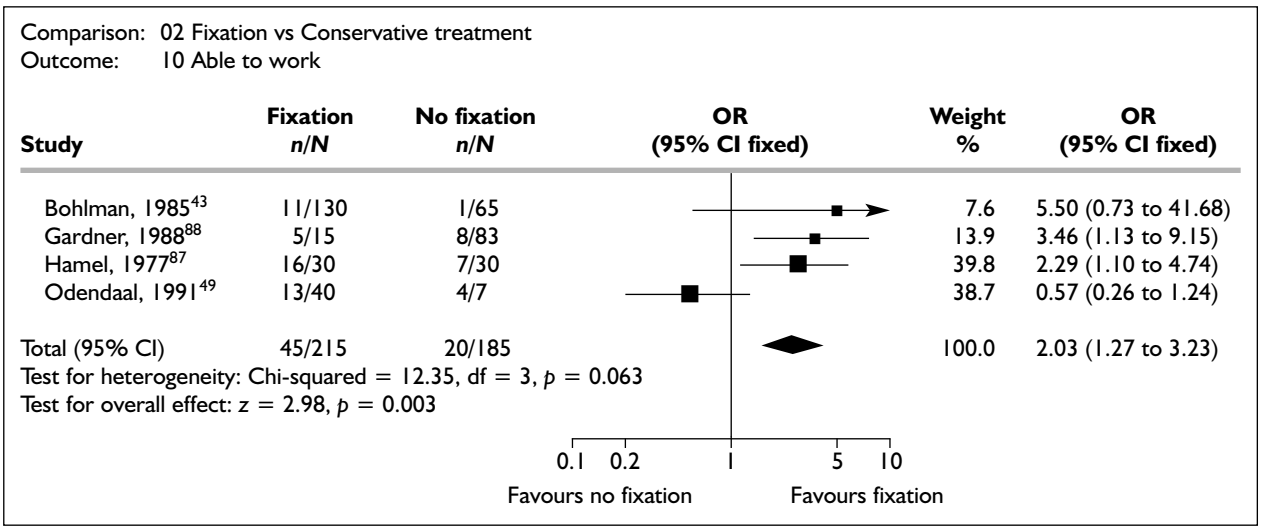

FIGURE 7 *Functional ability with spinal fixation*

movement. In the conservatively managed group, 4/32 people with complete cervical SCI and 4/51 with complete thoracolumbar SCI developed functional movement. This difference was significantly in favour of fixation (RR 3.46, 95% CI 1.31 to 9.15). However, not all participants included in the study were included in this analysis.

Bohlman and co-workers[43] assessed ability to walk, with or without crutches. The result showed no significant difference between fixation and non-fixation groups (RR 5.50, 95% CI 0.73 to 41.68). Hamel and co-workers[87] assessed ability to walk. The result favoured fixation (RR 2.29 CI 1.10, 4.74). Odendaal[49] also reported ability to walk, independently or with crutches, and independence with a wheelchair. No significant difference was seen between fixation and non-fixation groups when walking ability was compared (RR 0.57, 95% CI 0.26 to 1.24).

The pooled result for walking ability also favoured fixation (RR 2.03, 95% CI 1.27 to 3.23). Statistical heterogeneity was seen in this result (chi squared 12.35, $p = 0.0063$), which seemed to be due to Odendaal.[49] When this study was removed there was no significant heterogeneity and the result still favoured fixation.

Activities of daily living

Three studies assessed this outcome.[40,45,92] Murphy and co-workers,[40] Jacobs and co-workers[45] and Lui and Lee[92] all included people with SCI and also included people with spinal injury but without SCI. In Lui and Lee's study, all the surgical groups were treated with clamps and wires by a posterior approach. Jacobs and co-workers used rods and plates and reported some results separately for these groups. Murphy and co-workers did not state the method of surgery.

In Murphy and co-workers' study,[40] the following categories of activities were evaluated: feeding, wheelchair mobility, transfers from bed to chair, dressing above the waist, dressing below the waist and toileting. No appreciable differences in outcome were noted among the groups or between surgically treated and non-surgically treated patients with regard to their achievements in these activities. Jacobs and co-workers[45] measured activity using the Kenny Self Care score and found a significant advantage for fixation surgery (mean difference 7.07, 95% CI 6.15 to 7.99). Lui and Lee[92] reported briefly on activity and/or work and reported that the operative group had an earlier return to normal than the non-operative group. Argenson and co-workers[97] found no difference

between fixation and non-fixation treated groups in likelihood of return to work (RR 0.86, 95% CI 0.71 to 1.03).

Time to ambulation/mobilisation

Six studies[45,49,59,77,81,89] assessed this outcome, which is less dependent on social factors than time spent in hospital. Odendaal,[49] Soreff and co-workers[59] and Willen and co-workers[77] all included only patients with SCI whereas Jacobs and co-workers,[45] Willen and co-workers[81] and Jodoin and co-workers[89] also included people with spinal injury but without SCI. Willen and co-workers[77,81] used Harrington rods in the surgical group, Jodoin and co-workers[89] used Harrington and Knodt rods and the other studies used a mixture of surgical approaches and techniques.

Jodoin and co-workers[89] reported that the average time to ambulation was 27 days for non-instrumented and 22 days for instrumented patients. The difference was reported to be not statistically significant. No measure of variance was reported so we cannot calculate confidence intervals around the mean difference.

Jacobs and co-workers[45] reported the average time required to perform independent wheelchair transfers. In the group treated with Harrington rods this was 4.0 weeks (SD 0.4 weeks), in the group treated with Meurig–Williams plates it was 8.2 weeks (SD 0.8 weeks) and in the non-operated group it was 9.1 weeks (SD 0.8 weeks). The result significantly favoured Harrington rods (mean difference –5.10 weeks, 95% CI –5.40 to –4.80) and Meurig–Williams plates (mean difference –0.90, 95% CI –1.42 to –0.38) over no fixation.

Odendaal[49] also reported the time to mobilisation but did not report the standard deviation so we cannot calculate confidence intervals for the mean difference between groups. The mean time to mobilisation was reported to be 5.1 weeks in the surgical group and 9.5 weeks in the non-surgical group.

Willen and co-workers[77] reported mean time to mobilisation in days in a group treated with Harrington rods (19 days, SD 18.6 days), a group treated with laminectomy with or without fusion (90 days, SD 16.8 days) and a non-surgical group (74 days, SD 8.7 days). The result significantly favoured the Harrington rod group over the non-surgical group (mean difference –55 days, 95% CI –67 to –43) but favoured the non-surgical group over the laminectomy group (mean difference 16 days, 95% CI 6 to 26).

Soreff and co-workers[59] reported time to becoming active. No standard deviation was reported so we cannot calculate the confidence intervals around the mean difference. Time to becoming active was reported as 5.7 weeks in the surgical group and 16.8 weeks in the non-surgical group.

Willen and co-workers[81] also reported time to mobilisation in days. This was reported as 18 days (SD 8 days) in the surgical group and 67 days (SD 11 days) in the non-surgical group. This result significantly favoured the fixation group (mean difference –49 days, 95% CI –54 to –44).

Urinary status

Only two studies[40,61] assessed this outcome, which was identified by members of the expert advisory panel as being a key outcome for this review. Murphy and co-workers[40] included only people with SCI and compared early and late surgical stabilisation (method not stated) with no surgery. There was found to be no significant difference between groups with regard to the outcome 'urinary status – no catheter' (*Figure 8*). Chahal and co-workers[61] also included only people with

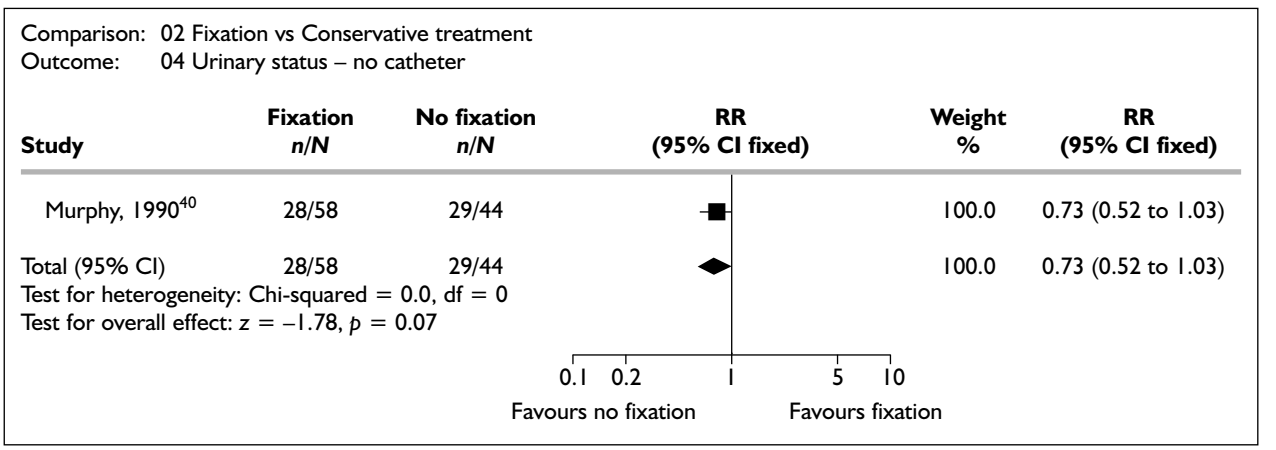

FIGURE 8 *Urinary status with spinal fixation*

SCI and compared fixation, some with Harrington rods and some not, with no surgery. This study did not provide numerical data for analysis but stated that urinary bladder recovery was much better in the conservatively treated group than in the surgical group.

Psychological outcomes
Only one study[41] assessed this outcome, which was identified as being a key outcome by the expert advisory panel at protocol stage. The assessment in this one study does not appear to be very detailed. The study by Prasad and co-workers[41] was carried out in India and included only people with SCI, treated with surgical wires and plates. The study did not provide numerical data for analysis but stated that the operated group of patients were found to be 'brighter' (no further explanation is given as to the meaning of this word) than the non-operative group, who had predominantly feelings of unworthiness, depression and suicidal tendencies.

Stability
Four studies[86,91,92,98] assessed aspects of spinal stability after fixation and compared them with a non-operated group. Three studies assessed aspects of spinal flexibility after fixation and non-fixation;[91,97,98] one of these studies was of athletes in the paralympic games.[91] Lemons and Wagner[86] and Takayanagi and co-workers[98] only included people with SCI whereas Lui and Lee[92] and Argenson and co-workers[97] also included people with spinal injury but without SCI. A mix of surgical approaches and techniques was used in the five studies.

Lemons and Wagner[86] reported that after identifying evidence of severe ligamentous injury (SLI) or severe vertebral body injuries (SVBI) on X-rays and treating SLIs by posterior fixation and SVBIs by anterior fixation, 100% stabilisation success was achieved. In the non-operative group only injuries without evidence of SLI or SVBI were stabilised adequately.

Lui and Lee[92] reported that the range of motion in the surgical group was normal or decreased, while the range of motion in the non-surgical group was normal.

Argenson and co-workers[97] reported increased likelihood of decreased flexibility in the fixation treated group compared with the non-fixation treated group (RR 1.98, 95% CI 1.13 to 3.47).

Hardcastle and co-workers[91] measured spinal movement (flexion, extension and rotation), static and dynamic sitting balance in spinal fusion and non-fusion groups, taken from a group of athletes in the paralympic games. Spinal flexion (mean difference –8.00, 95% CI –12.57 to –3.43) and rotation (mean difference –25.7, 95% CI –34.57 to 16.83) were reported to be significantly reduced in the fusion group compared with the non-fusion group. They also found that extension (mean difference –3.10, 95% CI –5.27 to –0.93) and dynamic sitting balance class 3 (mean difference –2.20, 95% CI –3.64 to –0.76) were significantly reduced in the fixation group.

Takayanagi and co-workers[98] performed a study of sitting balance and trunk muscle strength in paraplegic patients treated with Harrington instrumentation compared with no surgery and reported that sitting balance transfer from right to left and back and forth were both significantly reduced in the fixation group compared with the non-fixation group. However, these differences were not significant when the 95% confidence intervals of the mean differences were calculated (transfer from right to left mean difference 0.92, 95% CI –2.71 to 4.55; transfer back and forth mean difference 2.98, 95% CI –1.23 to 7.19).

Thoracolumbar fatigue
Two studies assessed this outcome, by Willen and co-workers[77,81] Both used Harrington rods in the surgical group. The former study only included people with SCI whereas the latter also included people with spinal injury but no SCI. No significant difference was seen between surgical and non-surgical groups for this outcome (*Table 7*, *Figure 9*, pooled RR 1.37, 95% CI 0.86 to 2.18).

Healing time
One study, by Soreff and co-workers,[59] assessed whether fractures healed within 6 months (*Table 8*, *Figure 10*). The study only included people with SCI and used Harrington distraction or compression rods or both in the surgical group. The result strongly favoured fixation (RR 5.93, 95% CI 2.06 to 17.04).

Radiological outcome (angulation)
This was assessed in six studies,[45,46,53,56,67,88] but it was not identified as an important outcome in the protocol stage and so should not be given undue emphasis (*Table 9*, *Figure 11*). Gardner and co-workers,[88] Lewis and Mckibbin,[67] and Fang and co-workers[53] only included people with SCI whereas Jacobs and co-workers[45] and Koivikko and co-workers[46] also included people with spinal injury but without SCI. In Vaccaro and co-workers' study,[56] it was unclear how many people had SCI.

TABLE 7 *Thoracolumbar fatigue with spinal fixation*

Study	Fixation *n/N*	No fixation *n/N*	OR (95% CI)
Willen, 1983[77]	12/23	4/9	1.17 (0.51 to 2.69)
Willen, 1985[81]	16/26	10/24	1.48 (0.84 to 2.59)

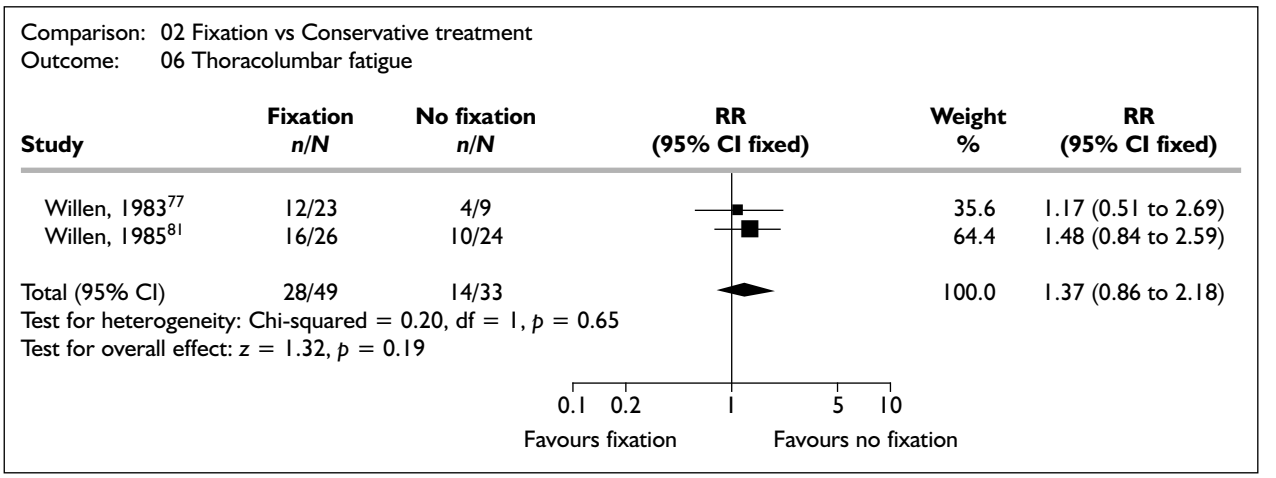

FIGURE 9 *Thoracolumbar fatigue with spinal fixation*

TABLE 8 *Healing time with spinal fixation*

Study	Fixation n/N	No fixation n/N	RR (95% CI)
Soreff, 1982[59]	16/18	3/20	5.93 (2.06 to 17.04)

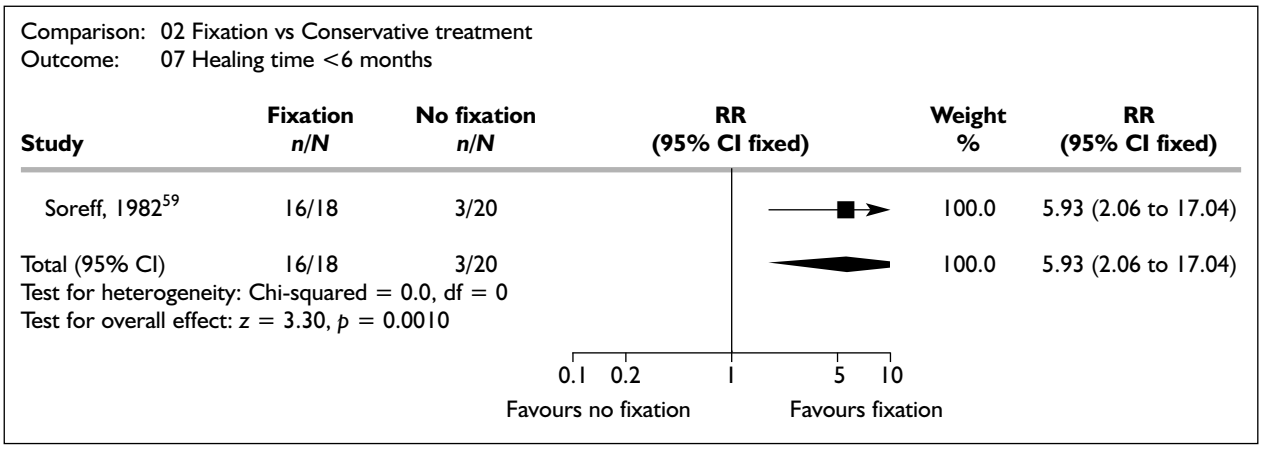

FIGURE 10 *Healing time with spinal fixation*

A mix of surgical approaches and techniques was used in the six studies.

Gardner and co-workers[88] reported radiological outcome as being moderate or good in 17/22 surgical patients compared with 167/176 non-surgical patients. The result showed no significant difference between groups (RR 0.81, 95% CI 0.65 to 1.02). Jacobs and co-workers[45] also assessed radiological outcome as satisfactory or not, and in this case the outcome favoured the fixation group (RR 1.15, 95% CI 1.00 to 1.33). Vaccaro and

TABLE 9 *Radiological outcome satisfactory with spinal fixation*

Study	Fixation *n/N*	No fixation *n/N*	RR (95% CI)
Fang, 1982[53]	10/18	6/11	1.02 (0.52 to 2.01)
Gardner, 1988[88]	17/22	167/176	0.81 (0.65 to 1.02)
Jacobs, 1980[45]	63/64	29/34	1.15 (1.00 to 1.33)
Lewis, 1974[67]	15/29	3/12	2.07 (0.73 to 5.86)
Vaccaro, 2001[56]	16/16	5/8	1.60 (0.94 to 2.74)

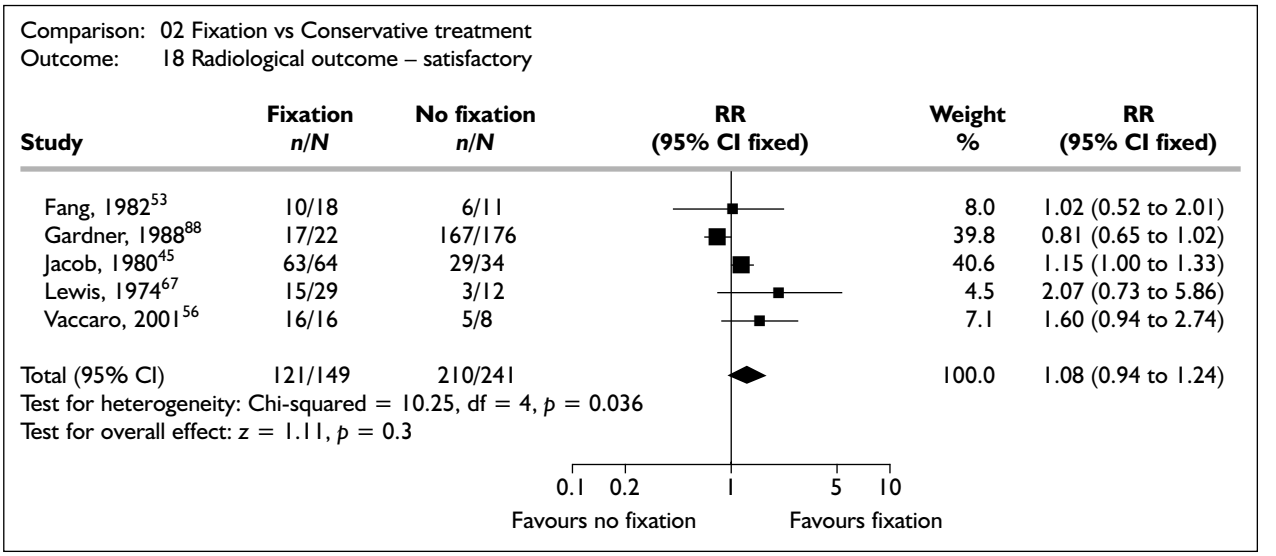

FIGURE 11 *Radiological outcome satisfactory with spinal fixation*

co-workers,[56] assessing the same outcome found no significant difference between the groups (RR 1.60, 95% CI 0.94 to 2.74). Koivikko and co-workers[46] reported degree of kyphosis and found this to be less in the fixation group than in the non-fixation group (mean difference –10.40, 95% CI –16.10 to –4.70). Fang and co-workers[53] and Lewis and McKibbin[67] assessed the presence of kyphosis and found no significant difference between groups (Fang and co-workers, RR 1.02, 95% CI 0.52 to 2.01; Lewis and McKibbin, RR 2.07, 95% CI 0.73 to 5.86).

Early versus late fixation

Of studies which met the inclusion criteria (i.e. those which had a no-fixation control group), six[34,38,40,64,65,71] also reported some outcomes separately for people who had had 'early' versus 'late' surgery. Definitions of early and late were not consistent between the studies. Kiwerski[38] did not define cut-offs for early and late but commented on how time to admission affected the results. Murphy and co-workers[40] defined a cut-off of 2 weeks and Asazuma and co-workers[34] chose 4 weeks for early versus late surgery. Heiden and co-workers[65] set the cut-off at 48 hours and Petitjean and co-workers[71] set it at 24 hours.

Neurological improvement

All five studies reported this outcome. Kiwerski[38] reported that outcome in terms of improvement is largely dependent on time of commencement of specialist treatment and clinical condition of the patient. However, no numerical data were reported regarding the early versus late fixation surgery comparison. Heiden and co-workers[65] reported that no patient in the early or the delayed surgical groups improved. Murphy and co-workers[40] found no significant difference between early and late groups (RR 0.95, 95% CI 0.37 to 2.49) but Petitjean and co-workers[71] and Asazuma and co-workers[34] found a significant advantage for early surgery (RR 18.82, 95% CI 1.11 to 319.54 and RR 2.25, 95% CI 1.34 to 3.77) (see *Table 10, Figure 12*).

Duh and co-workers[64] reported neurological scores (*Figure 13*). All measures, using both anterior and

TABLE 10 *Neurological improvement – early vs late fixation*

Study	Early fixation *n/N*	Late fixation *n/N*	RR (95% CI)
Asazuma, 1996[34]	8/8	8/18	2.25 (1.34 to 3.77)
Murphy, 1990[40]	12/44	4/14	0.95 (0.37 to 2.49)
Petitjean, 1995[71]	4/10	0/22	18.82 (1.11 to 319.54)

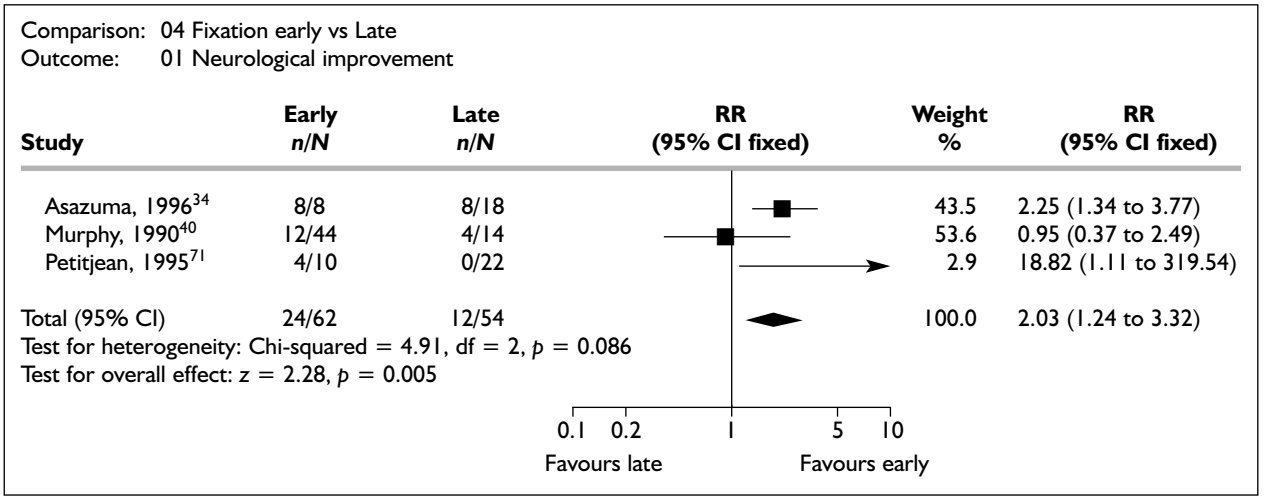

FIGURE 12 *Neurological improvement – early versus late fixation*

posterior approaches, found in favour of early fixation surgery compared with late fixation surgery.

Duration of hospitalisation

Three studies reported this outcome.[40,77,85] Place and co-workers[85] compared 'stabilisation and fusion' (the authors do not give any further information) to laminectomy only. The duration of hospitalisation was reported to be 168.6 days in people stabilised within 2 weeks of injury compared with 197.1 days in patients stabilised more than 2 weeks after injury. No measure of variance was provided so we could not calculate if this difference was statistically significant.

Place and co-workers[85] reported that mean rehabilitation hospital stay was 52.2 days in the surgical fusion group compared with 64.2 days in the laminectomy group. This difference was reported to be statistically significant ($p < 0.05$) but no measure of variance was given so we could not calculate 95% confidence intervals around the mean difference.

Willen and co-workers[77] reported a significantly shorter length of hospitalisation in people treated with Harrington rods than in people treated with laminectomies (mean difference –98 days, 95% CI –186 to –10).

Duration of rehabilitation

Only one study reported this outcome.[40] The duration of rehabilitation was reported to be 85.3 days in people stabilised within 2 weeks of injury compared with 90.6 days in people stabilised 2 weeks or more after injury. No measure of variance was provided so we could not calculate if this difference was statistically significant.

Urinary status

Only one study reported this outcome (*Table 11*, *Figure 14*).[40] No difference was seen between people stabilised within 2 weeks of injury and people stabilised later than this with regard to this outcome (RR 0.95, 95% CI 0.52 to 1.75).

Time of surgery/blood loss

One study[71] assessed these outcomes, which relate to the surgical group only. The study was conducted in France; all the included patients had SCI but those with gunshot wounds were excluded. Early surgery took on average 130 minutes (range 75 minutes to 4 hours). Mean blood loss in early surgery was 1000 ml (SD 424 ml) compared with 1508 ml (SD 800 ml) in late surgery.

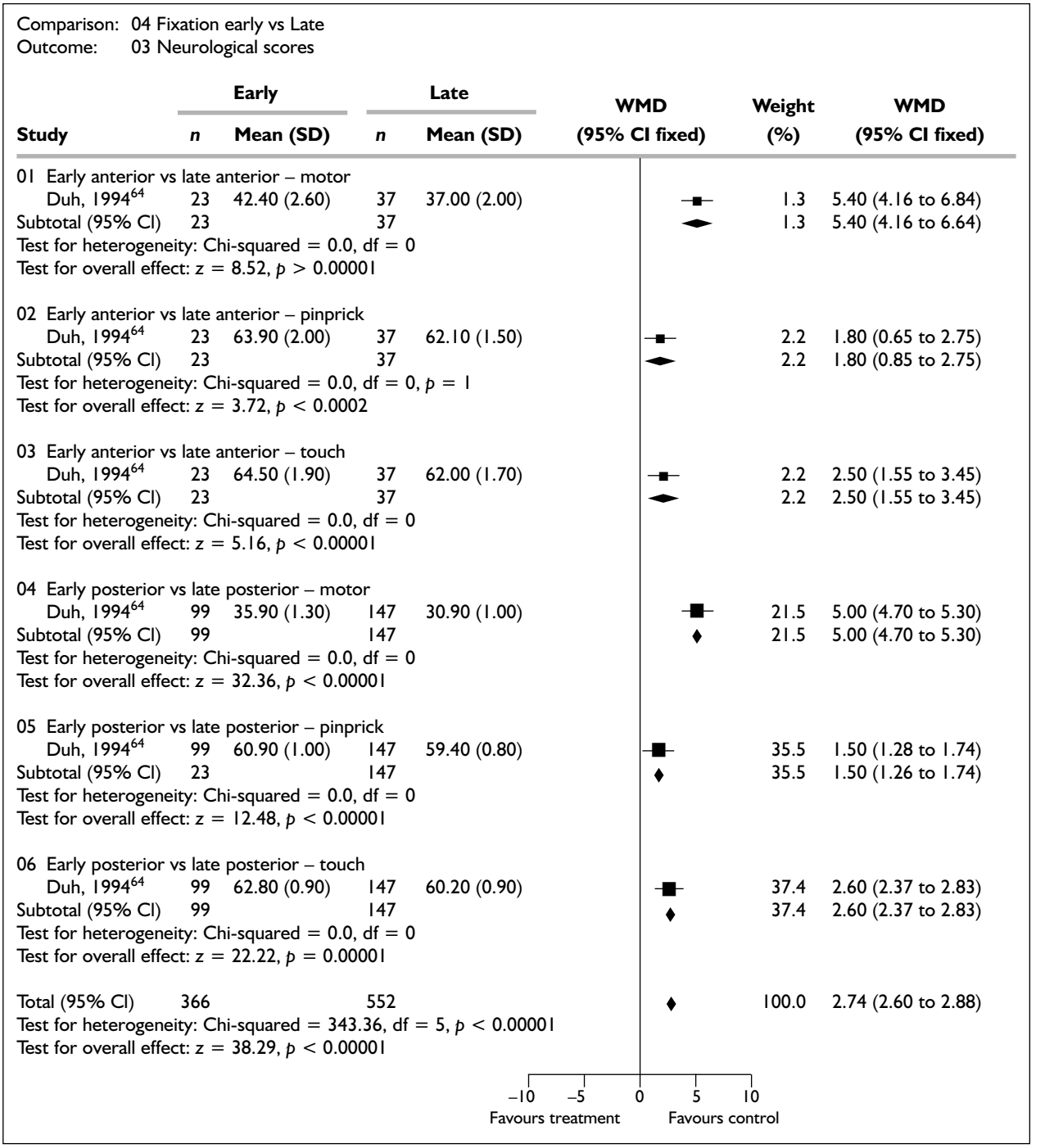

FIGURE 13 *Neurological improvement scores – early versus late fixation*

Studies which compared different types of fixation

Twenty-four studies compared different types of surgical fixation but did not meet inclusion criteria for the review because they did not have a 'no fixation' control group.[99–122]

Nine studies which did meet the review inclusion criteria contained some data comparing different types of fixation.[45,51,55,62,64,70,77,89,96] Jacobs and co-workers[45] compared Harrington rods with Meurig–Williams plates. Lifeso and Colucci,[55] Chen and co-workers,[62] Nikolskii and Protas[70] and Duh and co-workers[64] compared anterior and posterior surgical approaches. Jodoin and co-workers[89] compared fusion with instrumentation with fusion without instrumentation. Ahn and co-workers[96] compared several different types of surgery. Willen and co-workers[77] compared surgery with Harrington rods

TABLE 11 *Urinary status – no catheter – early versus late fixation*

Study	Early fixation *n/N*	Late fixation *n/N*	OR (95% CI)
Murphy, 1990[40]	21/44	7/14	0.95 (0.52 to 1.75)

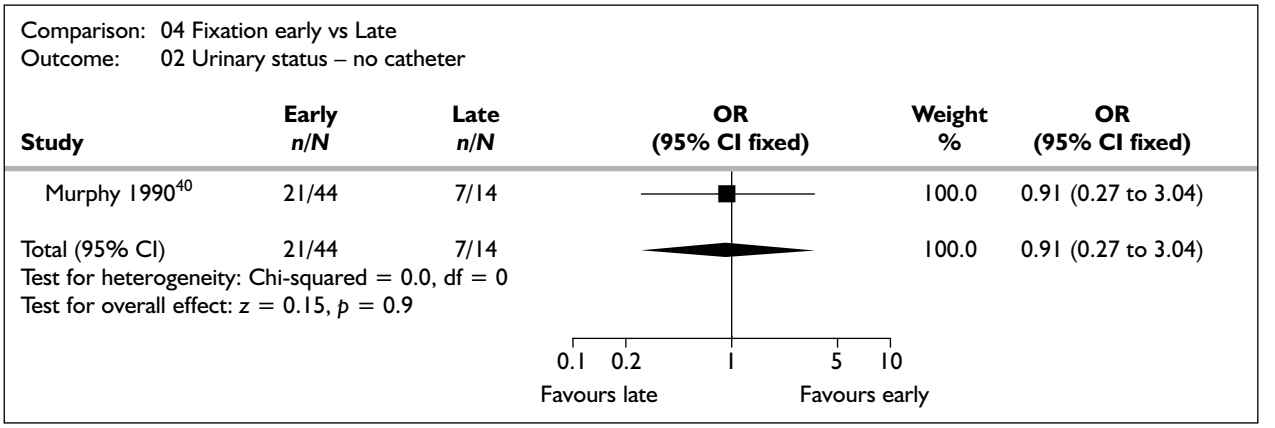

FIGURE 14 *Urinary status – no catheter – early versus late fixation*

with 'fusion' plus laminectomy. Wilmot and Hall[51] compared fixation surgery in a UK SIU with that in a US SIU.

Time to ambulation/mobilisation

Jacobs and co-workers[45] reported the average time required to perform independent wheelchair transfers. In the group treated with Harrington rods this was 4.0 weeks (SD 0.4 weeks), in the group treated with Meurig–Williams plates it was 8.2 weeks (SD 0.8 weeks) and in the non-operated group it was 9.1 weeks (SD 0.8 weeks). The result significantly favoured Harrington rods over Meurig–Williams plates (mean difference –4.20, 95% CI –4.65 to –3.75).

Willen and co-workers[77] reported mean time to mobilisation in days in a group treated with Harrington rods (19 days, SD 18.6 days), a group treated with laminectomy with or without fusion (90 days, SD 16.8 days) and a non-surgical group (74 days, SD 8.7 days). The result significantly favoured the Harrington rod group over the laminectomy group (mean difference –71 days, 95% CI –85 to –57).

Jodoin and co-workers[89] reported that the average time to ambulation was 27 days for non-instrumented and 22 for instrumented patients. The difference was not statistically significant.

Length of hospitalisation

Ahn and co-workers[96] reported that bony fusion plus Harrington rod and the triple procedure were associated with the shortest hospital stays in both acute and rehabilitation facilities ($p < 0.05$). Laminectomy plus bony fusion was consistently associated with prolonged hospital stays in both facilities ($p < 0.05$). The mean acute hospital stay was 34.9 days with bony fusion plus Harrington rod and 37.5 days with the triple procedure. Also associated with significantly shorter acute care duration ($p < 0.05$) were the single use of Harrington rod instrumentation (mean 36.5 days) and of laminectomy (mean 40 days) and the absence of surgical procedure (mean 36.9 days). The longest stays ($p < 0.05$) were associated with laminectomy plus Harrington rod (mean 52.2 days). The only treatments associated with significantly shortened ($p < 0.05$) rehabilitation stay were bony fusion plus Harrington rod (mean 77.1 days) and the triple procedure (mean 76.6 days). Rehabilitation stay with the other treatments, including non-surgical, ranged from a mean of 83.1 to a mean of 101.4 days.

Wilmot and Hall[51] reported that acute hospitalisation and rehabilitation stay at a centre which used mostly posterior surgery averaged 144.1 days compared with 194.6 days in other places which used mostly anterior surgery. The stay at the centre which used posterior surgery was significantly shorter (mean difference –51 days, 95% CI –91 to –6). However, other aspects of care are likely to have differed.

Neurological improvement

Willen and co-workers[77] found that neurological scores at 3 months significantly favoured the

Harrington rod group over the laminectomy group (mean difference, 19.40, 95% CI 9.86 to 28.94) but at 2 years there was no significant difference between groups.

Chen and co-workers[62] reported on residual major sensory complaints at 3 months with anterior or posterior surgery. No significant differences were seen between anterior and posterior groups with regard to this outcome (RR 1.64, CI 0.72 to 3.73).

Duh and co-workers[64] reported neurological improvement scores (*Figure 15*). All favoured anterior over posterior fixation.

Comparison: 05 Fixation techniques
Outcome: 02 Neurological scores

Study	Anterior *n*	Anterior Mean (SD)	Posterior *n*	Posterior Mean (SD)	WMD (95% CI fixed)	Weight (%)	WMD (95% CI fixed)
01 Anterior early vs posterior early motor							
Duh, 1994[64]	23	42.40 (2.60)	99	35.90 (1.30)		6.3	6.50 (5.41 to 7.59)
Subtotal (95% CI)	23		99			6.3	6.50 (5.41 to 7.59)
Test for heterogeneity: Chi-squared = 0.0, df = 0							
Test for overall effect: $z = 11.66$, $p < 0.00001$							
02 Anterior early vs posterior early – pinprick							
Duh, 1994[64]	23	63.90 (2.00)	99	60.90 (1.00)		10.7	3.00 (2.16 to 3.84)
Subtotal (95% CI)	23		99			10.7	3.00 (2.16 to 3.84)
Test for heterogeneity: Chi-squared = 0.0, df = 0, $p = 1$							
Test for overall effect: $z = 6.99$, $p < 0.00001$							
03 Anterior early vs posterior early touch							
Duh, 1994[64]	23	64.50 (1.90)	99	62.80 (0.90)		11.9	1.70 (0.90 to 2.50)
Subtotal (95% CI)	23		99			11.9	1.70 (0.90 to 2.50)
Test for heterogeneity: Chi-squared = 0.0, df = 0							
Test for overall effect: $z = 4.18$, $p < 0.00003$							
04 Anterior late vs posterior late motor							
Duh, 1994[64]	37	37.00 (2.00)	147	30.90 (1.00)		17.2	6.10 (5.44 to 6.76)
Subtotal (95% CI)	37		147			17.2	6.10 (5.44 to 6.76)
Test for heterogeneity: Chi-squared = 0.0, df = 0							
Test for overall effect: $z = 17.99$, $p < 0.00001$							
05 Anterior late vs posterior late pinprick							
Duh, 1994[64]	37	62.10 (1.50)	147	59.40 (0.80)		30.3	2.70 (2.20 to 3.20)
Subtotal (95% CI)	37		147			30.3	2.70 (2.20 to 3.20)
Test for heterogeneity: Chi-squared = 0.0, df = 0							
Test for overall effect: $z = 10.58$, $p < 0.00001$							
06 Anterior late vs posterior late touch							
Duh, 1994[64]	37	62.00 (1.70)	147	60.20 (0.90)		23.6	1.80 (1.23 to 2.37)
Subtotal (95% CI)	37		147			23.6	1.80 (1.23 to 2.37)
Test for heterogeneity: Chi-squared = 0.0, df = 0, $p = 1$							
Test for overall effect: $z = 6.22$, $p < 0.00001$							
07 Overall at 3 months							
Willen 1983	12	44.30 (15.10)	14	24.90 (8.10)		0.1	19.40 (9.86 to 28.94)
Subtotal (95% CI)	12		14			0.1	19.40 (9.86 to 28.94)
Test for heterogeneity: Chi-squared = 0.0, df = 0							
Test for overall effect: $z = 3.99$, $p < 0.0001$							
Total (95% CI)	180		738			100.0	3.22 (2.95 to 3.50)
Test for heterogeneity: Chi-squared = 149.29, df =5, $p < 0.00001$							
Test for overall effect: $z = 22.97$, $p < 0.00001$							

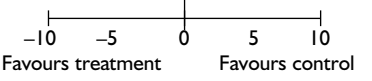

FIGURE 15 *Neurological improvement scores – anterior versus posterior fixation*

Jacobs and co-workers[45] reported neurological improvement of 53% with Harrington rods and 50% with Meurig–Williams plates. The difference was not statistically significant (RR 0.98, 95% CI 0.56 to 1.72).

Lifeso and Colucci[55] reported neurological improvement in anterior and posterior surgery groups. The result favoured anterior over posterior surgery (RR 3.00, 95% CI 0.97 to 9.30). The study also reported 'success' rates (defined as restoration of spinal column, no secondary surgery, complete recovery from radiculopathy, stabilisation of any cord deficit and late kyphosis no more than 10 degrees). This result also favoured anterior over posterior surgery (RR 1.83, 95% CI 1.07 to 3.14).

Pain
Willen and co-workers[77] found no significant difference between groups treated with Harrington rods and with laminectomies in terms of number with pain (RR 0.71, 95% CI 0.41 to 1.24) or pain scores (mean difference –1.10, 95% CI –3.25 to 1.05).

Jodoin and co-workers[89] reported that pain was less severe in patients with instrumentation of five or more levels than with short instrumentation.

Thoracolumbar fatigue
Willen and co-workers[77] found no difference between groups treated with Harrington rods and with laminectomies in terms of daily thoracolumbar fatigue (RR 1.28, 95% CI 0.57 to 2.87).

Radiographic evaluation
Jacobs and co-workers[45] reported that this was satisfactory in 98% of people treated with Harrington rods and 61% of people treated with Meurig–Williams plates. This translates into a significant advantage for Harrington rods over Meurig–Williams plates (RR 1.59, 95% CI 1.03 to 2.45).

Question 1b. Outcomes of fixation surgery in SIUs compared with non-SIU hospitals

Four studies contained data relevant to this question.[7,42,51,52,123] However, one of the studies did not seem to report outcomes separately for SIU and non-SIU treated patients.[7] The study reported that 35% of delayed admissions to the SIU were due to surgery and its complications, and that the incidence of pressure sores was higher in patients treated surgically than those treated non-surgically (but they did not state whether treated at an SIU or elsewhere). One was a comparison of two SIUs, Stoke Mandeville and Arizona,[52] but has been included here owing to the dearth of available evidence. This paper reported neurological improvement only. The third study was published in two papers[42,51] and reported complications, length of hospitalisation and neurological improvement by Frankel grade. Length of acute hospitalisation was significantly less in both surgical groups than in the non-surgical group (mean difference SIU group –46.8 days, 95% CI –75.4 to –18.2; mean difference non-SIU group –36.6 days, 95% CI –66.03 to –7.17). However, there was no statistically significant difference between length of acute hospitalisation in the surgical SIU group and the surgical non-SIU group (mean difference –10.2 days, 95% CI –30.32 to 9.92).

A fourth study, which was not well reported,[123] stated that complications due to inappropriate surgical treatment (such as inadequate bone grafting or spinal instrumentation) in patients admitted to an SIU more than 48 hours after injury made a further operation necessary in 15 out of 77 patients.

Characteristics associated with delayed referral to an SIU

Nineteen studies[3,5–7,123–140] were found which related to this question or to the related comparison of acute management in an SIU versus acute management in a general hospital.

Ten studies were focussed on the question of delayed referral,[5,125,126,130–134,137,138] five studies addressed the question of referral to an SIU compared with referral to a non-SIU[3,123,128,129,135,139] (two of these also contained data on surgery in SIUs versus non-SIUs, relevant for question 1b[6,7]) and six studies were able to address aspects of both questions.[6,7,124,127,136,140]

Validity
All studies had a control group in that they compared early referral to an SIU with late referral and/or no referral. However, they were all retrospective observational studies rather than experimental studies. On the whole, the studies were more poorly described than the fixation studies and there was some doubt over the comparability of groups, at baseline or on confounding factors, in 16 of the 22 studies. Confounding factors were not adjusted for or this was not stated in 16 of the 22 studies. Several

TABLE 12 *Neurological improvement – early versus late referral*

Study	Early referral *n/N*	Late/no referral *n/N*	RR (95% CI)
DeVivo, 1990[123]	10/315	4/401	3.18 (1.01 to 10.05)
Kiwerski, 1981[130]	136/385	20/83	1.47 (0.98 to 2.20)
Meyer, 1987[137]	175/1610	?/793	Not estimable
Tator, 1995[135]	50/173	34/262	2.23 (1.51 to 3.29)

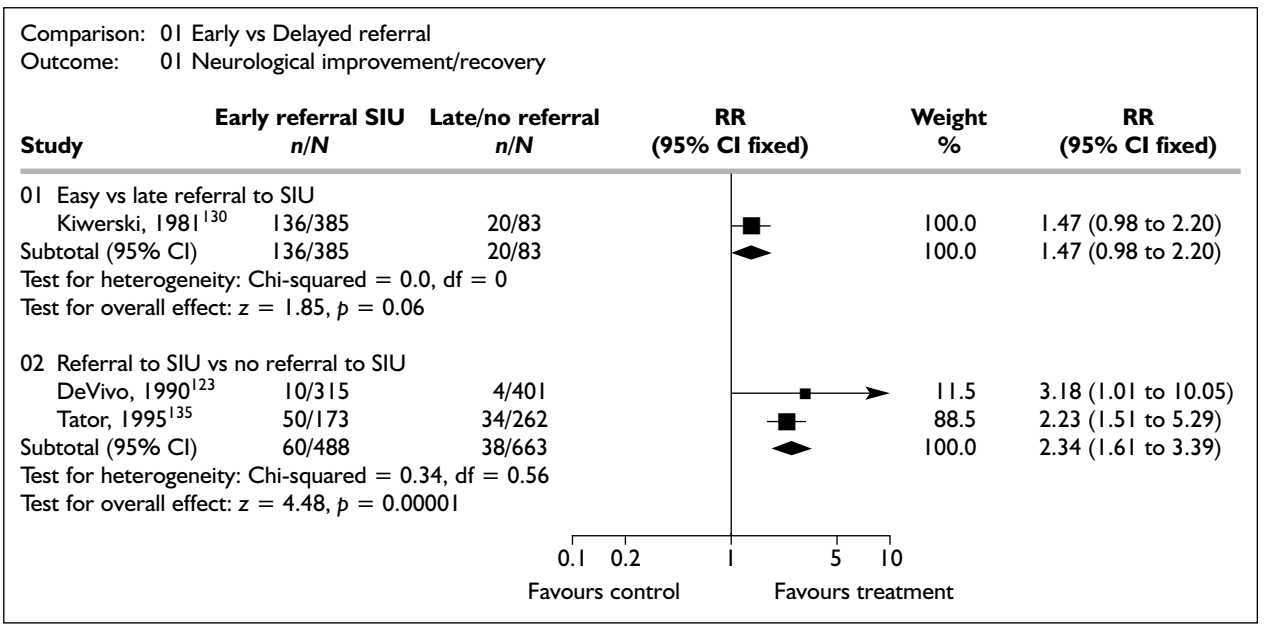

FIGURE 16 *Neurological improvement – early versus late referral*

studies did not report how many people were in each group but reported only percentages. Some studies only reported outcomes for one group and stated whether these were better or worse than for the other group or groups. In the included studies it was not possible to separate the time of referral and the time of transfer. True late referrals may be a different group of patients with a medical reason why they could not be referred at an earlier stage. Given that the groups referred early and late to SIUs may not be comparable in many cases, all results in this section should be treated with caution.

Neurological improvement

Four studies addressed the outcome of neurological improvement, using either Frankel grades or an unspecified grading system (*Table 12*).[123,130,135,137,139] Only two[123,135,139] seemed to have comparable groups at baseline and on important confounding factors. One of these[135,139] was also the only study that had made adjustment for confounding factors. However, the groups in that study were not concurrent – the control group consisted of people who had SCI between 1948 and 1973 whereas the intervention group was people referred to the SIU after its establishment in 1974.

One of the four studies that addressed this outcome only gave numbers for neurological improvement in the group who were referred to the SIU in less than 24 hours.[137] It was reported that this group had a higher rate of improvement (10.9%) and a lower rate of neurological deterioration (0.9%) than those admitted after 24 hours or more ($p < 0.05$). This study was conducted in the USA. The other study of referral within 24 hours versus referral later than 24 hours[130] was conducted in Poland and showed no significant difference between early and late referrals in terms of neurological improvement (RR 1.47, 95% CI 0.98 to 2.20).

The two studies which compared care in an SIU with care in non-SIU centres[123,135] both found a significant advantage for SIU care in terms of neurological improvement (RR = 3.18, 95% CI 1.01 to 10.05; RR = 2.23, 95% CI 1.51 to 3.29). However, as mentioned above, Tator and co-workers[135] did not use a concurrent control group. DeVivo and co-workers[123] did use a concurrent

TABLE 13 *Functional improvement – early versus late referral*

Study	Early referral *n/N*	Late/no referral *n/N*	RR (95% CI)
Heinemann, 1989[129]	152/185	113/153	1.11 (0.99 to 1.25)

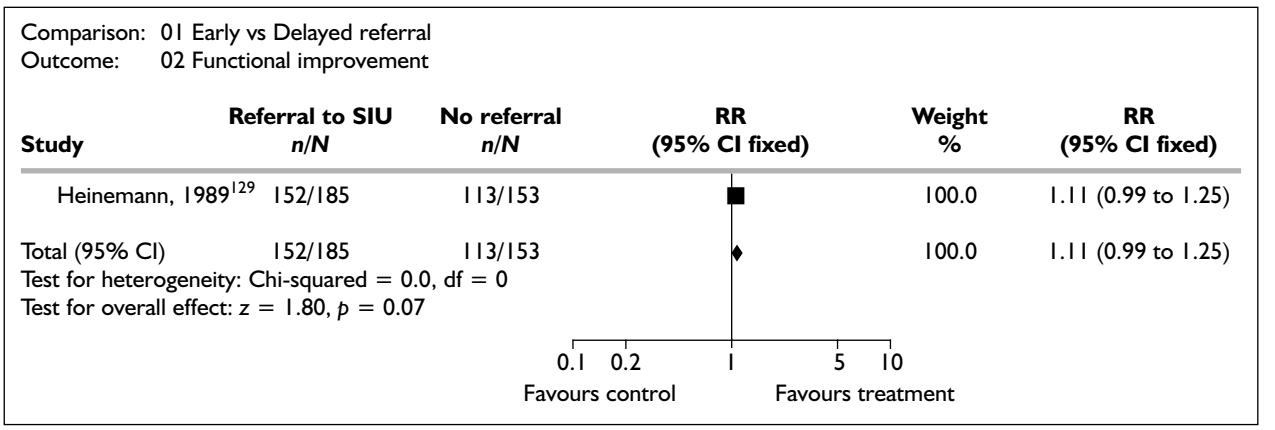

FIGURE 17 *Functional improvement – early versus late referral*

control group but the group referred to an SIU included only those referred within 24 hours whereas the non-referred group included all SCI patients not referred to an SIU. Results may be in favour of the SIU group simply because late referrals were excluded. This study does not adequately answer either the questions of delayed referral versus early referral or referral to an SIU versus no referral.

The pooled result for these two studies was also in favour of referral to an SIU (*Figure 16*, RR = 2.34, 95% CI 1.61 to 3.39).

Functional improvement

One study measured this outcome using the MRSCICS scale for functional skills (*Table 13*, *Figure 17*).[129] The study was of reasonable quality with comparable groups at baseline. No significant difference was found between those referred to a SIU in the USA and those treated in non-specialist hospitals.

Death

There were five studies that reported death as an outcome.[123,128,130,134,135,139] Only two[123,135,139] seemed to have comparable groups at baseline and on important confounding factors. One of these[135,139] was also the only study that had made adjustment for confounding factors. However, the groups in that study were not concurrent – the control group consisted of people who had SCI between 1948 and 1973 whereas the intervention group was people referred to the SIU after its establishment in 1974.

One Australian study,[134] which looked at delayed referral, did not report enough data to calculate a relative risk; however, it was reported that more of the deaths than survivors had a delay to admission of more than 24 hours, although this difference was not significant. One UK study,[128] which compared SIU referral with non-referral, reported deaths in the intervention group but not in the non-SIU group, so the results cannot be used in this review.

The other three studies (*Table 14*, *Figure 18*) were a Polish study about delayed referral[130] of more than 24 hours, a USA study[123] about referral to an SIU within 24 hours or only for rehabilitation (this may give a biased estimate for risk of death as the more severe cases may not have been referred to the SIU within 24 hours) and a Canadian study[135] about referral to an SIU compared with non-referral before the SIU was established. In this study, other aspects of care may differ between groups as the groups were not concurrent. The USA study reported only mortality during the rehabilitation phase whereas the other two studies seemed to report all mortality.

The Polish study reported a significantly higher risk of death in people who were referred to the SIU in 24 hours or less from the time of injury. This is not unexpected, as the nature of the injury leads to a high death rate. Deaths in the late referral group were only reported from the time they arrived at the SIU. People in this group who died within 24 hours were not reported. It is also possible that people who were not referred to the

TABLE 14 *Mortality – early versus late referral*

Study	Early referral *n/N*	Late/no referral *n/N*	RR (95% CI)
DeVivo, 1990[123]	5/315	6/401	1.06 (0.33 to 3.44)
Kiwerski, 1981[130]	109/385	13/83	1.81 (1.07 to 3.05)
Tator, 1995[135]	15/201	49/531	0.81 (0.46 to 1.41)

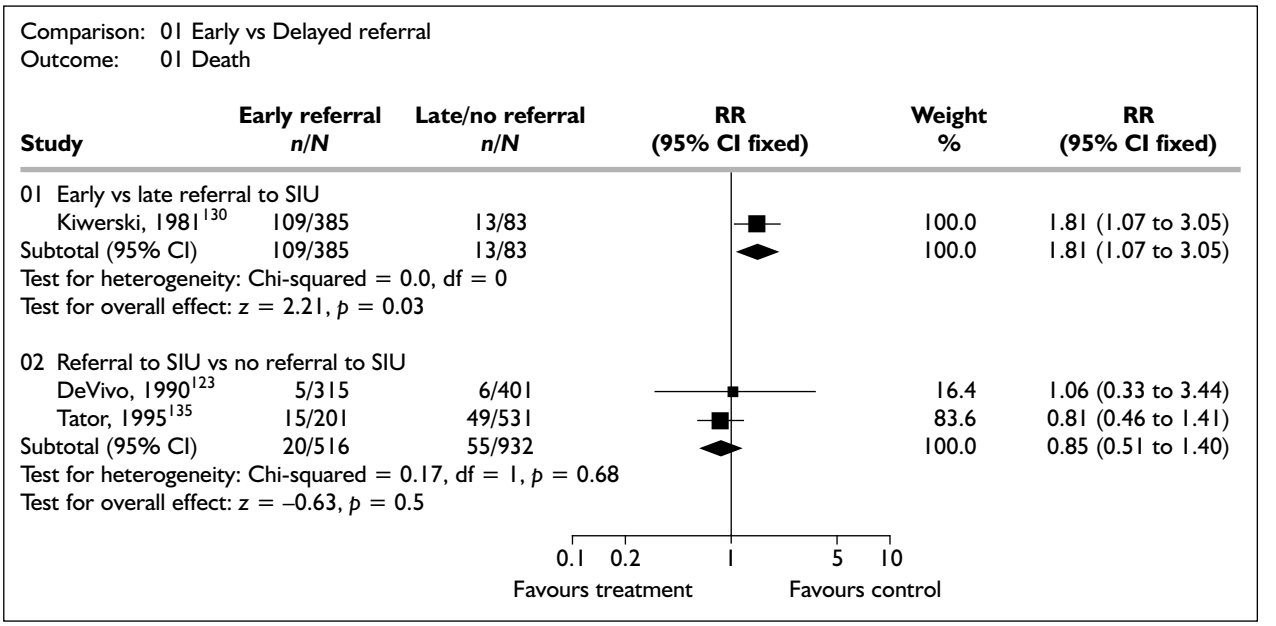

FIGURE 18 *Mortality – early versus late referral*

SIU within 24 hours had more severe injuries than those who were referred.

The other two studies reported no significant difference in risk of death between those referred to an SIU and those not referred (pooled RR = 0.85, 95% CI 0.51 to 1.40).

Inappropriate treatment

One study reported how many patients were given inappropriate treatment as a result of delayed referral to a SIU.[134] This was an Australian study and did not give enough data to calculate a relative risk; however, it reported that preventable delay in transport, inappropriate treatment and failure to correct shock may have been causative factors in 16 deaths in a series of 202 people with SCI. Inappropriate treatment occurred significantly more frequently in deaths than in survivors ($p < 0.05$). Methodological details of the study were poorly reported so it is unclear how valid the results are, and they are unlikely to be generalisable to the UK population.

A UK study about referral to an SIU versus general hospital care[128] did not report any numerical data for the results.

Complications

There were 14 studies that reported data on complications.[3,5,7,123–127,131–133,136,138,140] Eight reported that groups were comparable at baseline.[123,125–127,131,136,138,140] None of the studies in which groups were not comparable at baseline (or this was not stated) later adjusted for potential confounding factors. Three studies report results for SIU versus non-SIU care[127,136,140] (*Table 15*, *Figure 19*); all three used comparable groups at baseline. Eleven studies investigated the consequences of delayed referral to an SIU. Complications reported included skin mark, superficial sore, chest infection, urinary tract infection, other urological complications, uncontrolled autonomic dysreflexias, sleep problems, abdominal pain, severe depression, problematic spasm, problems with relatives, pressure sores, DVT, heterotopic ossification, pneumonia, contractures, atelectasis, pulmonary embolism, gastrointestinal ulcer, respiratory complications, infection, cardiovascular complications, complications associated with tracheotomy, major haemothorax and gibbus formation.

An Italian study on delayed referral[124] presented data in the form of percentage complications by

TABLE 15 *Complications – SIU versus non-SIU care*

Complication	Study	Early referral *n/N*	Late/no referral *n/N*	RR (95% CI)
All complications	Wang, 2001[140]	6/34	22/68	0.55 (0.24 to 1.22)
Pressure sores	Donovan, 1984[127]	0/66	195/1606	Pooled RR 0.07 (0.01 to 0.49)
	Wang, 2001[140]	0/34	14/68	
Pulmonary embolism	Donovan, 1984[127]	3/66	22/1606	3.32 (1.02 to 10.81)
Heterotopic ossification	Donovan, 1984[127]	0/66	1/1606	8.00 (0.33 to 194.44)
Bronchopneumonia	Donovan, 1984[127]	3/66	109/1606	0.67 (0.22 to 2.05)
Urological complication	Donovan, 1984[127]	18/66	305/1606	1.44 (0.96 to 2.16)
Contracture	Yarkony, 1985[136]	11/88	15/86	0.72 (0.35 to 1.47)
Atelectasis	Donovan, 1984[127]	4/66	132/1606	0.74 (0.28 to 1.93)
Gastrointestinal ulcer	Donovan, 1984[127]	0/66	22/1606	0.53 (0.03 to 8.69)
Respiratory complication	Wang, 2001[140]	3/34	4/68	1.50 (0.36 to 6.33)

time to admission, but did not report numbers in each subgroup, therefore relative risks cannot be calculated. The study reported a higher incidence of complications in the latest admission group than in the earlier admission groups (time to admission <48 hours, 8.9%; 48 hours–7 days, no data; 7–14 days, 15.5%; 15–30 days, 38.6%; 30–60 days, 49.8%). However, it is not clear whether this refers to pre-existing complications only or includes those which arose during SIU hospitalisation.

A UK study[7] on delayed surgery reported no development of pressure sores in patients admitted to the SIU within 48 hours of injury but a rate of 14–29% (higher rate in surgical patients) in whom transfers were delayed for more than 8 days. However, the incidence of pressure sores in patients who were admitted between 48 hours and 8 days was not reported and the numbers in each subgroup were not given, so relative risks cannot be calculated for this study.

In a US study of delayed referral,[126] the authors reported that the study demonstrates a significant association of contractures in acute SCI with pressure ulcers and co-existing head injury.

A study conducted in Israel[132] reviewed 18 cases of gibbus formation and concluded that a common factor was the time that had elapsed between injury and transfer from orthopaedic or neurosurgical wards to the SIU. However, it was not reported how much time had elapsed.

In the analysis of SIU versus non-SIU care, all outcomes were reported in only one study, except that for pressure sores, which was reported in two studies.[127,140] Both studies reported a favourable result for SIU care, with the pooled RR being 0.07 (95% CI 0.01 to 0.49). No significant heterogeneity was seen in this result.

One study[140] reported the outcome 'all complications': the relative risk of experiencing any complication in this study did not differ significantly between those receiving SIU care and those receiving acute care elsewhere (RR = 0.55, 95% CI 0.24 to 1.22).

In Donovan and co-workers' study,[127] those receiving SIU care were significantly more likely to experience a pulmonary embolism than those receiving care elsewhere (RR = 3.32, 95% CI 1.02 to 10.81). All the other outcomes reported in this study showed no significant difference between groups (heterotopic ossification RR = 8.00, 95% CI 0.33 to 194.44; bronchopneumonia RR = 0.67, 95% CI 0.22 to 2.05; urological complications RR = 1.44, 95% CI 0.96 to 2.16; atelectasis RR = 0.74, 95% CI 0.28 to 1.93; gastrointestinal ulcer RR = 0.53, 95% CI 0.03 to 8.69).

Wang and co-workers[140] investigated respiratory complications and found no significant difference in risk between those receiving SIU care and those receiving care elsewhere (RR = 1.50, 95% CI 0.36 to 6.33).

Yarkony and co-workers[136] reported the incidence of contractures and found no significant difference between those receiving SIU care and those receiving care elsewhere (RR = 0.72, 95% CI 0.35 to 1.47).

In the analysis of early versus delayed referral to SIU care (*Table 16*, *Figure 20*), results from one study[131] indicated that early referral patients experienced fewer complications than late referrals (RR = 0.70, 95% CI 0.56 to 0.87).

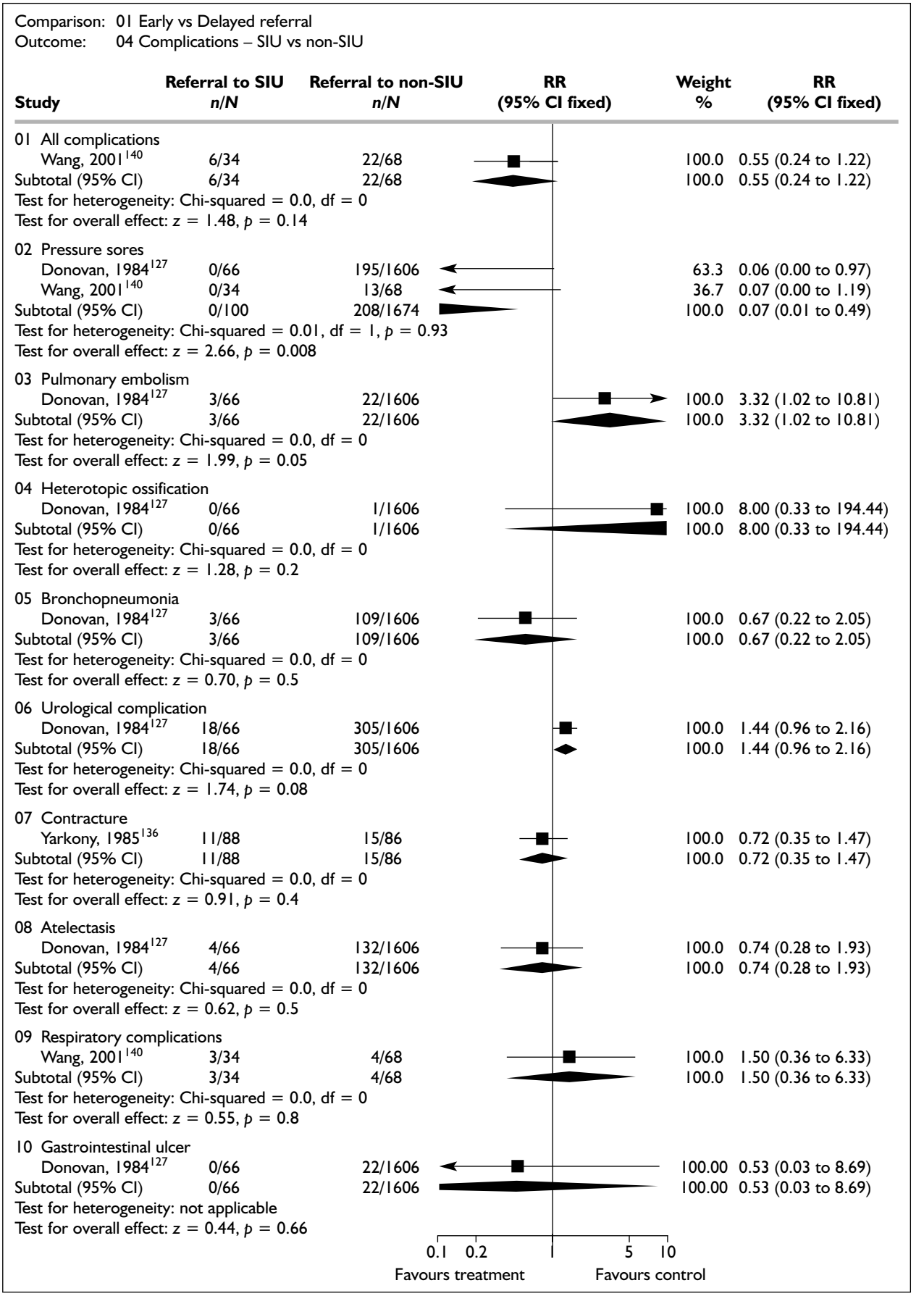

FIGURE 19 *Complications – SIU versus non-SIU care*

TABLE 16 *Complications – early versus delayed referral to SIU care*

Complication	Study	Early referral *n/N*	Late/no referral *n/N*	RR (95% CI)
All complications	Oakes, 1990[131] [a]	52/98	75/99	0.70 (0.56 to 0.87)
Pressure sores	Aung, 1997[5] [b]	2/155	13/64	0.27 (0.14 to 0.55)
	Bravo-Payno, 1992[125] [d]	7/39	32/49	0.20 (0.15 to 0.26)
	DeVivo, 1990[123]	23/284	99/387	0.06 (0.01 to 0.27)
	Donovan, 1984[127] [c]	72/1248	123/424	0.32 (0.21 to 0.49)
	Richardson, 1981[133] [e]	81/219	176/330	0.69 (0.57 to 0.85)
	Soopramanien, 1994[138] [b]	33/305	26/107	0.45 (0.28 to 0.71)
				Pooled RR 0.38 (0.33 to 0.43)
Pressure mark	Smith, 1999[3] [f]	317/702	58/98	0.76 (0.64 to 0.92)
Superficial pressure sore	Smith, 1999[3] [f]	225/702	47/98	0.67 (0.53 to 0.84)
Deep pressure sore	Smith, 1999[3] [f]	92/702	15/98	0.86 (0.52 to 1.42)
DVT	Aung, 1997[5] [b]	18/702	4/98	Pooled RR 0.87 (0.34 to 2.21)
	Smith, 1999[3] [f]	5/155	1/64	
Pulmonary embolism	Donovan, 1984[127] [c]	18/1248	17/424	0.36 (0.19 to 0.69)
Chest infection	Smith, 1999[3] [f]	197/702	39/98	0.71 (0.54 to 0.92)
Urinary tract infection	Smith, 1999[3] [f]	456/702	76/98	0.84 (0.74 to 0.94)
Constipation	Smith, 1999[3] [f]	325/702	63/98	0.72 (0.61 to 0.85)
Diarrhoea	Smith, 1999[3] [f]	236/702	38/98	0.87 (0.66 to 1.14)
Regular shoulder pain	Smith, 1999[3] [f]	312/702	74/98	0.59 (0.51 to 0.68)
Regular abdominal pain	Smith, 1999[3] [f]	177/702	43/98	0.57 (0.44 to 0.74)
Wound infection	Smith, 1999[3] [f]	81/702	13/98	0.87 (0.50 to 1.50)
Uncontrolled autonomic dysreflexia	Smith, 1999[3] [f]	96/702	21/98	0.64 (0.42 to 0.97)
Problematic spasm	Smith, 1999[3] [f]	248/702	52/98	0.67 (0.54 to 0.82)
Poor sleep pattern	Smith, 1999[3] [f]	296/702	51/98	0.81 (0.66 to 1.00)
Syringomyelia	Smith, 1999[3] [f]	28/702	2/98	1.95 (0.47 to 8.08)
Severe depression	Smith, 1999[3] [f]	104/702	26/98	0.56 (0.38 to 0.81)
Relationship problems with partner	Smith, 1999[3] [f]	111/702	20/98	0.77 (0.51 to 1.19)
Relationship problems with family/friends	Smith, 1999[3] [f]	75/702	19/98	0.55 (0.35 to 0.87)
Heterotopic ossification	Aung, 1997[5] [b]	3/155	2/64	Pooled RR 0.72 (0.47 to 1.10)
	Bravo-Payno, 1992[125] [d]	0/1248	1/424	
	Donovan, 1984[127] [c]	17/39	27/49	
Bronchopneumonia	Aung, 1997[5] [b]	7/155	3/64	Pooled RR 0.45 (0.32 to 0.63)
	Donovan, 1984[127] [c]	62/1248	50/424	
Urological complication	Aung, 1997[5] [b]	4/155	8/64	Pooled RR 0.26 (0.22 to 0.31)
	Donovan, 1984[127] [c]	141/1248	182/424	
Contracture	Aung, 1997[5] [b]	0/155	2/64	Pooled RR 0.45 (0.26 to 0.79)
	Dalyan, 1998[126] [g]	29/382	15/100	
Atelectasis	Donovan, 1984[127] [c]	27/1248	69/424	0.13 (0.09 to 0.20)
Gastrointestinal ulcer	Donovan, 1984[127] [c]	7/1248	15/424	0.16 (0.07 to 0.39)

[a] Delay of 11 days or more for quadriplegics and 21 days or more for paraplegics.
[b] Delay of 1 week or more.
[c] Delay of 1 month or more.
[d] Delay of 15 days or more.
[e] Delay of 72 hours or more.
[f] Within last 2 years.
[g] Delay of 24 hours or more.

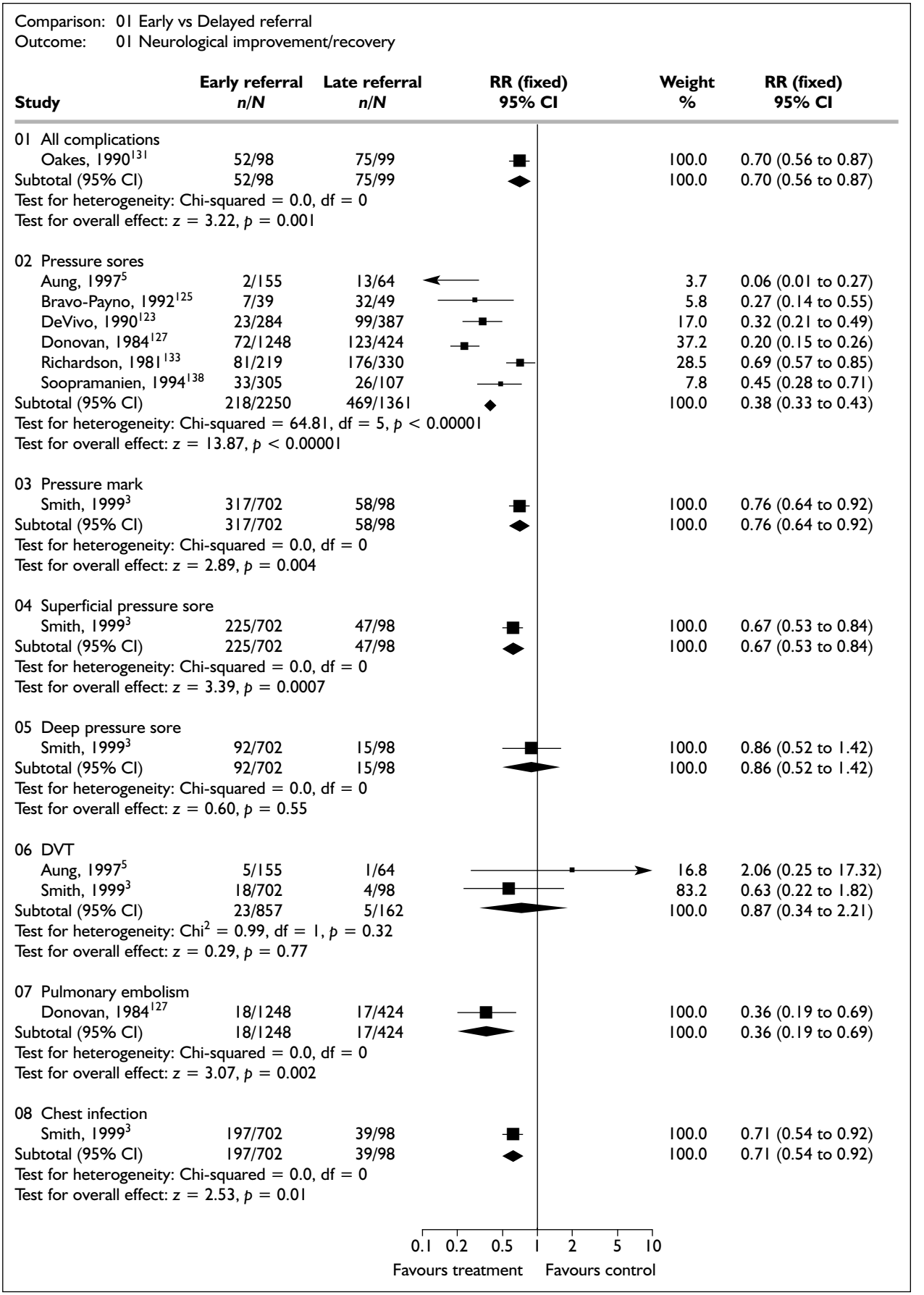

FIGURE 20 *Complications – early versus delayed referral*

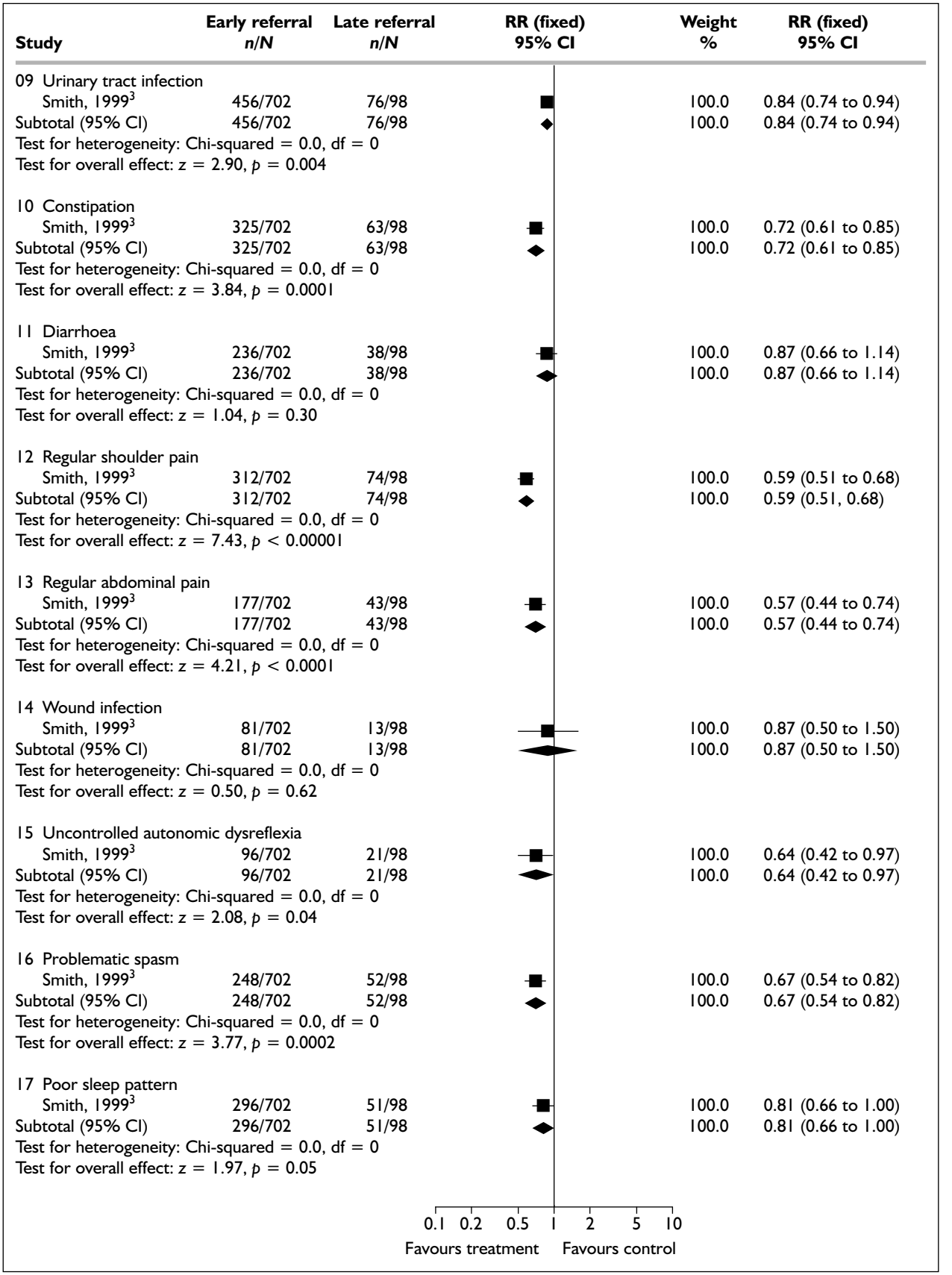

FIGURE 20 *Complications – early versus delayed referral (continued)*

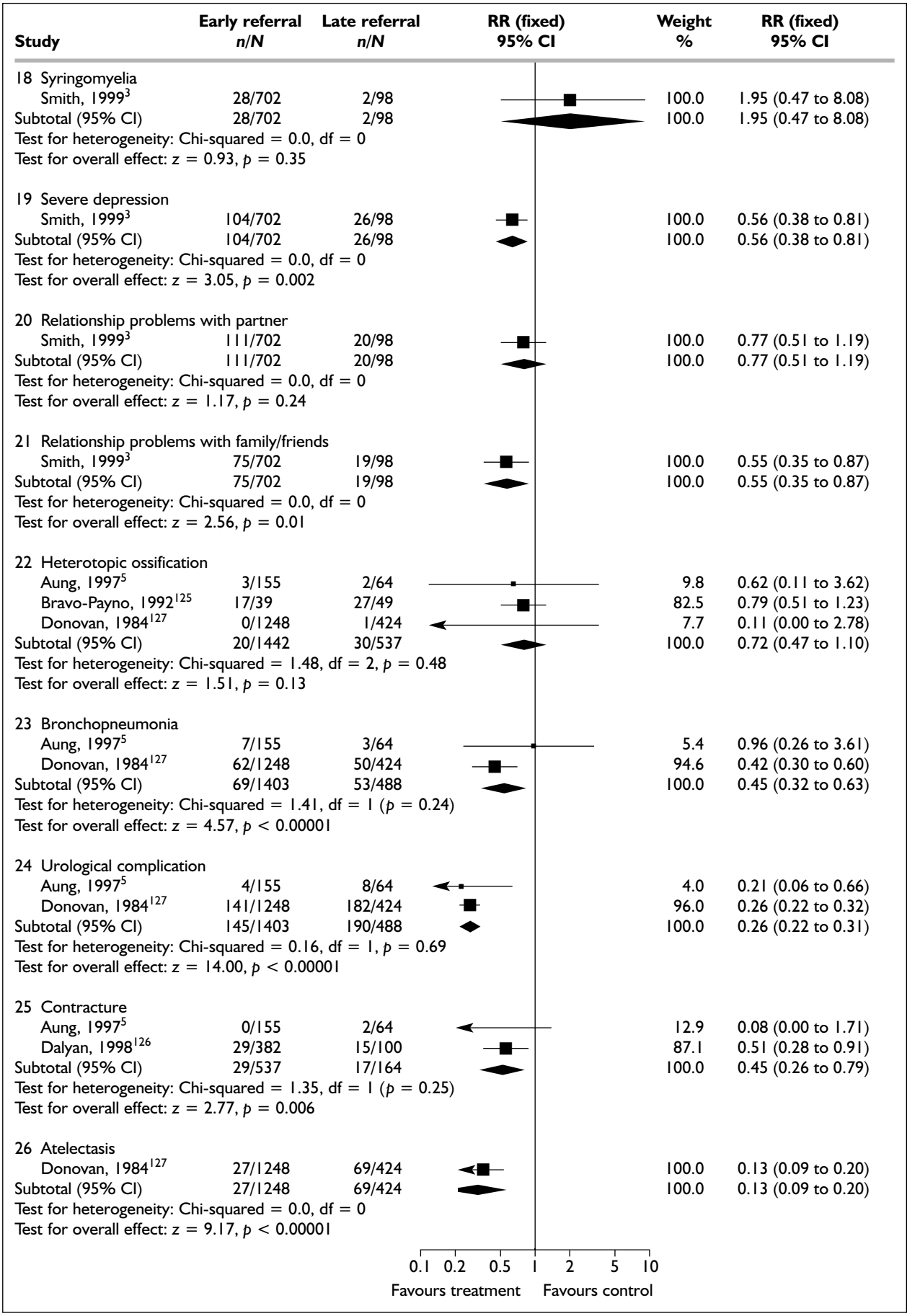

FIGURE 20 *Complications – early versus delayed referral (continued)*

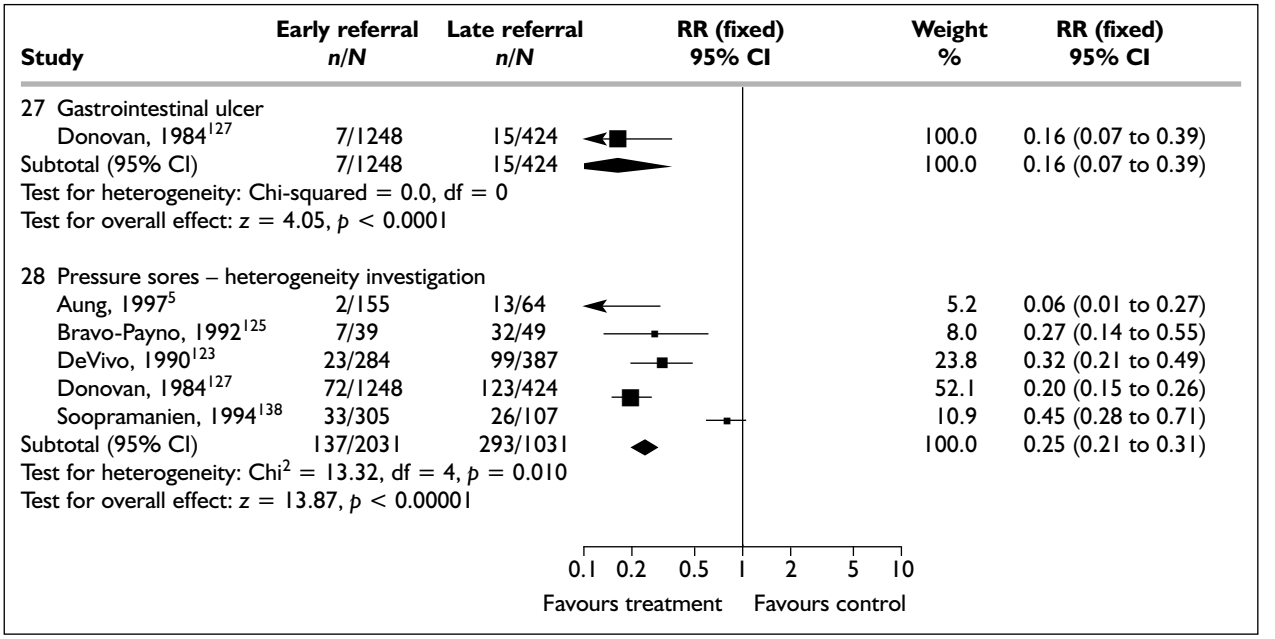

FIGURE 20 *Complications – early versus delayed referral (continued)*

Six studies[5,123,125,127,133,138] reported incidence of pressure sores as an outcome. In all six studies the relative risk with 95% confidence intervals significantly favoured early referrals (pooled RR = 0.38, 95% CI 0.33 to 0.43). However, there was significant statistical heterogeneity in this result (chi-squared 64.81, $p < 0.00001$). This can be explained to some extent by the differing definitions of 'early' and 'late' in the included studies. In the study in which the relative risk was lowest (RR = 0.20, 95% CI 0.15 to 0.26), the late referral group consisted of people who were referred to SIU care 1 month or more after SCI had occurred.[127] In the group with the relative risk estimate which was closest to the line of no effect (RR 0.69, 95% CI 0.57 to 0.85), the late referral group consisted of people who were referred to SIU care 72 hours or more after SCI had occurred.[133] The other four studies fell between these two extremes.[5,123,125,138] Hence it is possible that the beneficial effect seen in the early referral group is time dependent, that is, the earlier a person with SCI is referred, the lower is the risk of developing pressure sores.

One study[3] reported on pressure sore incidence in more detail. People referred early to SIU care were significantly less likely to develop pressure marks or superficial pressure sores than those referred late (RR = 0.76, 95% CI 0.64 to 0.92 and RR = 0.67, 95% CI 0.53 to 0.84, respectively) but no more or less likely to develop deep pressure sores (RR = 0.86, 95% CI 0.52 to 1.42).

Two studies reported incidence of DVT.[3,5] There was no significant difference between early and late referral groups (RR = 0.87, 95% CI 0.34 to 2.21).

Donovan and co-workers[127] found that early referrals were significantly less likely to experience a pulmonary embolism than late referrals (RR = 0.36, 95% CI 0.19 to 0.69).

Smith[3] found that early referrals were significantly less likely than late referrals to experience chest infection (RR = 0.71, 95% CI 0.54 to 0.92), urinary tract infection (RR = 0.84, 95% CI 0.74 to 0.94), constipation (RR = 0.72, 95% CI 0.61 to 0.85), regular shoulder pain (RR = 0.59, 95% CI 0.51 to 0.68), regular abdominal pain (RR = 0.57, 95% CI 0.44 to 0.74), uncontrolled autonomic dysreflexia (RR = 0.64, 95% CI 0.42 to 0.97), problematic spasm (RR = 0.67, 95% CI 0.54 to 0.82), severe depression (RR = 0.56, 95% CI 0.38 to 0.81) and relationship problems with family and friends (RR = 0.55, 95% CI 0.35 to 0.87). There was no significant difference between the groups with regard to occurrence of diarrhoea (RR = 0.87, 95% CI 0.66 to 1.14), wound infection (RR = 0.87, 95% CI 0.50 to 1.50), poor sleep pattern (RR = 0.81, 95% CI 0.66 to 1.00), syringomyelia (RR = 1.95, 95% CI 0.47 to 8.08) or relationship problems with partner (RR = 0.77, 95% CI 0.51 to 1.19).

Three studies reported the outcome of heterotopic ossification.[5,125,127] No studies found a significant

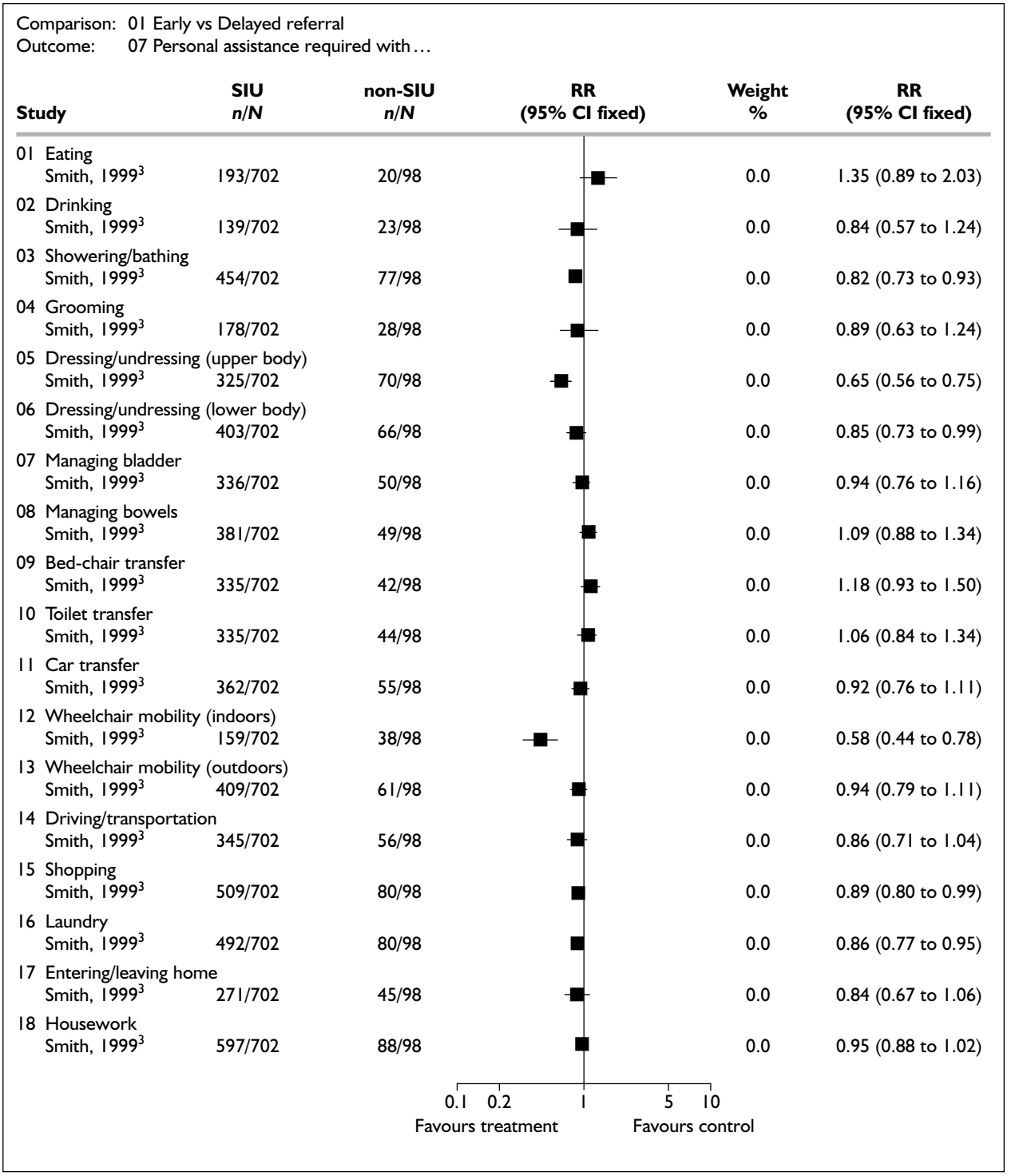

FIGURE 21 *Assistance required with daily living activities – SIU versus non-SIU care*

difference between early and late referrals with respect to development of this complication (pooled RR = 0.72, 95% CI 0.47 to 1.10).

Two studies reported the outcome of pneumonia or bronchopneumonia.[5,127] The larger study[127] found a significant advantage for the early admission group (RR = 0.42, 95% CI 0.30 to 0.60) whereas the smaller study[5] did not (RR = 0.96, 95% CI 0.26 to 3.61). No significant heterogeneity was seen in the pooled RR, which was also in favour of early referral (RR = 0.45, 95% CI 0.32 to 0.63). The same two studies reported on the outcome of urological complications and both found in favour of early referral (pooled RR = 0.26, 95% CI 0.22 to 0.31).

TABLE 17 *Assistance required with daily living activities – SIU versus non-SIU care (Smith, 1999[3])*

Activity personal assistance required with	SIU *n/N*	Non-SIU *n/N*	RR (95% CI)
Eating	193/702	20/98	1.35 (0.89 to 2.03)
Drinking	139/702	23/98	0.84 (0.57 to 1.24)
Showering/bathing	454/702	77/98	0.82 (0.73 to 0.93)
Grooming	178/702	28/98	0.89 (0.63 to 1.24)
Dressing/undressing (upper body)	325/702	70/98	0.65 (0.56 to 0.75)
Dressing/undressing (lower body)	403/702	66/98	0.85 (0.73 to 0.99)
Managing bladder	336/702	50/98	0.94 (0.76 to 1.16)
Managing bowels	381/702	49/98	1.09 (0.88 to 1.34)
Bed–chair transfer	355/702	42/98	1.18 (0.93 to 1.50)
Toilet transfer	335/702	44/98	1.06 (0.84 to 1.34)
Car transfer	362/702	55/98	0.92 (0.76 to 1.11)
Wheelchair mobility (indoors)	159/702	38/98	0.58 (0.44 to 0.78)
Wheelchair mobility (outdoors)	409/702	61/98	0.94 (0.79 to 1.11)
Driving/transportation	345/702	56/98	0.86 (0.71 to 1.04)
Shopping	509/702	80/98	0.89 (0.80 to 0.99)
Laundry	492/702	80/98	0.86 (0.77 to 0.95)
Housework	597/702	88/98	0.95 (0.88 to 1.02)
Entering/leaving home	271/702	45/98	0.84 (0.67 to 1.06)

Aung and Masry[5] and Dalyan and co-workers[126] both reported on the outcome of contracture. The smaller study[5] found no significant difference between early and late referrals with respect to development of contractures (RR = 0.08, 95% CI 0.00 to 1.71) while the larger one found in favour of early referral (RR = 0.51, 95% CI 0.28 to 0.91). No significant heterogeneity was seen in the pooled result, which was in favour of early referral (pooled RR = 0.45, 95% CI 0.26 to 0.79).

Donovan and co-workers[127] found in favour of early referral when looking at occurrence of atelectasis (RR = 0.13, 95% CI 0.09 to 0.20) and gastrointestinal ulcer (RR = 0.16, 95% CI 0.07 to 0.39).

Independence in daily living activities

Two studies[3,129] measured this outcome. One[129] used the Barthel index whereas the other[3] used a questionnaire to elicit responses about various aspects of daily living activities. Heinemann and co-workers' study[129] stated that patients were similar at baseline in both groups; Smith[3] found a difference in gender distribution but adjusted for this in the analysis (*Figure 21*). Smith's study included people who had suffered a SCI as far back as the 1950s. Heinemann and co-workers report mean scores by Frankel grade at discharge. No measure of variance is reported so we cannot calculate mean differences. In the study, it was reported that mean MBI scores were similar for the two groups at the time of discharge.

Smith asked participants if they required personal assistance with the following daily living activities (*Table 17*).[3] The SIU cohort were significantly less likely than the non-SIU cohort to need assistance with showering/bathing, dressing/undressing upper body, dressing/undressing lower body, wheelchair mobility indoors, shopping or laundry. There was no significant difference between groups with regard to the amount of assistance required with eating, drinking, grooming, managing bladder or bowels, bed–chair transfer, toilet transfer, car transfer, wheelchair mobility outdoors, driving/transportation, entering and leaving the home or housework.

Social activities

One study measured this outcome.[3] The study used a questionnaire to elicit responses from participants on the following outcomes: hours out of bed per day; hours out of the house per week, driving, employment, education, having a partner, happiness with sex, contact with and visiting others (*Table 18*, *Figure 22*). The study included people who had suffered a SCI as far back as the 1950s.

The authors found no significant difference between SIU and non-SIU cohorts, using the Mann–Whitney *U*-test, for the outcome hours out of bed per day. For the outcome hours out of the house per week there was a statistically significantly better outcome for the SIU cohort ($p < 0.05$) using the Mann–Whitney *U*-test. For the outcomes contact with others and visiting others no significant difference between groups was found using the Mann–Whitney *U*-test. The SIU cohort were significantly more likely to be in paid employment (RR 1.60, 95% CI 1.09 to 2.34)

TABLE 18 *Social activities – SIU versus non-SIU care*

Activity	SIU *n/N*	Non-SIU *n/N*	RR (95% CI)
Driving/being driven – not available at time of choice	238/702	27/98	1.23 (0.88 to 1.72)
Paid employment	252/702	22/98	1.60 (1.09 to 2.34)
Voluntary employment	195/702	53/98	0.51 (0.41 to 0.64)
Education	368/702	54/98	0.95 (0.79 to 1.15)
Not having a partner	270/702	47/98	0.80 (0.64 to 1.01)
Not happy with sex	380/702	59/98	0.90 (0.75 to 1.07)

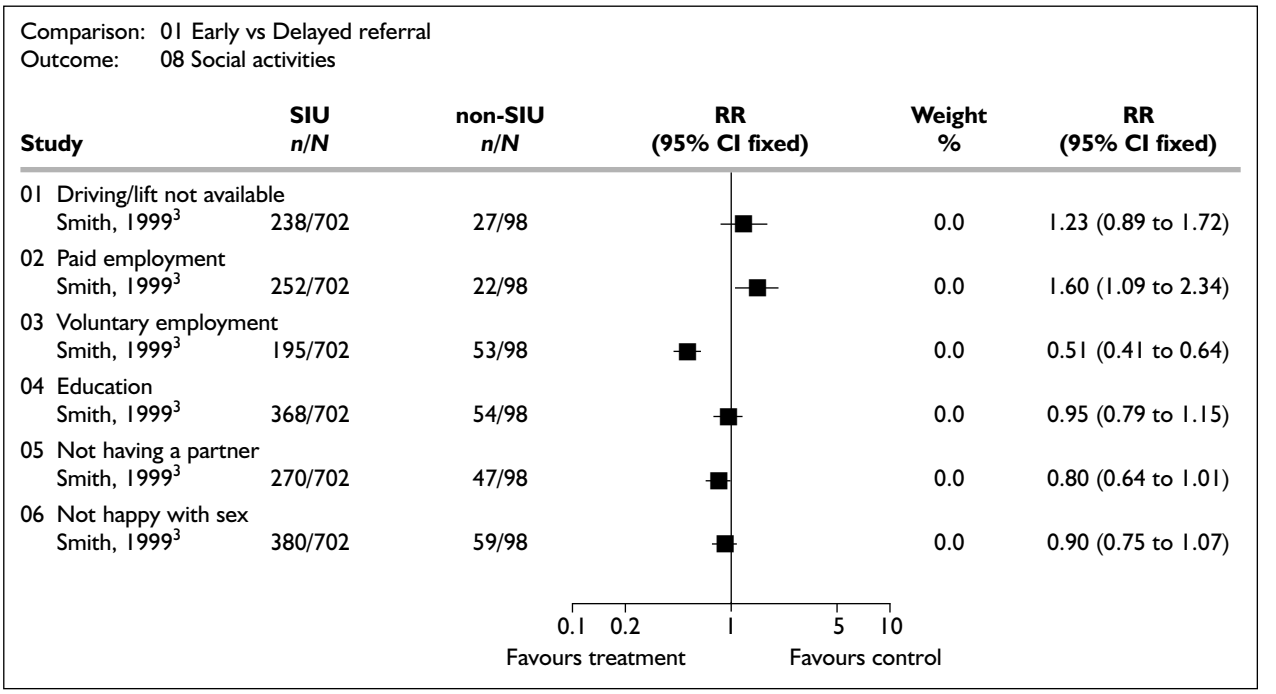

FIGURE 22 *Social activities – SIU versus non-SIU care*

and significantly less likely to undertake voluntary work (RR 0.51, 95% CI 0.41 to 0.64) than the non-SIU cohort. No significant difference was seen between the two groups with respect to likelihood of driving/lift not being available, education, having a partner or happiness with sex.

Life satisfaction

One study measured this outcome.[3] The study used a questionnaire to elicit responses from participants about overall satisfaction level and how their satisfaction has changed. No significant difference between groups was found for either outcome using the Mann–Whitney *U*-test.

Time in hospital

Four studies measured this outcome.[5,123,131,135,139] One[5] did not have comparable groups at baseline and did not adjust for confounding factors. The other three studies did have comparable groups at baseline.

One study[131] reported mean days of hospitalisation in early and late groups. Two reported mean days of hospitalisation in those receiving SIU care compared with those receiving care elsewhere.[123,135,139] The fourth[5] reported the median length of hospitalisation in weeks in early and late groups. None of the studies which reported the group means reported a measure of variance so weighted mean differences between groups cannot be calculated.

The two studies which measured SIU care versus care received elsewhere both reported significantly shorter lengths of stay in SIU compared with non-SIU treated patients (Tator and co-workers[135,139] SIU mean 48.2 days versus non-SIU mean 86.9 days, $p < 0.001$; DeVivo and co-workers[123] length of acute hospitalisation ranged from 19.5 to 31.2 days in the SIU group compared with 30.7 to 38.4 days in the non-SIU group, $p < 0.05$ in all but the quadriplegia, complete injured group).

The two studies which compared early referrals with late referrals also both found that early referrals had shorter acute hospitalisation times.[5,131]

Rehabilitation – length of stay
Two studies measured this outcome.[129,131] Both studies were poorly reported as regards methodology but both seemed to have groups which were comparable at baseline. Oakes and co-workers[131] found no significant difference between early and late referral groups with regard to length of rehabilitation stay. Heinemann and co-workers[129] found no significant difference between SIU-treated and non-SIU-treated patients with regard to this outcome.

Time to mobilisation
One study which compared SIU care with care elsewhere measured this outcome.[140] The methodology of this study was not well reported but it was seen that groups were similar at baseline. It was found that of 34 people treated in SIUs, all were mobilised within 77 days, but 13 of 68 people treated elsewhere were still not mobile within 77 days. The relative risk estimation did not show a significant difference between the groups (RR 0.08, 95% CI 0.01 to 1.35).

How many people with a new SCI are discharged from hospital without ever being transferred to an SIU?

Apart from one Australian study,[134] which reported that 28/202 people were never transferred to a SIU and 24 of those 28 died, we found no published studies of any design which would help to answer this question. The Australian experience is probably not similar to that of the UK. Primary research involving audit of selected UK hospital records or a search of national hospital activity data should be commissioned and published.

The effectiveness of steroids for people with SCI

We found two systematic reviews relating to this question. One was a Cochrane review (updated)[10] and the other was not.[11] The two reviews reached different conclusions. Each review was assessed using a template for critical appraisal of systematic reviews from the DARE database (Appendix 5). A summary of the results and the validity of each review are presented below.

A third systematic review was found of steroids in trauma patients.[141] Patients with many different injuries were included but only one study out of 25 included people with acute SCI, so the results of the review were not thought to be applicable and it was excluded.

Validity
The Cochrane review was found to be of higher validity (results likely to be more reliable) than the non-Cochrane review. The Cochrane review included only RCTs whereas the other review included all study designs. The other review was more focused in terms of the review question and included only studies which looked at high-dose methylprednisolone administered within 12 hours of injury. The Cochrane review included all RCTs of steroids in acute SCI; however, subgroup analysis was undertaken to investigate the differential effects of administering steroids within 8 hours of injury. The Cochrane review appeared to contain several RCTs that would have fitted the inclusion criteria for the other review but were not in it. This implies that the search strategy for the other review was inadequate and/or that the other review was out of date. The other review used a 1998 version of the Cochrane review as a reference source. The Cochrane review that we used was updated in 2002. The research question was clearly stated for the Cochrane review and inclusion criteria seemed appropriate. The search strategy was likely to be comprehensive, as our own extensive search strategy found no extra RCTs. Validity assessment was appropriate but could have been more detailed. Data extraction and synthesis seemed sound. The main drawback of the Cochrane review was that only one reviewer was involved in the review process, increasing the potential for human error. However, the review has been extensively peer-reviewed as part of the Cochrane process.

For the other review, the inclusion of all study designs probably weakened its validity, particularly for the outcomes of mortality and morbidity. The main drawback of this review was the fact that relevant RCTs were not included. Validity assessment, data extraction and synthesis seemed reasonably sound. However, on balance, the results of the Cochrane review are more likely to be reliable than the results of the non-Cochrane review.

Results
The Cochrane review included six good-quality RCTs and two of moderate quality. Three RCTs which had data available for subgroup analysis of patients treated within 8 hours of injury found that high-dose methylprednisolone resulted in

greater motor function recovery, measured by clinical examination, at 6 weeks, 6 months and final follow-up (WMD = 4.06, 95% CI 0.58 to 7.55). However, the practical relevance of this improvement was not stated. No effect was seen when all patients treated with methylprednisolone within 24 hours were compared with those treated with placebo. In the same three trials, the methylprednisolone group had greater pinprick sensation in all patients at 6 months (WMD = 3.37, 95% CI 0.74 to 6.00) but not at 1 year. One trial which compared a 10-day regimen of high to low dose methylprednisolone found no differences between groups except that wound infection was higher in the high-dose group (RR = 3.50, 95% CI 1.18 to 10.41). One trial which reported on 24 versus 48 hour regimens of methylprednisolone did not find any meaningful differences between groups.

The non-Cochrane review included three RCTs (one of questionable validity) and six cohort studies. None were reported to be fully up to current standards of validity. For the outcome of neurological improvement no significant differences were seen between methylprednisolone-treated and non-steroid groups in any studies. In one RCT sensory scores were significantly better in the methylprednisolone group at 6 months but not at 6 weeks or 1 year. One cohort study reported a significantly better level of mobility in the non-steroid group than in the steroid group on discharge from hospital ($p < 0.05$). There did not seem to be any significant differences between the steroid and non-steroid groups in the five studies that reported on acute mortality. One cohort study reported more pneumonia in the steroid than the non-steroid group and one RCT reported more hyperglycaemia in the steroid than the non-steroid group. One cohort study reported a greater duration of ventilation in the steroid than the non-steroid group and one RCT found no difference between groups for this outcome. One cohort study reported a longer stay in intensive care in steroid than in non-steroid groups and one RCT found no difference between groups for this outcome.

Cost-effectiveness

Economic evaluation is important as resources are scarce and choices must be made regarding their use (Drummond and co-workers[828]). Economic evaluations consider both the costs and consequences of activities, in this case health care-related activities. Ultimately, the aim of these evaluations is to provide useful information to improve the decision making process.

Whereas economic evaluations are useful, assessing the validity of the results of these studies is essential. Different evaluations use different methodologies which may be inappropriate or may influence or even invalidate the results. Identified evaluations should be quality assessed using a checklist such as that derived from Drummond and co-workers.[828]

The search strategy did not identify any full economic evaluations. That is, no study considered the costs as well as the impact on patient outcomes of a given intervention. A list of excluded studies, with reasons for exclusion, can be found in Appendix 7. The majority of the studies were cost analyses, cost of illness studies or cost function analyses. Cost analyses consider simply the cost of a given resource (for instance, the cost associated with hospital stays for patients with SCI). Cost of illness studies estimate the burden of a particular condition such as SCI, while cost function analyses attempt to describe the influence of certain variables on cost; for instance, the severity of the condition or the age of the patient may influence the cost of treatment or management of SCI.

Each of these types of analysis is of limited use. While it has been claimed that these types of studies are useful to decision makers, economists have questioned whether they can be an aid to moving towards an efficient health care system (Byford and co-workers[830]). Estimating that a condition consumes large amounts of resources does not imply that there is inefficiency, nor does it suggest how these resources would be better utilised. A highly effective treatment may be overlooked if the condition it treats has a low cost of illness associated with it. Similarly, cost analyses and cost function analyses fail to describe adequately the impact on patient outcomes and/or how resources may be better utilised.

Research should be concentrated on full economic evaluations, possibly alongside a large RCT, which fully consider the costs and consequences of implementing interventions.

Chapter 5
Discussion

Major findings

The effectiveness and cost-effectiveness of spinal fixation

Question 1a. Is there a difference in functional outcome, cost and length of stay between those who have had a spinal fixation and those who have not?

Sixty-eight studies were found to answer this question; however, many were poorly reported in terms of methodology and, overall, validity seemed to be poor. Most were retrospective observational studies. Many included people with spinal injury but without SCI together with people with SCI. The decision on whether to operate often depended on the severity of the injury, which will confound the results. In many studies, results of surgery with fixation and surgery without fixation were reported together and so the results of these studies relate to the effects of surgery, rather than fixation. There was great heterogeneity in terms of participants' severity of injury, types of surgery performed and country of study. Heterogeneity was seen in many results which did not seem to be explained by any of the above or by year of publication or sample size. The results are therefore mostly inconclusive.

It is unclear whether fixation surgery is associated with neurological improvement, owing to heterogeneity in the results. This heterogeneity cannot easily be explained. Fixation surgery was no more or less likely than no surgery to lead to neurological deterioration. Significantly less mortality was seen in the fixation group but it is possible that the most severely injured patients were excluded from surgery. Fixation surgery was more likely to be associated with failure of fixation devices and wound infection than no surgery, and less likely to be associated with symptomatic instability of the spine. Fifteen studies assessed length of hospital stay. However, they did not give any clear indication of whether fixation surgery reduced, lengthened or had no impact on length of stay. Data on urinary status were equivocal. One study reported better psychological outcomes in the fixation group. Fixation was associated with increased functional ability (to walk) and shorter time to mobilisation and may have been associated with increased independence in daily living activities. One study showed reduced spinal flexibility and one reported shorter healing time in the fixation group. Results on satisfactory radiographic evaluation were equivocal.

It is unclear whether early fixation is more likely to lead to neurological improvement, shorter duration of hospitalisation or improved urinary status than late fixation.

In studies which compared different types of fixation, Harrington rods were favoured over Meurig–Williams plates for time to mobilisation and satisfactory radiographic results, and Harrington rods were favoured over laminectomies (with and without fusion) for time to mobilisation, time spent in hospital and short term neurological improvement. One study reported that bony fusion plus Harrington rod and the triple procedure were both associated with the shortest hospital stays, compared with a variety of other surgical techniques. Posterior surgery was favoured over anterior surgery for time spent in hospital; however anterior surgery was favoured over posterior surgery for neurological improvement. One study reported that pain was less severe in patients with long instrumentation than with short instrumentation.

There is weak evidence to suggest that spinal fixation may be associated with possible benefits in terms of mortality, stability of the spine, mobility, time to mobilisation and independence in daily living activities. Possible disbenefits include wound infection, device failure and spinal inflexibility.

Question 1b. Outcomes of fixation surgery in SIUs compared with non-SIU hospitals

Only four studies were found with data to answer this question. No significant differences were seen.

Question 2. Characteristics associated with delayed referral to an SIU

All studies were retrospective observational studies. In the majority of cases, study details were poorly reported and there was doubt over the comparability of groups at baseline and on confounding factors. In the included studies it was

not possible to separate the time of referral and the time of transfer. True late referrals may be a different group of patients with a medical reason why they could not be referred at an earlier stage. As in many cases the groups may not have been comparable, all results should be interpreted with caution.

Evidence from studies comparing care in SIUs with care in non-SIUs suggested a beneficial effect in favour of the SIU group in terms of neurological improvement. No differences were seen between early and late referrals. There was no difference in functional outcome for patients treated in SIUs compared with non-SIUs. In studies which compared death rates in early referral patients with those in late referral patients, the data were equivocal, although there did not appear to be an overall difference between the two groups, nor did there appear to be a difference between SIU and non-SIU groups.

For SIU versus non-SIU care the majority of complications did not differ significantly between the two groups. A result in favour of the SIU group was seen in patients developing pressure sores. For early versus delayed referral to SIU care, one study showed that patients undergoing early referral may experience fewer overall complications. There was evidence that patients in the early referral group had a lower risk of developing pressure sores and that this effect may have been time dependent. Patients experiencing delayed referral to an SIU compared with early referral may have been more likely to encounter the following complications: chest infection, urinary tract infection, constipation, regular shoulder pain, regular abdominal pain, uncontrolled autonomic dysreflexia, problematic spasm, severe depression, relationship problems with friends and family, pneumonia and bronchopneumonia, contractures, atelectasis and gastrointestinal ulcer.

Data from one study showed that patients treated in SIUs compared with those treated in non-SIUs were less likely to need assistance with the following activities of daily living: showering/bathing, dressing/undressing (upper and lower body), wheelchair mobility (indoors), shopping and laundry. Given that the results of this study were based on questionnaire data, there is a possibility of recall bias. The study also looked at social activities and found that patients in the SIU compared with the non-SIU cohort spent more hours out of the house per week and were more likely to be in paid employment.

Patients receiving treatment in SIUs compared with patients treated elsewhere were more likely to have experienced shorter lengths of stay in hospital. There was also evidence to suggest that patients undergoing early referral compared to patients undergoing delayed or late referral experienced shorter acute hospitalisation times.

There is weak evidence to suggest that the characteristics associated with delayed or no referral to a SIU may include inferior neurological improvement, greater risk of some complications (e.g. pressure sores), greater assistance required with some activities of daily living and longer hospital stay.

Question 3. How many people with a new spinal cord injury are discharged from hospital without ever being transferred to an SIU?

No relevant published studies of any design were found which would have helped to answer this question. It may be possible to find further information by searching the UK Trauma Audit and Research Network (TARN) database. If not, primary research involving audit of selected UK hospital records or a search of national hospital activity data should be commissioned and published.

Question 4. The effectiveness and cost-effectiveness of steroids for people with SCI

Of the two systematic reviews which addressed this question, it was judged that the results of the Cochrane review were more reliable.

There was evidence to suggest that treatment with high-dose methylprednisolone within 8 hours of injury resulted in greater motor function recovery (of around 4 points measured by standard clinical assessment) compared with placebo. However, the practical relevance of this improvement was not stated. No effect was seen when all patients treated with methylprednisolone within 24 hours were compared with those treated with placebo. Greater pinprick sensation was shown in all patients in the methylprednisolone group at 6 months but this beneficial effect was not evident at 1 year. Comparison of a 10-day regimen of high-dose with low-dose methylprednisolone found no differences between groups except that wound infection was higher in the high-dose group.

No published economic evaluations of steroids for people with SCI were found.

There is evidence to suggest that high-dose methylprednisolone given within 8 hours of injury results in greater motor function recovery compared with placebo.

Economics: no studies were identified that considered costs as well as the impact of patient outcomes of a given intervention. We were, therefore, unable to present any useful cost information which may have helped to improve the decision making process.

Assumptions, limitations and uncertainties

Methodology of review

The review was carried out in a limited timescale and the search strategy was restricted to produce a manageable set of references. The search terms used were restricted to SCI with trauma. It is possible that including spinal cord diseases and more general spinal injury terms in the search would have produced more information.

Methodological quality of included studies

Most included studies were poorly reported in terms of methodological quality. All included spinal fixation studies were controlled studies in that they contained a group who received surgical fixation and a group who did not. However, the *a priori* design of most of these studies was not as controlled studies. Most were retrospective case series of people with SCI attending a particular unit. Some of the cases were treated surgically and some were not. Often, the decision on whether to treat surgically or not was made on the basis of the severity of the patient's injuries (more severe injuries led to non-operative treatment in some units and to operative treatment in others). In these instances, it cannot be said that the groups are comparable in terms of injury severity or prognostic or confounding factors. This may lead to bias in the results. Sometimes, earlier patients in a case series were treated non-operatively because techniques for surgical fixation were not yet available. Later patients were treated with spinal fixation. In these cases, other aspects of care were likely to be different between the groups and so they are not comparable either. Only two studies of out 61 spinal fixation studies stated that they made adjustment for confounding factors, although eight out of 61 were assessed as being non-comparable for confounding factors and a further 29 were 'unclear'.

All included referral studies were also controlled in that an early referral group was compared with a late referral group, or a group referred to a SIU was compared with a group referred elsewhere. However, they were all retrospective observational studies rather than experimental studies. On the whole, the studies were more poorly described than the fixation studies and there was some doubt over the comparability of groups, at baseline or on confounding factors, in 16 of the 22 studies.

Patients

In many studies, few details of baseline severity or patient demographics were reported so it was difficult to tell how comparable the treatment groups were. In the included spinal fixation studies it was seen that clinical heterogeneity existed between study participants in terms of level of spinal injury (some cervical, some thoracolumbar) and also in terms of whether patients had SCI in addition to spinal injury. Studies which only included people with spinal fracture and no neurological damage were excluded. However, studies which included some of these patients plus patients with SCI were included. The results of these studies may not be generalisable to people with SCI. Results were rarely reported separately for SCI and non-SCI patients within these studies.

Several referral studies did not report how many people were in each group but reported only percentages.

It is likely that bias existed in the way in which people were allocated to treatments. It is possible that more severely injured patients would be less likely than less severely injured patients to receive spinal fixation surgery. This would lead to results being biased in favour of the fixation group because this group would contain less severely ill people. It is also possible that more severely ill people are more likely to be referred to an SIU than less severely ill people, which would bias results against SIUs. If, in contrast, more severely ill people were less likely than less severely ill people to be referred to SIUs, results would be biased in favour of SIUs. Because so few participant details were reported in most studies, it is unclear which way bias would operate in the studies included in this review.

Outcomes

In some studies, few details of outcomes were reported. Some spinal fixation studies did not report results for surgical and non-surgical groups separately, which meant the results could not be used to answer the review question. The outcome

of neurological improvement was not reported consistently: some studies reported Frankel or ASIA grades at baseline and at follow-up for individual patients whereas some studies reported the number of people improving at least one Frankel grade, and some studies converted Frankel grade improvement to a percentage and gave an overall figure for the group. Other studies reported other ways of assessing neurological improvement. Continuous outcomes, such as neurological improvement scores or days in hospital, were often reported without measures of variance, which makes it impossible to tell whether differences in mean scores between groups were statistically significant or not. Some studies did not report denominators for groups but reported results as a percentage, making it impossible to calculate relative risks.

Length of hospitalisation could be an important outcome as it relates to cost-effectiveness; however, the results may be more dependent on factors such as housing and level of support at home than on success or otherwise of surgical fixation of referral to SIU. They may also relate to the level or complexity of the lesion. Future research should report data on length of hospitalisation with this in mind. An alternative would be that studies reported time to medical fitness for discharge.

Some studies did not report any numerical data, but made statements about which treatment was more effective. This is inadequate reporting.

Some referral studies only reported outcomes for one group and stated whether these were better or worse than for the other group or groups.

In general, there was little investigation of the implications of the interventions from the point of view of the patients, relatives or partners. Primary qualitative research should be carried out among users to understand what outcomes are important, and patients should be involved more in study design.

Interventions

Four spinal fixation studies were published before 1980. We would expect surgical techniques to have improved in the last 20 years, so the relevance of these studies to today's practice is unclear. A mixture of techniques and different combinations of instrumentation (Harrington rods, Meurig–Williams plates, Caspar plates, etc.) and anterior and posterior approaches were used for spinal fixation carried out in different studies. Also in some studies results for non-fixation surgery (such as decompressive laminectomy) are reported together with results for fixation surgery. It is unclear how generalisable these results will be. In one study which compared fixation surgery with no surgery and with laminectomy, the fixation surgery group had very different outcomes from the laminectomy group.[77] Treatment received by the control group also varied, some undergoing postural reduction by skull traction and others not. Some studies indicated that surgery was carried out in SIUs and some in general hospitals, and in some the setting was unclear. The country of origin of the study is another factor which may influence the study results, as aspects of care other than the procedure being studied may differ from country to country and influence the results of the study. Included studies were from many different countries, including the UK, USA, Poland, Romania, Israel, Australia, Germany, Russia, Saudi Arabia and France.

Analysis of data

Given the high degree of heterogeneity between included studies in terms of participants and interventions, it is not surprising that statistical heterogeneity exists in many of the pooled results. This heterogeneity often cannot be explained in terms of factors such as differing level of injury, country of origin and surgical techniques. Where heterogeneity cannot be explained we have presented relative risk estimates for individual studies as well as the pooled result. It would also have been a valid approach not to have calculated pooled results at all, but we have done so to demonstrate possible directions of effect. Where heterogeneity is present, the pooled summary statistic is not unduly emphasised and should be used with caution.

Missing data

Some outcomes which were identified by the expert panel at protocol stage as being most important for people with SCI were very poorly reported by the available evidence. These were psychological outcomes, spasticity and bladder control. This underlines the importance of consulting people with SCI and their carers about outcomes of importance to them and carrying out primary qualitative research before commissioning more research. It is essential that future research addresses relevant and appropriate questions.

Many studies did not report details of participants' baseline characteristics or study methodology and some did not even report the numbers of people in each group. This means that sometimes it is hard to tell whether an intention to treat analysis

had taken place or not. People initially included in the study could have been excluded from the results section, which would bias the results of the study. Outcomes were often poorly reported, as mentioned above.

Need for further research

All future research should be planned in association with people with SCI and their carers, to ensure that appropriate and relevant research is carried out. Important outcomes which have already been identified as being poorly reported are psychological outcomes, bladder control and spasticity. Primary qualitative research should be carried out among users to understand what outcomes are important, and patients should be involved more in study design.

Well-designed prospective cohort studies with concurrent and appropriate controls are required to assess the effectiveness and safety of fixation surgery.

Well-designed, prospective studies with appropriately matched controls are required to assess properly the benefits which may be associated with early referral to SIUs. It has been suggested that an interesting comparison would be within an early referral group, comparing those who were transferred early with those who were transferred late.

Primary research involving audit of selected UK hospital records should be commissioned and published in order to determine how many people with new spinal cord injuries do not come into contact with SIUs.

Economics: cost-effectiveness research should be concentrated on full economic evaluations which consider both the costs and consequences of implementing the given intervention. Where appropriate, such as in the case of steroids for SCI, these should be run alongside RCTs.

Chapter 6
Conclusions

Only retrospective observational studies were found which assessed the consequences of spinal fixation surgery or of delayed referral to SIUs. In the majority of studies there was doubt over the comparability of groups, at baseline and on confounding factors. Although there was evidence to suggest some benefits of fixation surgery and also a benefit of immediate referral to SIUs compared with delayed or no referral, owing to the limitations of the data these should be interpreted with caution.

Data on effectiveness of spinal fixation surgery are high in quantity but low in quality. Spinal fixation does not appear to offer advantages in terms of neurological improvement, length of hospital stay or urinary status. Spinal fixation groups experienced less mortality, spinal instability and psychological problems. They were more likely to be mobile in a shorter time and independent in activities of daily living than non-fixation groups. They were more likely to experience wound infection, device failure and loss of spine flexibility. Not enough data were found to assess whether surgery is more beneficial when carried out in SIUs. Further research of higher quality is required in this area.

Patients undergoing immediate referral to SIUs may experience better outcomes than patients whose referral is delayed, or patients who are treated elsewhere (e.g. in a general hospital). Owing to the questionable comparability of groups in the majority of studies, the evidence to support this conclusion is weak. Well-designed prospective observational studies with appropriately matched controls are needed.

High-dose methylprednisolone steroid therapy may be effective in promoting some degree of neurological recovery if given within 8 hours of injury. There is a need for more RCTs of pharmacological therapy for acute SCI.

We found no published studies of any design which would help to answer the question of how many people with acute SCI are discharged from hospital without ever being transferred to an SIU. Primary research involving audit of selected hospital records should be commissioned and published.

The search strategy did not identify any full economic evaluations. That is, no study considered both the costs and the impact on patient outcomes of a given intervention. The majority of the studies were cost analyses, cost of illness studies or cost function analyses. Future research should include full economic evaluations, possibly alongside a large RCT, which fully consider the costs and consequences of implementing interventions.

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A-M Bagnall was involved in protocol writing, study selection, data extraction, validity assessment and report writing.

L Jones was involved in protocol writing, study selection, data extraction, validity assessment and report writing.

G Richardson was involved in cost-effectiveness part of protocol writing, study selection, data extraction and report writing.

S Duffy devised search strategy and carried out literature searches; wrote the search methodology sections of the report.

R Riemsma provided input at all stages, commented on various drafts of the report.

External reviewers

External reviewers are selected from a range of backgrounds and their role is to read and comment on a near-final draft of the report. They are not responsible for the final report, which may not reflect their views.

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Appendix 1

Literature search strategy

MEDLINE. Spinal Fixation Search Strategy

MEDLINE: Silverplatter. CD-ROM. 1966–2001/08. 25 October 2001

The MEDLINE 'spinal fixation' search covered the date range 1966 to August 2001. The search was carried out on 25 October 2001 and identified 3296 records.

#1 explode "Spinal-Cord-Injuries"/all subheadings
#2 "Quadriplegia"/all subheadings
#3 explode "Paraplegia"/all subheadings
#4 (spinal cord near (injur* or trauma* or transect* or transsect* or lacerat* or damag* or impair* or lesion* or compress* or shock or contus* or syndrome* or d?sfunction* or disrupt*)) in ti,ab
#5 (spinal column near (injur* or trauma* or transect* or transsect* or lacerat* or damag* or impair* or lesion* or compress* or shock or contus* or syndrome* or d?sfunction* or disrupt*)) in ti,ab
#6 (central cord near (injur* or trauma* or transect* or transsect* or lacerat* or damag* or impair* or lesion* or compress* or shock or contus* or syndrome* or d?sfunction* or disrupt*)) in ti,ab
#7 ((brown sequard* or brown-sequard*) near syndrome) in ti,ab
#8 flaccid paralysis in ti,ab
#9 autonomic dysreflexia in ti,ab
#10 (quadr?pleg* or parapleg* or tetrapleg*) in ti,ab
#11 #1 or #2 or #3 or #4 or #5 or #6 or #7 or #8 or #9 or #10
#12 "Spinal-Fusion"/all subheadings
#13 explode "Fracture-Fixation"/all subheadings
#14 explode "Orthopedic-Fixation-Devices"/all subheadings
#15 explode "Spinal-Cord"/surgery
#16 (fixate or fixation or fixator) in ti,ab
#17 (screw* or nail* or pin or pins or rod* or wire* or plate* or hook*) in ti,ab
#18 instrumentation in ti,ab
#19 osteosynthes* in ti,ab
#20 (laminectom* or laminoplas* or cordotom* or rhizotom* or diskectom* or discectom*) in ti,ab
#21 (fusion or fuse or fused or fusing) in ti,ab
#22 (spinal near (graft or grafts or grafted or grafting)) in ti,ab
#23 (spine near (graft or grafts or grafted or grafting)) in ti,ab
#24 ((vertebral or vertebrae) near (graft or grafts or grafted or grafting)) in ti,ab
#25 #12 or #13 or #14 or #15 or #16 or #17 or #18 or #19 or #20 or #21 or #22 or #23 or #24
#26 #11 and #25
#27 "animal" in tg
#28 "human" in tg
#29 #27 not (#27 and #28)
#30 #26 not #29

MEDLINE. Referral, Transfer and Discharge Search Strategy

MEDLINE: Silverplatter. CD-ROM. 1966–2001/08. 25 October 2001

The MEDLINE 'referral, transfer and discharge' search covered the date range 1966 to August 2001. The search was carried out on 25 October 2001 and identified 2766 records.

#1 explode "Spinal-Cord-Injuries"/all subheadings
#2 "Quadriplegia"/all subheadings
#3 explode "Paraplegia"/all subheadings
#4 (spinal cord near (injur* or trauma* or transect* or transsect* or lacerat* or damag* or impair* or lesion* or compress* or shock or contus* or syndrome* or d?sfunction* or disrupt*)) in ti,ab
#5 (spinal column near (injur* or trauma* or transect* or transsect* or lacerat* or damag* or impair* or lesion* or compress* or shock or contus* or syndrome* or d?sfunction* or disrupt*)) in ti,ab
#6 (central cord near (injur* or trauma* or transect* or transsect* or lacerat* or damag* or impair* or lesion* or compress* or shock

or contus* or syndrome* or d?sfunction* or disrupt*)) in ti,ab
#7 ((brown sequard* or brown-sequard*) near syndrome) in ti,ab
#8 flaccid paralysis in ti,ab
#9 autonomic dysreflexia in ti,ab
#10 (quadr?pleg* or parapleg* or tetrapleg*) in ti,ab
#11 #1 or #2 or #3 or #4 or #5 or #6 or #7 or #8 or #9 or #10
#12 explode "Hospitalization"/all subheadings
#13 explode "Referral-and-Consultation"/all subheadings
#14 (refer or referred or referral* or referring) in ti,ab
#15 (admit or admitted or admission*) in ti,ab
#16 (transfer or transfers or transferred or transferral) in ti,ab
#17 (hospitali?ed or hospitali?ation or (hospital near stay)) in ti,ab
#18 ((length of stay) or LOS) in ti,ab
#19 (discharge or discharges or discharged) in ti,ab
#20 #12 or #13 or #14 or #15 or #16 or #17 or #18 or #19
#21 #11 and #20
#22 tg=animal
#23 tg=human
#24 #22 not (#22 and #23)
#25 #21 not #24

MEDLINE. Steroids Search Strategy

MEDLINE: Silverplatter. CD-ROM. 1966–2001/08. 25 October 2001

The MEDLINE 'steroids' search covered the date range 1966 to August 2001. The search was carried out on 11 October 2001 and identified 354 records.

#1 Randomized-controlled-trial in pt
#2 explode "randomized controlled trials"/all subheadings
#3 "random allocation"/all subheadings
#4 "double blind method"/all subheadings
#5 "single blind method"/all subheadings
#6 clinical-trial in pt
#7 explode "clinical trials"/all subheadings
#8 "controlled clinical trials"/all subheadings
#9 (clin* near3 trial*) in ti, ab
#10 ((singl* or doubl* or trebl* or tripl*) near3 (blind* or mask*))in ti,ab
#11 placebo* in ti,ab
#12 "placebos"/all subheadings
#13 random* in ti,ab
#14 explode "research design"/all subheadings
#15 explode "Evaluation-Studies"/all subheadings
#16 "Follow-Up-Studies"/all subheadings
#17 "Prospective-Studies" /all subheadings
#18 (control* or prospectiv* or volunteer*) in ti,ab
#19 #1 or #2 or #3 or #4 or #5 or #6 or #7 or #8 or #9 or #10 or #11 or #12 or #13 or #14 or #15 or #16 or #17 or #18
#20 explode "economics"/all subheadings
#21 (cost or costs or costed or costly or costing) in ti,ab
#22 (utilit* or benefit* or effective* or stud* or minimi* or analys*) in ti,ab
#23 #21 near #22
#24 (economic* or pharmacoeconomic* or price* or pricing) in ti,ab
#25 #20 or #23 or #24
#26 #19 or #25
#27 explode "Spinal-Cord-Injuries"/all subheadings
#28 "Quadriplegia"/all subheadings
#29 explode "Paraplegia"/all subheadings
#30 (spinal cord near (injur* or trauma* or transect* or transsect* or lacerat* or damag* or impair* or lesion* or compress* or shock or contus* or syndrome* or d?sfunction* or disrupt*)) in ti,ab
#31 (spinal column near (injur* or trauma* or transect* or transsect* or lacerat* or damag* or impair* or lesion* or compress* or shock or contus* or syndrome* or d?sfunction* or disrupt*)) in ti,ab
#32 (central cord near (injur* or trauma* or transect* or transsect* or lacerat* or damag* or impair* or lesion* or compress* or shock or contus* or syndrome* or d?sfunction* or disrupt*)) in ti,ab
#33 ((brown sequard* or brown-sequard*) near syndrome) in ti,ab
#34 flaccid paralysis in ti,ab
#35 autonomic dysreflexia in ti,ab
#36 (quadr?pleg* or parapleg* or tetrapleg*) in ti,ab
#37 #27 or #28 or #29 or #30 or #31 or #32 or #33 or #34 or #35 or #36
#38 explode "Steroids"/all subheadings
#39 explode "Anti-Inflammatory-Agents-Steroidal"/all subheadings
#40 explode "Adrenal-Cortex-Hormones"/all subheadings
#41 explode "Glucocorticoids-Synthetic"/all subheadings
#42 explode "Neuroprotective-Agents"/all subheadings

#43 steroid* in ti,ab,pn,nm
#44 pharmacol* in ti,ab
#45 (anti-inflammatory or antiinflammatory) in ti,ab
#46 corticosteroid* in ti,ab,pn,nm
#47 glucocortico* in ti,ab,pn,nm
#48 neuroprotective* in ti,ab,pn,nm
#49 dexamethasone* in ti,ab,pn,nm
#50 (Methylprednisolone* or promedrol*) in ti,ab,pn,nm
#51 (predisolone* or prednisone* or meprednisone*) in ti,ab,pn,nm
#52 (aminosteroid* or amino-steroid* or amino steroid*) in ti,ab,pn,nm
#53 hydrocortisone* in ti,ab,pn,nm
#54 lazaroid* in ti,ab,pn,nm
#55 tirilazad* in ti,ab,pn,nm
#56 #38 or #39 or #40 or #41 or #42 or #43 or #44 or #45 or #46 or #47 or #48 or #49 or #50 or #51 or #52 or #53 or #54 or #55
#57 #26 and #37 and #56
#58 tg=animal
#59 tg=human
#60 #58 not (#58 and #59)
#61 #57 not #60

EMBASE: Silverplatter. CD-ROM. 1980–2001/09

The EMBASE 'spinal fixation' search was undertaken on 25 October 2001, covered the date range 1980 to September 2001 and identified 2844 records.

The EMBASE 'referral, transfer and discharge' search was undertaken on 25 October 2001, covered the date range 1980 to September 2001 and identified 2234 records.

The EMBASE 'steroids' search was undertaken on 12 October 2001, covered the date range 1980 to September 2001 and identified 586 records.

Cumulative Index to Nursing and Allied Health Literature (CINAHL): Silverplatter. CD-ROM. 1982–2001/07

The CINAHL 'spinal fixation' search was undertaken on 25 October 2001, covered the date range 1982 to July 2001 and identified 215 records.

The CINAHL 'referral, transfer and discharge' search was undertaken on 25 October 2001, covered the date range 1982 to July 2001 and identified 519 records.

The CINAHL 'steroids' search was undertaken on 12 October 2001, covered the date range 1982 to July 2001 and identified 56 records.

Cochrane Controlled Trials Register (CCTR): Cochrane Library, 2001:3. CD-ROM

The CCTR 'spinal fixation' search was undertaken on 25 October 2001 and identified 76 records.

The CCTR 'referral, transfer and discharge' search was undertaken on 25 October 2001 and identified 62 records.

The CCTR 'steroids' search was undertaken on 12 October 2001 and identified 55 records.

NHS Economic Evaluation Database (NHS EED): Cochrane Library, 2001:3. CD-ROM

NHS EED was searched at the same time as the CCTR on the Cochrane Library, using the same search strategy.

The NHS EED 'spinal fixation' search was undertaken on 25 October 2001 and identified 1 record.

The NHS EED 'referral, transfer and discharge' search was undertaken on 25th October 2001 and identified 17 records.

The NHS EED 'steroids' search was undertaken on 12 October 2001 and identified 0 records.

Health Economic Evaluations Databases (HEED): OHE-IFPMA Database Ltd. CD-ROM. 1995–2001/09

The HEED 'spinal fixation' search was undertaken on 25 October 2001, covered the date range 1995 to September 2001 and identified 1 record.

The HEED 'referral, transfer and discharge' search was undertaken on 25 October 2001, covered the date range 1995 to September 2001 and identified 1 record.

The HEED 'steroids' search was undertaken on 12 October 2001, covered the date range 1995 to September 2001 and identified 1 record.

Health Management Information Consortium (HMIC): Silverplatter. CD-ROM. 1979–2001/07

The HMIC 'spinal fixation' search was undertaken on 25 October 2001, covered the date range 1979 to July 2001 and identified 1 record.

The HMIC 'referral, transfer and discharge' search was undertaken on 25 October 2001, covered the date range 1979 to July 2001 and identified 8 records.

The HMIC 'steroids' search was undertaken on 12 October 2001, covered the date range 1979 to July 2001 and identified 0 records.

Allied and Complementary Medicine (AMED): Silverplatter. CD-ROM. 1985–2001/07

The AMED 'spinal fixation' search was undertaken on 25 October 2001, covered the date range 1985 to July 2001 and identified 137 records.

The AMED 'referral, transfer and discharge' search was undertaken on 25 October 2001, covered the date range 1985 to July 2001 and identified 255 records.

The AMED 'steroids' search was undertaken on 12 October 2001, covered the date range 1985 to July 2001 and identified 21 records.

PsycINFO: Silverplatter. CD-ROM. 1887–2001/08

The PsycINFO 'spinal fixation' search was undertaken on 25 October 2001, covered the date range 1887 to August 2001 and identified 61 records.

The PsycINFO 'referral, transfer and discharge' search was undertaken on 25 October 2001, covered the date range 1887 to August 2001 and identified 154 records.

The PsycINFO 'steroids' search was undertaken on 12 October 2001, covered the date range 1887 to August 2001 and identified 15 records.

Internet Resources

A number of Internet sites were searched for further information about spinal cord injury. 'Spinal cord' was used as a search term.

Copernic

http://www.copernic.com
This site was searched on 26 November 2001 and was limited to the first 100 hits.

Google

http://www.google.com/
This site was searched on 3 January 2002 and all relevant hits had already been retrieved on Copernic.

Alta Vista

http://www.altavista.com/
This site was searched on 3 January 2002 and all relevant hits had already been retrieved.

OMNI

http://omni.ac.uk/
This site was searched on 3 January 2002 and had 17 relevant hits.

Spinal Injuries Association

http://www.spinal.co.uk
This site was searched on 4 January 2002 and found useful background information.

British Association of Spinal Cord Injury Specialists

http://www.bascis.pwp.blueyonder.co.uk
This site was searched on 4 January 2002 and found nothing useful.

National Spinal Cord Injury Association

http://spinalcord.org/
This site was searched on 4 January 2002 and provided background information and further links.

American Spinal Injury Association (ASIA)

http://www.asia-spinalinjury.org/
This site was searched on 4 January 2002 and provided background information, an extensive research bibliography, injury classification table and further links.

Spinal Cord Injury Information Network

http://www.spinalcord.uab.edu/show.asp?durki=19679
This site was searched on 4 January 2002 and provided background information and further links.

American Association of Spinal Care Nurses (AASCIN)

http://www.aascin.org
This site was searched on 4 January 2002 and provided background information and further links. Membership is required for greater access.

National Institute of Neurological Disorders & Stroke (NINDS)

http://www.ninds.gov/index.htm
This site was searched on 4 January 2002 and found nothing of interest.

National Institute on Disability & Rehabilitation Research (NIDRR)

http://www.ed.gov/offices/OSERS/NIDRR/
This site was searched on 4 January 2002 and found nothing of interest.

Appendix 2

Data extraction sheets for fixation studies

Study details	Intervention details	Participant details	Adverse events	Comments
Author (Year) Ahn (1984)[96] **Description of study:** Retrospective study using data from the National Spinal Cord Injury Data Research Centre (NSCIDRC)	**Intervention:** Laminectomy; bony fusion; Harrington rod placement; laminectomy + bony fusion; laminectomy + Harrington rod; bony fusion + Harrington rod; laminectomy + bony fusion + Harrington rod (triple procedure) *N*: 932 **Control:** No operation *N*: 453 **Duration:** Not stated **Follow-up:** Not stated **Concomitant treatments:** None reported	**Age:** not reported **Sex:** not reported **Severity:** On admission, 498 had incomplete paraplegia and 887 had complete paraplegia *N*: 1385 **Patient characteristics:** High thoracic: $n = 630$ (45.5%) Incomplete 90; complete 540 Thoracolumbar: $n = 755$ (54.5%) incomplete 408; complete 347 **Inclusion/exclusion criteria:** Excluded were those who: had died during treatment; had severe medical complications; and whose injuries resulted from gunshot or stab wounds **Further details:** Patients were those registered with the NSCIDRC during 1973 and 1979	None reported	**Authors' conclusions:** None stated
Results				
General comments: Bony fusion plus Harrington rod and the triple procedure were associated with the shortest hospital stays in both acute and rehabilitation facilities ($p < 0.05$). Laminectomy plus bony fusion was consistently associated with prolonged hospital stays in both facilities ($p < 0.05$). The mean acute hospital stay was 34.9 days with bony fusion + Harrington rod and 37.5 with the triple procedure. Also associated with significantly shorter acute care durations ($p < 0.05$) were the single use of Harrington rod instrumentation (mean 36.5 days) and of laminectomy (mean 40 days) and the absence of surgical procedure (mean 36.9 days). The longest stays ($p < 0.05$) were associated with laminectomy + Harrington rod (mean 52.2 days). The only treatments associated with significantly shortened ($p < 0.05$) rehabilitation stay were bony fusion + Harrington rod (mean 77.1 days) and the triple procedure (mean 76.6 days). Rehabilitation stay with the other treatments, including non-surgical, ranged from a mean of 83.1 to a mean of 101.4 days				

Study details	Intervention details	Participant details	Withdrawals	Adverse events	Comments
Author (Year) An (1991)[57] **Description of study:** Series of 31 patients with low lumbar burst fractures. 13 had SCI. Procedure chosen according to level of injury, etc.	**Intervention:** Fixation with Harrington rods (7), Luque rods (11), Steffee plates (6), primary anterior strut graft (1) *N*: 25 **Control:** Body cast *N*: 6 **Duration:** 1981 to 1989 **Follow-up:** 46 months **Concomitant treatments:** 16 had laminectomy with posterior instrumentation and 3 had anterior decompression procedures	**Age:** mean 30.3 y **Sex:** 23 M; 8 F **Severity:** 13 of 31 had neurological impairment. Levels of fractures were: L3 in 14 patients L4 in 11 patients L5 in 5 patients L2–L4 in 1 patient *N*: 31 **Patient characteristics:** Low lumbar burst fractures. 13 secondary to motor vehicle accidents, 12 to falls, 4 to motorcycle accidents, 1 glide plane accident, 1 car falling accident **Inclusion/exclusion criteria:** Damage to at least one end plate and loss of both anterior and posterior vertebral height with retropulsion of bone into the canal as documented by CT scanning	4 were lost to follow-up	**Intervention:** Persistent complaints of back pain seemed to be found more in patients with long instrumentation and fusion. Complaints of back pain were more evident in patients treated with Harrington or Luque instrumentation, with fusion extending 2 levels above and below the injured segment, than in those treated with Steffee plates Complications only occurred in the surgical group. 4 cases of DVT, 1 PE, 1 wound infection, 3 paralytic ileus, 1 UTI, 1 rod prominence, 1 neurogenic bladder	**Authors' conclusions:** Long instrumentation and fusion (e.g. Harrington or Luque rod) in patients with low lumbar burst fractures should be avoided. As pointed out by other investigators, back pain is probably associated with long fusion masses in the lumbar spine with loss of lumbar lordosis. Patients with low lumbar fractures with minimal loss of lordosis and height and with intact neurological status should be treated conservatively. In patients where surgical stabilisation is thought to be beneficial, pedicular fixation system is preferred in restoring lumbar lordosis, preserving valuable motion segments, and improving clinical outcomes

Results

General comments:
No numbers are given for results relevant to this review, only comments in the text

Outcome 1

Outcome:
Neurological improvement ($n = 13$)

Intervention:
The majority improved their neurological impairment significantly

Control:
($n = 1$) 'excellent'

Outcome 2

Outcome:
Clinical outcome ($n = 27$)

Intervention:
Harrington rod 5 good, 2 fair; Luque rod 3 excellent, 5 good, 2 fair; Steffee group 2 excellent, 2 good

Study details	Intervention details	Participant details	Withdrawals	Adverse events	Comments
Author (Year) Argenson (1989)[97] **Description of study:** Retrospective case series of thoracic spine fractures at one centre over 9 y. 30.4% also had SCI. 47 had spinal fixation	**Intervention:** Harrington rods (31) or Cotrel–Dubousset instrumentation (7) or other instrumentation (9) *N*: 47 **Control:** 'Functional' treatment (47) or postural reduction (10) *N*: 57 **Duration:** Not stated **Follow-up:** Up to 9 y **Concomitant treatments:** Not stated	**Age:** mean 38 y **Sex:** 47 F; 58 M **Severity:** 35.2% had injuries at multiple levels, 30.4% had neurological impairment including 20% complete paraplegia *N*: 105 **Patient characteristics:** 57 compression fractures, 21 burst fractures, 3 flexion–distraction fractures, 24 fracture–dislocations. 42% caused by traffic accidents, 52% by falls, 6% by sporting accidents **Inclusion/exclusion criteria:** Thoracic traumatic spine fractures in people aged 16–90 y treated at a centre in Nice	1 missing, no explanation. Results only reported for 62 patients: 38 in the control group and 24 in the fixation group	**Intervention:** Wound infection 6/43 (HR 4/31, CD 2/7) Instrument failure 5/43 (HR 4/31, CD 1/7) Phlebitis 6/43 (HR 4/31, CD 1/7, other 1/5) Pulmonary embolism 3/43 (HR 2/31, CD 0/7, other 1/5) **Control:** Not reported	**Authors' conclusions:** Thoracic spine fractures merit individual treatment as they differ in physiopathology and clinical aspects from lumbar and dorsolumbar fractures. Fractures at this level are often caused by violent trauma and associated with damage to internal organs. The severity of these fractures does not prevent there being a favourable prognosis for incomplete lesions. The principles of treatment for neurological fractures should be the same. The authors recommend Cotrel–Dubousset instrumentation based on a further 14 cases not included in the article. They state that it offers the advantages of Harrington rods while providing better stabilisation. This prevented later loss of reduction and obviated the need for a postoperative brace

Results

General comments:	Outcome 1	Outcome 2	Outcome 3	Outcome 4
Results only reported for 62 patients	**Outcome:** Absence of pain **Intervention:** 11/24 **Control:** 26/38	**Outcome:** Reduced flexibility of spine **Intervention:** 15/24 **Control:** 12/38	**Outcome:** Return to work **Intervention:** 20/24 **Control:** 37/38	**Outcome:** Neurological improvement Not reported by treatment category

Study details	Intervention details	Participant details	Withdrawals	Adverse events	Comments
Author (Year) Arima (1994)[35] **Description of study:** Retrospective series over 17 y of cervical SCI patients. Divided into two groups based on days of hospitalisation; group A >180 days (*n* = 13); group B, >90 <180 days (*n* = 29). Suitable group A data are provided in table	**Intervention:** Surgery, including posterior reduction (PR) (*n* = 3), anterior spinal fusion (ASF) (*n* = 2), PR + ASF (*n* = 3), Luque rod (*n* = 1), Luque rod + ASF (*n* = 1) *N*: 10 **Control:** No surgery *N*: 3 **Duration:** Not stated **Follow-up:** Unclear, but till death or discharge to rehabilitation **Concomitant treatments:** 7 patients received tracheotomy (*n* = 5 surgery) and 1 surgery patient was intubated	**Age:** range 16–77 y **Sex:** 11 M; 2 F **Severity:** Frankel grade (surgery, no surgery). Complete (A): 12 (10, 2) Incomplete (B): 1 (0, 1) *N*: 13 **Patient characteristics:** Cause of injury: fall 9, traffic accident 2, sports accident 2. **Diagnosis:** hyperextension injury 3, fracture–dislocation 5, burst fracture 5 **Further details:** Days spent in hospital ranged from 184 to 730 days (average 281 days)	**Intervention group:** 2 patients died	**Intervention:** Pneumonia: 4 Decubitus ulcer: 1 GI bleeding: 2 Haemothorax: 1 Cystitis: 1 Dislodging of grafting bone: 1 **Control:** Pneumonia: 2 Decubitus ulcer: 1 GI bleeding: 0 Haemothorax: 0 Cystitis: 0	**Authors' conclusions:** 1. The problems of cervical SCI patients hospitalised in university hospitals for 3 months or more have been investigated. 2. The patients hospitalised for 6 months or longer, in particular, were characterised by having an injury at a high spinal cord level, complete paralysis and complications such as pneumonia. These features are considered factors which make transfer to other hospitals difficult. 3. Assertive measures at the national and prefectural levels are called for in the future, such as an expansion of facilities

Results

General comments:
Only data for group A were extractable

Outcome 1

Outcome:
Neurological improvement by Frankel grade

Intervention:
Frankel grade:
A–A: 9
A–B: 1
B–B: 0

Control:
Frankel grade:
A–A: 2
A–B: 0
B–B: 1

Study details	Intervention details	Participant details	Adverse events	Comments
Author (Year) Asazuma (1996)[34] **Description of study:** Retrospective study of patients with incomplete SCI	**Intervention:** Surgery: anterior decompression and fusion (n = 16), posterior decompression and fusion (n = 9), or anterior decompression and posterior decompression and fusion (n = 1) *N*: 26 **Control:** No surgery: skull traction (n = 12), Glisson traction (n = 6), or bed rest (n = 1) *N*: 19 **Duration:** Not stated **Follow-up:** Mean 1 y 7 mths (1 y to 6 y 11 mths) **Concomitant treatments:** 29 patients received dexamethasone sodium phosphate (8–16 mg day^{-1}) for 2–3 days on admission **Comments:** Surgery took place from 2 days to 2 y 3 mths after injury (mean 6.5 mths)	**Age:** mean 51 y (range 15–82) y **Sex:** 38 M; 7 F **Severity:** Central cord injury: 32 (71.1%) (type I, 7; type II, 11; type III, 14) Brown–Sequard: 7 (15.6%) Transverse cord injury: 5 (11.1%) Anterior cord injury: 1 (2.2%) *N*: 45 **Patient characteristics:** Mechanism of injury: Extension injury: 22 (48.9%) Axial compression and extension: 4 (8.9%) Pure axial compression: 1 (2.2%) Type of injury: No bony injury or dislocation: 25 (55.6%) Anterior displacement: 12 (26.7%) Compression fracture: 5 (11.1%) Tear drop fracture: 4 (8.9%) Spinous process fracture: 1 (2.2%) Facet fracture: 1 (2.2%) (3 patients had both dislocations and fractures) Abnormalities of the cervical spine: Posterior osteophytes: 24 Cervical canal stenosis: 10 Ossification of the posterior longitudinal ligament (OPPL): 5 Congenital abnormalities: 1 **Inclusion/exclusion criteria:** None reported. Study only included patients with incomplete cervical SCIs	None reported	**Authors' conclusions:** 1. 37 (82.2%) of 45 patients showed neurological improvement of at least one grade. 2. Patients with disc herniation improved better than those with OPLL. 3. There were no correlations between the mechanism of the injury, the magnitude of the injury and neurological improvements. 4. Patients who underwent the early stage surgery improved better than those who had the late stage surgery
Results				
General comments: Clinical results were compared for the surgical and non-surgical treatments. A total of 22 patients (84.6%) in the surgical treatment improved more than one grade, as did 15 (78.9%) in the conservative treatment group. There was no statistically significant difference between the two groups. The effects of surgical treatment were compared between surgery done in the early stage and in the late stage after injury. The preoperative neurological state was assessed using Frankel grade just prior to surgery. In early stage surgery group, all of the patients improved neurologically, whereas 10 (55.6%) remained unchanged in the late surgery group ($p < 0.01$)				

Study details	Intervention details	Participant details	Withdrawals	Adverse events	Comments
Author (Year) Bohlman (1985)[43] **Description of study:** Retrospective series of patients treated at the Acute Spinal Cord Injury Units of the Veterans Administration Medical Center, Highland View Hospital and University Hospitals of Cleveland, Ohio between 1950 and 1978	**Intervention:** Surgery, including posterior fusion, stabilisation with Harrington instrumentation *N*: 41 **Control 1:** No surgery. Kept at bed rest until the bone lesion was judged to be healed enough to allow sitting *N*: 65 **Control 2:** Surgery without fixation (including laminectomy and cord cooling) *N*: 89 **Duration:** Not reported **Follow-up:** Ranged from 2 to 20 y **Concomitant treatments:** Not reported	**Age:** ranged from 16 to 72 y. **Sex:** not reported **Severity:** 184 patients had complete paralysis and 34 patients had incomplete paralysis on admission. Of 30 patients with incomplete injuries (>2 y follow-up), 23 had anterior cord syndrome, 4 had central cord syndrome and 3 had Brown–Sequard syndrome *N*: 218 **Patient characteristics:** Causes of injury: Missile or falling object: 70 Athletic injury: 66 Fall: 63 Motor vehicle: 19 Level of bone injury: T1–T4: 53 T5–T10: 152 Unclear: 13 **Inclusion/exclusion criteria:** Included patients who had had trauma to the upper region of the thoracic spine that resulted in paralysis. Patients with less than 2 y follow-up were excluded from the analysis **Further details:** Complete SCI was defined as a total motor and sensory loss below the level of the bone injury that lasted for more than 48 h after admission. Incomplete SCI was defined as an incomplete motor paralysis or sparing of sensation, or both, distal to the bone injury	**Intervention group:** Complete: 25 patients were lost to long term follow-up. Incomplete: 4 patients had less than 2 y follow-up	**Intervention:** Complete: 10 patients died. Incomplete: 1 patient died	**Authors' conclusions:** None stated

Results

General comments:
Complete injuries: none of the 184 patients regained motor function or more than two levels of intercostal sensation, regardless of the type of treatment employed. None of the patients became functional walkers with the use of long braces.
Incomplete: in patients treated without surgery, 2 recovered from gB/gC to gD, 1 recovered from gB to gC and could walk with crutches, 1 with gC function did not recover and 1 patient with gB recovered minimum function. 17 patients were treated by laminectomy (1 wk–14 y after injury): 1 recovered to gD function, 4 with gB function improved to gC and walked with braces and crutches, 4 patients remained unchanged, 8 patients became either worse or completely paraplegic. 8 patients were treated with anterior transthoracic decompression and fusion (48 h–16 mths from injury): 5 patients (3 with gB and 2 with gA) recovered and were able to walk without aids, 2 (gB and bA) recovered partially and were able to walk with crutches and braces, 1 patient (gB) remained unable to walk but improved to gC

Study details	Intervention details	Participant details	Adverse events	Comments
Author (Year) Bucci (1988)[82] **Description of study:** Five year retrospective study	**Intervention:** Cervical spine fusion followed by immobilisation in halo vest or hard cervical collar *N*: 28 Control: Halo vest only *N*: 20 Control 2: Philadelphia collar *N*: 1 **Duration:** Not stated **Follow-up:** Not stated **Concomitant treatments:** None reported **Comments:** Average period of immobilisation was 3 mths	**Age:** mean 30.3 y (range 15–64 y) **Sex:** 42 M; 7 F **Severity:** Quadriplegia: 40 Central cord syndrome: 6 Brown–Sequard syndrome: 2 Radiculopathy: 1 *N*: 49 **Patient characteristics:** Cause of injury: Motor vehicle accident: 28 Fall from height: 7 Sporting accidents: Diving: 11 Tumbling: 2 Surfing: 1 Type of injury: Complex fractures/fracture dislocations: 24 Compression fracture: 17 Angulation/subluxation only: 8 **Inclusion/exclusion criteria:** Patients with C1–2 fractures and patients operated previously with cervical spine fusion were excluded	**Intervention:** Death: 0 Pneumonia: 1 Worsening of neurological deficit: 0 DVT: 2 Tracheal oedema: 1 Transient ascension of level: 0 **Control:** Death: 0 Pneumonia: 3 Worsening of neurologic deficit: 2 DVT: 0 Tracheal oedema: 0 Transient ascension of level: 1	**Authors' conclusions:** 1. The halo vest does not protect patients with cervical instability from neurological injury, nor does it absolutely immobilise the cervical spine. 2. Surgery may be required to provide spinal stability even after a 3 mth orthotic treatment period. 3. There appears to be an increased rate of spinal stability with fusion and immobilisation versus immobilisation alone

Results

General comments:
A total of 34 of the 49 patients eventually underwent operative therapy and 15 patients were treated without operation. There were 11 anterior and 23 posterior cervical fusions performed

Outcome 1

Outcome:
Complications

Intervention:	**Control:**
Spinal instability: 2	Spinal instability: 8 ($p < 0.01$ compared with surgery)
Treatment failure: 2	Treatment failure: 5
Loss of reduction: 2	Loss of reduction: 2
Neurological improvement: 6	Neurological improvement: 2
Neurological deterioration requiring reoperation: 1	

Study details	Intervention details	Participant details	Withdrawals	Adverse events	Comments
Author (Year) Bucholz (1989)[79] **Description of study:** Review of records of all patients with cervical spine injuries treated with either a halo device or fusion between August 1984 and June 1986	**Intervention:** Surgical reduction and spinal fusion for patients who could not be reduced conservatively *N*: 16 **Intervention 2:** Surgical fusion without halo fixation *N*: 15 **Control:** Conservative treatment, included treatment with halo vest and ring for min 3 mths *N*: 93 **Duration:** Not stated **Follow-up:** Not stated **Concomitant treatments:** Gardner–Wells tongs or halo ring were used for initial immobilisation, with starting traction of 5–15 lb, in all patients except those with old fractures (see Comments) **Comments:** Protocol established in 1984 for use of halo device in all patients with unstable acute cervical spine injuries. Surgery without preoperative fixation was reserved for patients with old or pathological fractures and for those whose diagnosis was delayed Surgical fusion without preoperative fixation was performed in patients with injuries >1 mth old, pathological fractures, partial SCI with continuing spinal compression or thoracic injuries precluding placement of the halo vest	**Age:** range 6–94 y **Sex:** 93 M; 31 F *N*: 124 **Patient characteristics:** Type of injury (C1–2 injuries): Odontoid fracture Type II: 17 Type III: 9 C1–2 subluxation without fracture: 2 Hangman's fracture: 12 C2 body fracture only: 5 C1 arch fracture: 3 Type of injury (C3–T1 injuries): Fractured facets: 6 Locked facets with or without fracture: 13 'Perched' facets with or without fracture: 7 Compression or burst fracture: 13 Subluxation without fracture: 6 Partial vertebral fracture: 6 Laminar fracture: 6 **Inclusion/exclusion criteria:** Patients with cervical spine injuries treated with either a halo device of fusion between Aug 1984 and June 1986 were included	**Intervention group n:** 0 **Control group n:** 4 deaths from pneumonia, aspiration and subsequent cardiopulmonary arrest, myocardial infarction and unknown	None reported	**Authors' conclusions:** None stated

Results

General comments:
Patients only had surgical reduction and fusion if they had failed halo treatment. Cannot compare groups!

Outcome 1

Outcome:
Neurological improvement

Intervention:
After halo: 3 patients who had increased neurological deficit during halo treatment improved after surgery, and 4 patients, stable in the halo device, improved following surgery (7 patients; 43%). 8 patients had no change; 7 were intact. 1 patient deteriorated

Study details	Intervention details	Participant details	Adverse events	Comments
Author (Year) Burke (1976)[60] **Description of study:** Retrospective study of 115 patients, conservative versus surgical treatment	**Intervention:** Early surgery (within 48–72 h of injury): open reduction and internal fixation (n = 13); laminectomy (n = 8); laminectomy, open reduction and internal fixation (n = 3), and internal fixation without reduction (n = 2). *N*: 26 **Control:** Conservative treatment based on the postural techniques described by Guttmann. *N*: 89 **Duration:** Not stated **Follow-up:** 3–8 y **Concomitant treatments:** None reported **Comments:** The hospital adhered essentially to a conservative policy. Surgical treatments are performed for a fracture–dislocation found to be irreducible or poorly reduced after a brief trial of postural reduction if the patient has an incomplete cord or cauda equina lesion but occasionally for a patient with a complete neurological lesion when the spine is grossly unstable	**Age:** range 0–79 y (70% <30 y) **Sex:** not reported **Severity:** 77 patients (62%) had complete or cauda equina lesions on admission, 43 patients presented with incomplete lesions of the cord, conus and cauda equina *N*: 115 **Patient characteristics:** Causes of injury: Motor car accident: 66 Fall from height: 21 Pedestrian accident: 7 Farming accident: 6 Industrial accident: 5 Motor cycle accident: 4 Aeroplane crash: 3 Gunshot wound: 2 Dive into shallow water: 1 Types of injury (based on Holdworth classification): Flexion–rotation fracture dislocation: 80 Compression fracture: 27 No bony injury: 3 Hyperextension disruption: 2 Gunshot wound: 2 Acute rupture of thoracic intevertebral disc: 1 **Inclusion/exclusion criteria:** Patients were excluded from the study because: (1) they died during the first admission to hospital and were therefore not followed long enough; (2) they were admitted more than 2 days after injury; or (3) they had transient or negligible neurological injury and bony injury **Further details:** All patients were admitted within 48 h. The commonest level of injury was at the thoracolumbar level	**Intervention:** Chronic pain: 8/26 (22%) **Control:** Chronic pain: 2/89 (2%)	**Authors' conclusions:** The authors' concluded that the place for early surgical management might be still further restricted
Results				
General comments: Neurological results: Of the patients treated conservatively, only 6 out of 60 with complete neurological lesions on admission showed significant recovery, against 25 of 29 patients with initially incomplete lesions. 31 (35%) of the patients treated conservatively made a significant neurological recovery, mostly from initially incomplete lesions. Of the patients treated surgically, 2 out of 14 with initially complete lesions showed significant neurological recovery, and 8 out of 12 patients with incomplete lesions improved. A total of 10 patients (38%) showed significant neurological improvement				

Study details	Intervention details	Participant details	Adverse events	Comments
Author (Year) Carvell (1994)[7] **Description of study:** Results of spinal surgery in 420 consecutive patients admitted to the Duke of Cornwall Spinal Treatment Centre, Salisbury, from 1984 to 1991	**Intervention:** Surgical stabilisation before transfer *N*: 127 **Intervention 2:** Surgical stabilisation at the centre *N*: 31 **Control:** No surgery *N*: 262 **Duration:** Not stated **Follow-up:** Not stated **Concomitant treatments:** None reported **Comments:** Indications for surgery were an unreduced dislocation or spinal stability	**Age:** not reported **Sex:** not reported **Severity:** All patients had SCI. *N*: 420 **Patient characteristics:** Site of injury: Cervical: 208 Thoracic: 121 Thoracolumbar: 69 Lumbar: 22 **Inclusion/exclusion criteria:** Not stated	**Intervention:** Cervical (n = 48): Failure to recognise or reduce dislocation: 4 Graft shift: 1 Myelographic block: 1 Recurrent laryngeal nerve palsy: 1 Screw displacement: 1 Oesophageal perforation: 1 Flexion deformity: 2 Wound infection: 1 Total: 13 (27%) Patients requiring further surgery: 6 (12.5%) Thoracic, thoracolumbar, lumbar (n = 79): Pain due to incorrect tech: 16 Complications without symptoms: 6 Neurological deterioration: 2 Wound infection: 3 Total: 27 (34%) Patients requiring further surgery: 17 (22%) All patients: Total: 40 (31%) Patients requiring further surgery: 23 (18%) Graft shift: 2 Re-displacement of reduced dislocation: 1 Harrington rod hook displacement: 1 Harrington rod painful: 1 Total: 5 (16%) Patients requiring further surgery: 2 (6.5%) **Control:** 31 patients required surgery	**Authors' conclusions:** Authors discuss ways to avoid complications

Results

General comments:
Not all surgeons adopted a uniform policy of bone grafting, following internal fixation. All patients undergoing surgery in the spinal centre had a bone graft (complication rate, 16%; reoperation rate, 6.5%). Only 83 of the 127 patients undergoing surgery elsewhere were bone grafted and 23 (28%) developed complications. A total of 17 of the 44 patients who were not bone grafted (39%) developed complications.
The 127 patients were treated by either orthopaedic surgeons (68%), neurosurgeons (22%), or by a combined approach (3%), 7% unknown. There did not appear to be a particular bias in the complications seen in relation to the site of injury or the discipline of the surgeon

Study details	Intervention details	Participant details	Adverse events	Comments
Author (Year) Chahal (1990)[61] **Description of study:** Neurological results in acute dorso-lumbar injuries with complete paraplegia, comparing surgical treatment with continuous lumbar traction, based on experience in an SCI centre in India. Assume it is case review, but not stated	**Intervention:** Surgical: open reduction and internal fixation. Harrington instrumentation has also been used *N*: 30 **Control:** Continuous lumbar traction (CLT) *N*: 84 **Duration:** Not stated **Follow-up:** Not stated **Concomitant treatments:** None reported	**Age:** 14 aged 10–19, 50 20–29, 30 30–39, 16 40–49, 4 50+ y **Sex:** 100 M, 14 F *N*: 114 **Patient characteristics:** Level of injury by treatment group for those making excellent/good recovery (CLT/surgery) NB. No data on level for poor recoverers D-12 15/3 L1 18/4 L2 8/3 L3 7/0 L4 3/1 L5 2/1 **Inclusion/exclusion criteria:** No data	None reported	**Authors' conclusions:** Traumatic paraplegia managed by continuous lumbar traction gave good results in 60% of cases, compared with 43% with surgical treatment by Harrington instrumentation of Luke. The quality of neurological recovery was significantly better in those treated by traction

Results

General comments:	Outcome 1	Outcome 2	Outcome 3
None	**Outcome:** Neurological: recovery, motor paralysis excellent (full recovery)/good(paralysis below L4)/poor(complete paralysis) **Intervention:** 8/5/17 **Control:** 41/12/31	**Outcome:** Sensory recovery **Intervention:** 25% **Control:** 63%	**Outcome:** Urinary bladder recovery Stated to be much better in CLT group but full figures not given for both

Study details	Intervention details	Participant details	Withdrawals	Adverse events	Comments
Author (Year) Chen (1997)[62] **Description of study:** Retrospective review of 114 patients with acute or chronic traumatic central cord syndrome (TCCS) to assess outcomes by surgical vs medical treatment, by age group. Admitted to Taiwanese hospital over 6 y period. Appears that follow-up period was that of hospital attendance	**Intervention:** Surgery: 6 posterior laminectomy or laminoplasty, 22 anterior with or without fixation *N*: 28 **Control:** Non-surgical treatment *N*: 86 **Duration:** Not stated **Follow-up:** Followed up for 2 weeks–28 months (mean 3.5 months) **Comments:** Surgery recommended if failure to improve ADL strength or less than grade 3 muscle power after 2 wks with compression or gross spinal instability. 3 late operations (8–24 mths), others performed within mean 10 days (range 3–20 days)	**Age:** 5 14–19, 13 20–40, 59 41–60, 37 61–75 y **Sex:** 85 M, 29 F **Severity:** 75/86 non-surgical had minimal or no radiographic pathology. Posterior all had cervical spondylotic bar (CSB) with buckling of the ligmentum flavum. Only 1 anterior had both these, although 8 out of the 11 non-surgical with abnormal radiographic findings did. Anteriors had either unstable fracture or disc protrusion, usually accompanied by one of subluxation/abnormal cord signal/CSB. *N*: 114 **Patient characteristics:** 74% also had head injury, chest or abdominal trauma **Inclusion/exclusion criteria:** Incomplete cervical cord (CC) injury classified as CC. Lesions admitted to hospital 1988–94. 19 excluded due to incomplete data	Losses not stated	**Intervention:** Loosening of screws in 2 patients. Unstable spines requiring further immobilisation in 2. Severe posterior wound pain in 1 and 1 with wound infection. All successfully treated **Control:** None reported	**Authors' conclusions:** Surgical intervention for TCCS must be addressed with careful clinical and radiographic survey. Removal of lesions in the subacute period results in significant sensory and motor improvement in short-term and long-term follow-up. Better results were achieved with younger patients and in patients with clinically correlated encroaching cord lesions who received early surgical decompression. Slow but steady improvement of hand function in non-surgical patients who did not show structure impinging on the spinal cord. Slow or poor functional recovery for non-surgical patients with extrinsic cord lesion

Results

General comments:
Appears as narrative account, with few comparisons of surgery vs medical

Outcome 1

Outcome:
No residual major sensory complaints within 3 months

Intervention:
Surgical: anterior 18/22, posterior 3/6

Control:
Non-surgical – no figures

Outcome 2

Outcome:
Hand motor function

Could be extracted from Figures 1–3 if required, aggregating IPD by treatment group

Study details	Intervention details	Participant details	Adverse events	Comments
Author (Year) Daneyemez (1999)[36] **Description of study:** Retrospective series of 235 patients with cervical spine injuries treated between 1985 and 1995	**Intervention:** Surgery: anterior approach (n = 89) and posterior approach (n = 83) *N*: 172 **Control:** Conservative treatment, including collar stabilisation (n = 35), halo vest application (n = 22) and skeletal traction (n = 20) *N*: 63 **Duration:** Not stated **Follow-up:** Not stated **Concomitant treatments:** Unless contraindicated, patients admitted in the first 8 h were given medical treatment with the standard methylprednisolone protocol. For the indicated patient, decompressive surgery was done **Comments:** The most significant criterion for the indication of surgery was the assessment of the lesion as unstable In upper cervical injury, except type II odontoid fracture with a dislocation >6 mm, conservative treatment modalities were performed. In lower cervical injury, an anterior approach with discectomy and anterior fusion were performed if there was spinal cord compression anteriorly. Otherwise a posterior approach with decompression and a variety of posterior fusion techniques were used	**Age:** mean 28 y (range 5–69 y) **Sex:** 110 M; 125 F **Severity:** Frankel grading scale: Surgery: A: 19 D: 36 B: 13 E: 93 C: 11 Conservative: A: 18 D: 5 B: 17 E: 16 C: 7 *N*: 235 **Patient characteristics:** Type of cervical injury: odontoid fracture (n = 5), Jefferson's fracture (n = 8), Hangman's fracture (n = 12), vertebral compression body fracture (n = 70), teardrop fracture (n = 50), dislocation (n = 54) and mixed (n = 50) **Inclusion/exclusion criteria:** Patients with cervical spine injury treated between 1985 and 1995 were included **Further details:** Time to admission ranged between 4 h and 1 wk	None reported	**Authors' conclusions:** None reported

Results

Outcome 1

Outcome:
Neurological improvement (Frankel grade)

Intervention:	**Control:**
Baseline: A, 19; B, 13; C, 11; D, 36; E, 93	Baseline: A, 18; B, 17; C, 7; D, 5; E, 16
End (n = 155): A, 8; B, 7; C, 7; D, 22; E, 111	End (n = 58): A, 13; B, 9; C, 10; D, 6; E, 20

Study details	Intervention details	Participant details	Adverse events	Comments
Author (Year) Denis (1982)[54] **Description of study:** Retrospective clinical study of 59 burst fractures	**Intervention:** Operative treatment *N*: 30 **Control:** Conservative treatment *N*: 29 **Duration:** Not stated **Follow-up:** Average 30 mths **Concomitant treatments:** Not stated	**Age:** not reported **Sex:** not reported **Severity:** Not clear *N*: 59 **Patient characteristics:** Not reported **Inclusion/exclusion criteria:** Patients with thoracolumbar burst fractures were included in the study **Further details:** Abstract. No patient data reported	None reported	**Authors' conclusions:** The beneficial effects of adequate decompression in addition to realignment and stabilisation were illustrated by the results
Results				
General comments: Harrington instrumentation alone reduced an average of only 50% of the cross-section of the bone fragment from the canal. Anterior decompression was used in 13 cases, either primarily or following Harrington rod instrumentation which had not allowed adequate decompression. The Frankel classification was used as the method of neurological assessment. A total of 27 of the non-operative patients were Frankel E on admission. 5 of these patients developed neurological deficits after beginning ambulation. One patient with a Frankel grade D lesion at the chronic stage developed progressive loss of his cauda equina. This case and 4 of the 5 (previously mentioned) improved neurologically after surgical decompression. None of the operatively treated patients became worse				

Study details	Intervention details	Participant details	Withdrawals	Adverse events	Comments
Author (Year) Donovan (1987)[44] **Description of study:** Progress of 61 patients with closed cervical SCI cared for within a defined spinal cord care system and followed up for at least 1 y. Patients were admitted to three acute care hospitals with segregated SCI area and one spinal injury rehabilitation unit in USA	**Intervention:** Surgery: 13 posterior approach fusion and 4 anterior fusion, all but one within 3 wks *N*: 17 **Control:** Non-surgical. 2 direct to halo-vest immobilisation and 2 direct to a cervical collar. Remainder with tongs and traction – majority for 6 wks in tongs and traction, then placed in SOMI brace for 6 wks *N*: 43 **Control 2:** Laminectomy without fusion before entering this care system. *N*: 1 **Duration:** 1 y **Follow-up:** Not stated **Concomitant treatments:** Not reported	**Age:** mean 30 y **Sex:** 52 M; 9 F **Severity:** Lowest intact segment C2 for 2 patients, C3 for 2, C4 for 10, C5 for 17, C6 for 16, C7 for 12 and C8 for 2 *N*: 61 **Patient characteristics:** Major vertebral injury at the following spinal segments: C2–3 in 3 patients, C3–4 in 6, C4–5 in 14, C5–6 in 19, C6–7 in 16, C7–T1 in 3 **Inclusion/exclusion criteria:** Losses to follow-up and death excluded. Patients with penetrating rather than closed injuries excluded, or with fractures of C1 or C2 only or with no bone injury **Further details:** Admission within 24 h of injury for baseline, except for laminectomy . Examined at 3, 6 and 12 mths by one of the authors	**Intervention group n:** Apart from losses excluded (see above), 1 only had follow-up at 3 months **Control group n:** 5 only had follow-up at 3 mths	None reported	**Authors' conclusions:** Improvement of neurological function was independent of surgery (performed mainly for stabilisation and realignment), angulation and presence of retropulsion of bone fragments into the neural canal. Improvement was noted in all groups, implying that other factors are more important in determining the degree of recovery than the method of surgical intervention or the morphology of the bone injury. Improvement included those with complete lesions in both groups. However, questionable if the diagnosis of complete lesion was always correct. The large percentage of patients in both groups with anterior reactive bone formation suggests that posterior fusion may be the surgical approach of choice to provide both anterior and posterior fusion. Better spinal alignment in surgical fusion group. Only patients with flexion–distraction injuries who did not undergo surgical fusion appeared to be at risk for progressive spinal column deformity

continued

Results				
General comments: Protocol not described so not known how patients were assigned to treatment groups. Laminectomy patient excluded from surgical outcomes, but s/he experienced worst angulation out of all patients	**Outcome 1** **Outcome:** Improvement by at least one Frankel class/deterioration from Frankel B to A **Intervention:** 10/17 1/17 deteriorated **Control:** 31/43 improved (difference non-significant) 1/43 deteriorated	**Outcome 2** **Outcome:** No spinal angulation at 3 mths/increased spinal angulation at 12 mths **Intervention:** 14/17/2/16 (no data for 1) **Control:** 18/43/13/38 (no data for 5)	**Outcome 3** **Outcome:** Improvement of those in class A (complete) **Intervention:** 5/10 **Control:** 20/28	**Outcome 4** **Outcome:** Reactive bone formation **Intervention:** Posterior surgical fusion: 9/13 (no data for anterior fusion) **Control:** 36/43
	Outcome 5 **Outcome:** Neurological improvement for <15 degrees vs >15 degrees angulation **Intervention:** <15 10/16 (63%) vs >15 0/1 **Control:** <15 24/32 (75%) vs >15 7/11 (64%)	**Outcome 6** **Outcome:** Neurological improvement with and without canal narrowing **Intervention:** With 1/4 (25%), without 8/13 (62%) **Control:** With 22/29 (76%), without 9/14 (64%)	**Outcome 7** **Outcome:** Spinal instability **Intervention:** 0/17 **Control:** 3/43 (made up of 3/9 of those whose injury involved flexion coupled with distraction, 0/34 of others with injury due to extension, compression or flexion with compression)	**Outcome 8** **Outcome:** Bone displacement experienced **Intervention:** 7/17 **Control:** 19/43

Study details	Intervention details	Participant details	Adverse events	Comments
Author (Year) Donovan (1992)[37] **Description of study:** Retrospective series of patients with closed cervical spinal injuries	**Intervention:** Surgical stabilisation and fusion: Anterior: 11 Posterior: 37 *N*: 48 **Control:** Cervical traction and maintenance of alignment followed by SOMI or halo-vest immobilisation. *N*: 65 **Duration:** Not stated **Follow-up:** At least 1 y **Concomitant treatments:** Medical management of organ systems followed a single protocol **Comments:** Median time from injury to surgery was 11 days (range 1–60 days)	**Age:** mean 28.6 y, SD 13.9 y **Sex:** 94 M; 19 F **Severity:** Frankel Grade A 71 (63%); B 30 (27%); C 12 (11%); D/E 0 *N*: 113 **Patient characteristics:** Cause: Motor vehicle: 53 (47%) Diving: 33 (29%) Falls: 16 (14%) Motorcycle: 5 (4%) Sports: 5 (4%) Other 3 (3%) Neurological level: C2 1 (0.9%); C3 3 (3%); C4 22 (19%); C5 38 (34%); C6 27 (24%); C7 19 (17%); C8 3 (3%) Skeletal level: C2–3 2 (2%); C3–4 10 (9%); C4–5 31 (27%); C5–6 40 (35%); C6–7 3 (3%); T1–2 2 (2%); C6–7 26 (23%); C7–T1 3 (3%) Mechanism: Flexion/distraction: 39 (35%) Flexion/compression 30 (27%) Compression: 31 (27%) Extension: 12 (11%) Shear 1 (0.9%) **Inclusion/exclusion criteria:** Patients were selected from consecutive cases of closed injury to the cervical spine who were admitted within 48 h of injury, over an 8-y period (July 1981 to June 1989)	None reported	**Authors' conclusions:** These data demonstrate that in lower cervical spine injuries, while surgical stabilisation results in better initial and 1-y skeletal alignment and stability, and a minor decrease in acute and rehabilitation hospital lengths of stay, it offers no advantage over non-surgical stabilisation in terms of the initial and 1-y neurological outcomes and the majority of skeletal outcomes, with the major exception being stability in injuries with flexion–distraction mechanisms

continued

Results

General comments:
Data were also reported on skeletal outcomes. Mean spinal angulation was significantly different between the surgery and non-surgical groups at 3 mths (3 vs 9 degrees; M–W $U = 985$, $p < 0.001$) and 12 mths (3 vs 9 degrees; M–W $U = 1014$, $p < 0.001$). A greater proportion of non-surgical than surgical patients had callus formation at 3 mths (16 vs 44; chi-squared $= 12.4$, $p < 0.01$) and 12 mths (21 vs 52; chi-squared $= 11.0$, $p < 0.05$). There was also a significant difference in rate of spinal instability between surgical and non-surgical patients at 3 mths (1 vs 10, chi-squared $= 5.9$, $p < 0.05$)

Outcome 1

Outcome:
Mean length of stay (days?)

Intervention:
Acute: 42.9
Rehabilitation: 88.5

Control:
Acute: 47.9
Rehabilitation: 99.2

Outcome 2

Outcome:
Neurological levels of improvement (12 mths)

Intervention:
0: 33
1: 13
2: 2

No improvement:
Complete: 21
Incomplete: 12
Improvement:
Complete: 10
Incomplete: 5

Control:
0: 53
1: 10
2: 2

No improvement:
Complete: 33
Incomplete: 20
Improvement:
Complete: 7
Incomplete: 5

Outcome 3

Outcome:
Frankel class improvement (12 mths)

Intervention:
0: 20
1: 18
2: 9
3: 1
4: 0

No improvement:
Complete: 14
Incomplete: 6
Improvement:
Complete: 17
Incomplete: 11

Control:
0: 23
1: 16
2: 18
3: 7
4: 1

No improvement:
Complete: 17
Incomplete: 6
Improvement:
Complete: 23
Incomplete: 19

Outcome 4

Outcome:
Changes in Frankel class (baseline to 12 mths)

Intervention:
A: 14 showed no improvement, 12 progressed to B, 4 to C and 1 to D
B: 5 showed no improvement, 3 progressed to C, and 5 to D
C: 1 showed no improvement, and 3 progressed to D

Control:
A: 17 showed no improvement, 10 progressed to B, 5 to C, 7 to D, and 1 to E
B: 4 showed no improvement, 1 progressed to C, and 12 to D
C: 2 showed no improvement, 5 progressed to D and 1 to E

Study details	Intervention details	Participant details	Adverse events	Comments
Author (Year) Dosen (1972)[63] **Description of study:** Cases treated over the previous 10 y for whom the authors have complete notes and who have had 'sufficient' follow-up	**Intervention:** Surgical treatment, no further details *N*: 98 **Control:** Conservative treatment, no further details *N*: 127 **Follow-up:** At least 8 months	**Age:** not stated **Sex:** not stated **Severity:** All had some neurological impairment, 37 had tetraplegia, 127 had paraplegia *N*: 225 **Patient characteristics:** 75 had cervical fractures, 64 thoracic, 86 lumbar **Inclusion/exclusion criteria:** People with traumatic paraplegia or tetraplegia with at least 8 months follow-up and full notes	2 missing from surgery results and 1 from conservative treatment results 2 in the intervention group died and 9 in the control group	**Authors' conclusions:** Surgical treatment when given as part of a package for neurologically injured patients gives worse results than conservative treatment in all levels of vertebral lesions

Results		
General comments:	**Outcome 1**	**Outcome 2**
Positive and negative results refer to degree of motor recovery evaluated using force tests	**Outcome:** Positive result **Intervention:** 14/98 **Control:** 44/127	**Outcome:** Negative result **Intervention:** 82/98 **Control:** 82/127

Study details	Intervention details	Participant details	Adverse events	Comments
Author (Year) Duh (1994)[64] **Description of study:** Retrospective study using data from NASCIS II	**Intervention:** Anterior surgery. Coded into 6 categories: excision of body, open dura technique, open cord technique, anterior fusion, internal fixation, and excision of disc *N*: 45 **Intervention 2:** Posterior surgery. Coded as laminectomy, open dura technique, open cord technique, posterior fusion, internal fixation, and excision of disc *N*: 250 **Control:** No surgery *N*: 189 Duration: 1 y **Follow-up:** Up to 1 y **Concomitant treatments:** All patients were randomised to receive either methylprednisolone, naxolone or placebo. Patients were generally evenly distributed according to drug treatment within each time interval, except between 26 and 50 h after injury	**Age:** not reported **Sex:** predominantly male **Severity:** On admission, patients who did not have surgery had somewhat lower neurological scores than either surgical group *N*: 487 **Patient characteristics:** Patients in the three groups were similar in gender, ethnicity, height and weight. Significantly more patients who did not undergo surgery were between the ages of 13 and 19 y (71.7% vs 24.9% posterior surgery and 19.2% anterior surgery, $p = 0.00$) **Inclusion/exclusion criteria:** The criteria for eligibility in the study were an acute SCI diagnosed by a physician associated with NASCIS II, written informed consent and randomisation within 12 hours of injury. Exclusion criteria were: spinal nerve root damage only; cauda equina lesion only; injury by gunshot; other serious comorbidity; pregnancy; use of maintenance corticosteroids for other reasons; narcotic addiction; age less than 13 y; and high likelihood of becoming unavailable at follow-up **Further details:** Causes of injury were significantly different among the 3 study groups. There was also a significant difference in the extent of injury, with a higher proportion of those who underwent posterior surgery having a complete injury (64.1% vs 38.5% anterior surgery and 50.4% no surgery, $p = 0.00$), and a higher proportion of patients who underwent anterior surgery having an incomplete injury (61.5% vs 35.9% posterior surgery and 49.6% no surgery, $p = 0.00$). Significantly more of those who underwent posterior surgery had no cord syndromes (83.2% vs 67.3% anterior surgery and 78.3% no surgery, $p = 0.002$)	None reported	**Authors' conclusions:** This study does not provide clinically relevant evidence concerning the efficacy of timing or the value of surgery in treating patients with spinal cord injuries

continued

Results				
General comments: Patients who did not have surgery showed no remarkable differences in neurological recovery compared with those who had surgery in any time period	**Outcome 1** **Outcome:** Neurological scores (mean, SD) **Intervention:** Early surgery: Anterior (*n* = 19): motor 26.2, 20.2; pinprick 56.7, 19.9; touch 59.4, 21.0 Posterior (*n* = 99): motor 28.4, 16.9; pinprick 56.1, 15.5; touch 57.7, 16.6 Late surgery: Anterior (*n* = 37): motor 25.1, 21.5; pinprick 57.4, 19.4; touch 59.4, 18.9 Posterior (*n* = 147): motor 25.0, 17.5; pinprick 54.1, 16.3; touch 55.2, 17.4 Neurological scores at 6 wks (mean, SD): Early surgery: Anterior (*n* = 23): motor 42.4, 2.6; pinprick 63.9, 2.0; touch 64.5, 1.9 Posterior (*n* = 99) motor 35.9, 1.3; pinprick 60.9, 1.0; touch 62.8, 0.9 Late surgery: Anterior (*n* = 37): motor 37.0, 2.0; pinprick 62.1, 1.5; touch 62.0, 1.7 Posterior (*n* = 147): motor 30.9, 1.0; pinprick 59.4, 0.8; touch 60.2, 0.9 **Control:** Motor 20.3, 18.0; pinprick 51.3, 17.4; touch 53.0, 18.7 Neurological scores at 6 wks (mean, SD): motor 20.3, 18.0; pinprick 51.3, 17.4; touch 53.0, 18.7	**Outcome 2** **Outcome:** Motor change scores: Interval from injury to surgery (≤25; 26–50; 1–100; 101–200; >200 h) **Intervention:** 6 wks: 6.6; 5.5; 8.2; 7.2;10.0 6 mths:16.3; 9.2; 13.2; 13.3; 16.0 1 y: 17.8; 10.2; 15.0; 15.2; 16.4 **Control:** Motor change scores: 6 wks (*n* = 166): 9.9 6 mths (*n* = 161): 13.3 1 y (*n* = 156): 13.8	**Outcome 3** **Outcome:** Pinprick change scores Interval from injury to surgery (≤25; 26–50; 1–100; 101–200; >200 h) **Intervention:** 6 wks: 7.5; 4.8; 7.4; 6.1; 6.7 6 mths: 8.6; 6.0; 8.8; 8.3; 9.0 1 y: 8.3; 8.5; 10.5; 8.3; 10.0 **Control:** Pinprick change scores 6 wks (*n* = 165): 6.0 6 mths (*n* = 160): 9.2 1 y (*n* = 156): 8.9	**Outcome 4** **Outcome:** Touch change scores Intervention: Interval from injury to surgery (≤25; 26–50; 1–100; 101–200; >200 h) 6 wks: 6.9; 4.5; 6.9; 5.5; 5.8 6 mths: 8.2; 6.8; 9.0; 7.6; 8.5 1 y: 8.8; 7.5; 10.2; 9.1; 8.9 **Control:** Touch changes scores: 6 wks (*n* = 165): 5.7 6 mths (*n* = 158): 8.1 1 y (*n* = 155): 7.9

Study details	Intervention details	Participant details	Adverse events	Comments
Author (Year) Ectors (1971)[142] **Description of study:** Retrospective review of 27 cases of cervical spine trauma admitted between 1960 and 1970. French/Belgian	**Intervention:** 7 had external reductions as well as skull traction *N*: 7 **Control:** 20 just had skull traction *N*: 20 **Duration:** Not stated **Follow-up:** Not stated	**Age:** not stated **Sex:** not stated **Severity:** 16 had SCI *N*: 27 **Patient characteristics:** Details of individual patients' fracture levels are reported; all had cervical fractures	The authors report that of the 7 cases who had external reduction, it resulted in aggravation of the neurological syndrome in 6 and in 1 patient it was ineffective Mortality overall was 22%	**Authors' conclusions:** The orthopaedic treatment seems preferable for congenital deformities or dislocation injuries of the spine, except for the odontoid fractures with displacement. In these cases, operative fusion is as justified as the non-operative treatment. For cervical spine trauma with cord injury, it is necessary to avoid any operation during the first 10 days; after that period a demonstrable medullary compression warrants operative intervention **Comments:** Results do not appear to be presented separately for operative and non-operative groups except for the adverse events. It is unclear whether the authors' conclusions are opinions or are based on the evidence of their study

Study details	Intervention details	Participant details	Adverse events	Comments
Author (Year) Fang (1982)[53] **Description of study:** Retrospective review of case records of 29 patients with thoracolumbar injuries with cord or corda equina lesion	**Intervention:** Posterior surgery: 11 Harrington rod distraction (5 with laminectomy and 8 with fusion) and 7 laminectomy and/or fusion without instrumentation *N*: 18 **Control:** Non-surgical – postural reduction. Patients were mobilised at 6–10 wks with or without a plaster jacket. *N*: 11 **Duration:** Average follow-up: 2 y 5 mths surgical; 10 mths non-surgical **Follow-up:** Not stated **Concomitant treatments:** Not stated	**Age:** mean 43 y (range 19–77 y) **Sex:** 21 M, 8 F **Severity:** Frankel grades A–E (A = complete) Surgical: 6A, 3C, 9D Non-surgical: 4A, 1C, 6D *N*: 29 **Patient characteristics:** Level of injury was at the thoracolumbar junction in 13 operated cases and in 5 non-operated cases. There were 13 fractures of L1 and 7 of T12 vertebra. Other fractures were scattered over the dorsal and lumbo-sacral spine **Inclusion/exclusion criteria:** Not stated	**Intervention** Urinary tract infection: 14 Pressure sores: 8 Surgery complications: 5 (3 early hook dislodgement, 1 rod pressure on skin, 1 accidental dural tear) Wound haematoma: 1 **Control:** Urinary tract infection: 5 Pressure sores: 5	**Authors' conclusions:** Surgery offered no definite advantage for neural recovery nor did it curtail duration of hospitalisation. However, it significantly decreased post-traumatic kyphotic deformity. Morbidity and implant failure in 27% of operative cases. Appears that surgery is indicated in selected cases where there is a risk of significant kyphotic deformity with gross vertebral body displacement

Results

General comments	Outcome 1	Outcome 2	Outcome 3	Outcome 4
General comments: Authors point out that it is a non-specialist acute hospital with limited experience of SCI and attributes poor results of postural reduction to this factor. Treatment groups were not strictly comparable in levels and degrees of injury and groups were small	**Outcome:** Neural function: No. with improved Frankel grades **Intervention:** Initial grade A: 3/6 Initial grade C/D: 4/11 **Control:** Initial grade A: 1/4 Initial grade C/D: 6/7	**Outcome:** Kyphosis: mean kyphotic angle (No. affected) **Intervention:** 24 degrees before, 13 degrees after (*n* = 10;) **Control:** 29 degrees before, 33 degrees after (*n* = 6)	**Outcome:** Kyphosis–anterior subluxation: average % vertebral forward displacement Intervention: 39% before, 11% after (*n* = 5) Control: 22% before, 22% after (*n* = 4)	**Outcome:** Hospitalisation: No. of days **Intervention:** 144 days **Control:** 114 days

Study details	Intervention details	Participant details	Adverse events	Comments
Author (Year) Gardner (1988)[88] **Description of study:** Retrospective series of SCI patients treated at the Mersey Regional Spinal Injuries Centre between 1975 and 1982	**Intervention:** Surgery: laminectomy alone (*n* = 7), posterior plates (*n* = 6), Harrington rods (*n* = 2), other posterior reduction with or without fusion (*n* = 5), anterior fusion (*n* = 1), unknown (*n* = 1). *N*: 22 **Control:** Conservative treatment *N*: 176 **Duration:** Not stated **Follow-up:** Not reported, but all had clinical evaluation every 2 y **Concomitant treatments:** Not reported **Comments:** Many of the operations were performed outside Great Britain. Majority of patients admitted within 48 h of injury	**Age:** range 0 to 70+ y **Sex:** not reported **Severity:** Not reported, but all SCI patients *N*: 198 **Patient characteristics:** None reported **Inclusion/exclusion criteria:** Included acute traumatic spinal cord damaged patients treated between 1975 and 1982	**Intervention:** Total: 9 Symptomatic deformity: 3 Pain at injury site: 1 Radicular pain: 1 Wound infection: 2 Plate/wire removal needed: 2 Symptomatic instability: 0 **Control:** Total: 23 Symptomatic deformity: 10 Pain at injury site: 6 Radicular pain: 4 Wound infection: 0 Plate/wire removal needed: 0 Symptomatic instability: 3	**Authors' conclusions:** It is not possible to compare the results of this study with those of other reports because of differences in the patients and the methods of investigation. Trials must be prospective, multicentred, statistically significant and, if possible, double blinded and with independent assessments if valid comparison between treatments is to be made. Functional movement is not the only important factor. It may be that patient expectations, state resources and local considerations will determine which philosophy of spinal treatment is most appropriate for different centres in different countries

Results

General comments:	Outcome 1	Outcome 2	Outcome 3	Outcome 4
None	**Outcome:** Radiological outcome **Intervention:** Good: 11 Moderate: 6 Poor: 2 Unknown: 3 **Control:** Good: 101 Moderate: 57 Poor: 14 Unknown: 4	**Outcome:** Time to discharge **Intervention:** 31 weeks **Control:** 29 weeks	**Outcome:** Functional movement (cervical) **Intervention:** 7 of the 96 cervical patients had spinal operations in the acute stage. following injury. 1 of the 4 of these who were initially complete developed functional movement **Control:** 32 conservatively managed cervical patients were initially complete. 4 of these developed functional movement	**Outcome:** Functional movement (thoracolumbar) **Intervention:** 15 of the 102 thoracolumbar patients had spinal operations in the acute stage following injury. 4 of the 11 of these who were initially complete developed functional movement **Control:** 51 conservatively managed thoracolumbar patients were initially complete. 4 of these developed functional movement

Study details	Intervention details	Participant details	Adverse events	Comments
Author (Year) Gerard (1977)[143] **Description of study:** retrospective study of 57 vertebral fractures admitted between 1967 and 1974	**Intervention:** Surgical (wire cage 1, Wilson plates 7, Roy–Camille plates 14) *N*: 22 **Control:** Non-surgical *N*: 35 **Duration:** Patients admitted between 1967 and 1974 **Follow-up:** Not stated	**Age:** not stated **Sex:** not stated **Severity:** Not stated *N*: 57 **Patient characteristics:** 32 cervical, 25 lumbar **Inclusion/exclusion criteria:** Vertebral body fractures caused by trauma	Could not translate	**Authors' conclusions:** The authors conclude that surgery was better than no surgery. They state that it never caused any aggravation and permitted better relief of the complications of bed rest during the early stages. It always permitted satisfactory vertebral position
Results				
General comments: Could not translate. Results were spread out in the text and did not appear to be reported by treatment category				

Study details	Intervention details	Participant details	Adverse events	Comments
Author (Year) Guthkelch (1987)[58] **Description of study:** Case series	**Intervention:** Spinal fusion (included decompression in 2 cases) *N*: 12 **Control:** Halo traction *N*: 13 **Duration:** Not stated **Follow-up:** Not stated **Concomitant treatments:** All patients having evidence of spinal cord damage received steroids, usually about 100 mg day^{-1} methylprednisolone sodium succinate or equivalent, for 2–4 days	**Age:** mean 30 y (range 5–83 y) **Sex:** 97 M; 26 F **Severity:** Cervical SCI occurred in 27 patients (22%) Complete lesions: 13 Anterior cord syndromes: 2 Central cord syndromes: 6 Brown–Sequard syndrome: 4 Concussion: 2 *N*: 123 **Patient characteristics:** Cause of injury: Traffic accident: 100 Falls from a building: 6 Industrial accident: 2 Gunshot wounds: 3 Sporting accident: 9 **Inclusion/exclusion criteria:** Included patients in whom a tentative diagnosis of acute injury to the cervical or spinal cord had been made. Excluded patients suffering only from an uncomplicated ligamentous strain and patients having generalised metastatic disease without a clear history of trauma **Further details:** Major injuries were those that required hospital admission, including all instances of neurological deficit. 2 patients died prior to treatment	None reported	**Authors' conclusions:** None reported **Results:** There was no difference in the eventual degree of return of neurological function between the two groups

Study details	Intervention details	Participant details	Adverse events	Comments
Author (Year) Hamel (1977)[87] **Description of study:** Comparison between patients treated with conservative methods and those treated surgically with stabilising ventral fusion	**Intervention:** Stabilising ventral fusion *N*: 30 **Control:** Conservative treatment with or without extension *N*: 30 **Duration:** Not reported **Follow-up:** Not reported **Concomitant treatments:** Not reported	**Age:** not reported **Sex:** not reported **Severity:** 53 patients had contusion of the cervical spinal cord (11 complete, 35 incomplete, 8 radicular syndrome) and 108 had cervical spine fractures (61 complete, 26 incomplete, 13 radicular syndrome and 8 without neurological reductions) *N*: 161 **Patient characteristics:** Not reported **Inclusion/exclusion criteria:** Not reported **Further details:** 60 patients had comparable primary neurology	**Intervention** 27% died **Control** 33% died	**Authors' conclusions:** When comparing patients treated conservatively and patients with surgical treatment by stabilising ventral fusion it was obvious that the results obtained by surgical therapy were pronouncedly better
Results				
General comments: None	**Outcome 1** **Outcome:** Mobility **Intervention:** 20% unchanged, unable to walk 53% improved, able to walk **Control:** 43% unchanged, unable to walk 24% improved, able to walk			

Study details	Intervention details	Participant details	Adverse events	Comments
Author (Year) Hardcastle (1987)[91] **Description of study:** Assessment of long-term results of surgical and non-surgical management in complete paraplegics with SCI in the thoraco-lumbar region – study of athletes in paralympics Games	**Intervention:** Surgery: spinal fusion. 15 had subsequently had their implants removed, with others remaining. *N*: 46 **Control:** Non-surgical *N*: 41 **Duration:** Study was follow-up 2–26 y after injury **Follow-up:** Not stated **Concomitant treatments:** Not stated	**Age:** range 18–57 y. Mean 31 y **Severity:** 31 had T10 neurological level (Class III) and 54 had level between T10 and L2 (Class IV). Two others (Class II) had T10 level with an extensive spinal fusion from upper thoracic to sacrum for paralytic scoliosis *N*: 87 **Inclusion/exclusion criteria:** Athletes from 10 countries attending Paralympic Games in 1984 with complete paraplegia due to lesions between T10 and L2	**Intervention:** Pain: none/mild/moderate/severe 14/16/9/5 **Control:** Pain: none/mild/moderate/severe 18/9/11/3	**Authors' conclusions:** This study demonstrates that spinal fusion, particularly over multiple segments in complete paraplegics, has a deleterious effect not only on spinal movement but also on body trunk strength

Results

General comments:
Although most differences were non-significant, they were all in favour of non-surgical treatment. Difficult to know if the quality of treatment within each group was similar because from different countries. Applicability limited – only comparing the best outcomes from each treatment who became athletes – the full range of patients from each treatment might give a different result

Outcome 1

Outcome:
Spinal movement: flexion and extension

Intervention:
Flexion, mean (SD): 26.3 degrees (10.2), $p > 0.01$
Extension, mean (SD): 6.1 degrees (5.2), NS

Control:
Flexion, mean (SD): 34.3 degrees (11.4)
Extension, mean (SD): 9.2 degrees (5.1)

Outcome 2

Outcome:
Spinal movement: rotation

Intervention:
Mean (SD) 98.6 degrees (22.9), $p > 0.05$

Control:
Mean (SD) 124.3 degrees (19.3)

Outcome 3

Outcome:
Static sitting balance: score out of 16

Intervention:
Mean (SD): Class III 8.1 (2.7), Class IV 12.6 (3.2)

Control:
Mean (SD): Class III 8.6 (3.9), Class IV 13.5 (4.4)

Outcome 4

Outcome:
Dynamic sitting balance: score out of 16

Intervention:
Mean (SD): Class III 3.3 (2.8), Class IV 9.9 (4.6)

Control:
Mean (SD): Class III 5.5 (3.9), Class IV 11.4 (4.7)

Outcome 5

Outcome:
Trunk strength: flexor force (kg force)

Intervention:
Mean (SD): Class III 18 (6.8), NS, Class IV 26.1 (4.6), NS

Control:
Mean (SD): Class III 22.1 (6.6), NS, Class IV 28.4 (6.6), NS

Outcome 6

Outcome:
Trunk strength: extensor force (kg force)

Intervention:
Mean (SD): Class III 11.3 (3.3), NS, Class IV 17.1 (6.7), $p > 0.05$

Control:
Mean (SD): Class III 14.1 (7.1), NS, Class IV 17.1 (6.7), $p > 0.05$

Study details	Intervention details	Participant details	Adverse events	Comments
Author (Year) Heiden (1975)[65] **Description of study:** Retrospective chart review of 356 major cervical SCI patients with complete and incomplete cervical myelopathies over a 10 y-period, 1963–72, admitted to two centres covering Los Angeles (30% University Medical Center and 70% to SCI Service)	**Intervention:** Surgery for Group 1 (i.e. with complete paralysis) – laminectomy (n = 48) or anterior discectomy (n = 73) for cord decompression – divided into early surgery within 48 hours (n = 37), and delayed surgery (n = 84) *N*: 121 **Intervention 2:** Surgery for Group 2 (i.e. incomplete paralysis) – laminectomy (n = 37) or anterior discectomy (n = 52) – divided into early surgery within 48 h (n = 25), and delayed surgery (n = 64) *N*: 89 **Control:** No surgery for Group 1 *N*: 78 **Control 2:** No surgery for Group 2 *N*: 67 **Duration:** Not stated **Follow-up:** Not stated **Concomitant treatments:** Not reported	**Age:** 50% aged 16–25 y **Sex:** no data **Severity:** 199 Group 1: initial complete areflexic motor paralysis and absence of response to all somatic sensory modalities 156 Group 2 with incomplete neurological defect *N*: 356 **Patient characteristics:** Not stated **Inclusion/exclusion criteria:** Excluded those with inadequate clinical information (No. excluded not stated) **Further details:** Very limited results for Group 2 outcomes	**Intervention:** Group 1: 37% of 73 with anterior cervical fusion (ACF) and 27% of 48 with laminectomy had complications within 6 weeks. Multiple complications more common with ACF and 46% of those with ACF in first week suffered severe respiratory problems. Group 1 ACF respiratory problems reduced to 27% when surgery performed 1–4 wks after. Otherwise, no data on delayed surgery complications Individual complications for ACF/laminectomy: Severe pulmonary 34%/15% Thrombophlebitis/pulmonary embolism 3%/5% Upper gastrointestinal haemorrhage 7%/5% Increased neurological deficit 1.5%/0% Wound infection 4%/2% Bone graft displacement 5%/0% Injury to contiguous structure 3%/0% Group 2: 29% of each type of surgery had complications within 6 weeks. Individual complications for ACF/laminectomy: Severe pulmonary 12%/12% Thrombophlebitis/pulmonary embolism 5%/5% Upper gastrointestinal haemorrhage 0%/2% Increased neurological deficit 2%/5% Wound infection 0%/5% Bone graft displacement 10%/0% **Control:** 37% of non-surgical Group 1 had one or more complications within 6 weeks Individual complications: Severe pulmonary 15% Thrombophlebitis/pulmonary embolism 5% Upper gastrointestinal haemorrhage 5% Increased neurological deficit 2% No data on overall Group 2 non-surgical complications Individual complications: Severe pulmonary 16% Thrombophlebitis/pulmonary embolism 5% Upper gastrointestinal haemorrhage 1.5% Increased neurological deficit 1.5%	**Authors' conclusions:** No neurological improvement was detected in any patient with a complete lesion who underwent early surgical decompression. With complete paralysis, anterior cervical fusion within first week of injury was associated with increased pulmonary morbidity. In those with incomplete sensorimotor paralysis, it was difficult to document any effect of surgical decompression on neurological recovery. Patients with some degree of sensory preservation had a similar incidence of motor recovery in the surgical and non-surgical groups

continued

Results				
General comments: Group 2 results incomplete	**Outcome 1** **Outcome:** Improvement in neurological status **Intervention:** None in early or delayed surgical group improved **Control:** 2/78 non-surgical improved (who regained useful motor function and walking with braces)	**Outcome 2** **Outcome:** Neurological improvement for acute central cervical cord syndrome **Intervention:** 15/18 in delayed surgery group improved. No early operations carried out **Control:** 15/18 in no surgery group improved	**Outcome 3** **Outcome:** Neurological improvement for those with complete motor deficit but incomplete sensory deficit Of total $n = 57$ (no breakdown) **Intervention:** 13% surgical walking at follow-up (all operations carried out within 1 week) **Control:** 12% non-surgical walking at follow-up	**Outcome 4** **Outcome:** Neurological improvement for anterior cervical cord syndrome **Intervention:** 0/5 in surgical group improved **Control:** 3/7 non-surgical improved

Study details	Intervention details	Participant details	Adverse events	Comments
Author (Year) Jacobs (1980)[45] **Description of study:** Evaluation of early neurological decompression and spinal stabilisation for fractures of the dorso-lumbar spine. Not clear where the cases came from	**Intervention:** Harrington rods *N*: 55 **Intervention 2:** Meurig–Williams spinous process plates *N*: 13 **Control:** Patients treated either on frame or ordinary hospital bed. Marked deformity was reduced and controlled by closed methods. Patients mobilised in orthosis or plaster cast *N*: 32 **Duration:** Not reported **Follow-up:** 1 y **Concomitant treatments:** None reported **Comments:** First reason for considering surgical treatment was neurological decompression. The majority in the recumbent group were treated earlier in the study and on rehabilitation	**Age:** not reported **Sex:** not reported **Severity:** 58 fractures were associated with paraplegia (little or no useful motor function below the lesion) and the remaining 48 were ambulatory (at least some useful motor function below the lesion) *N*: 100 **Patient characteristics:** The injuries were distributed throughout the thoraco-lumbar spine with concentration at the thoraco-lumbar junction in all three treatment groups Type of injury: Distraction: 3 Compression: 9 Burst: 32 Fracture dislocation: 62 **Inclusion/exclusion criteria:** Patients with dorso-lumbar spine injuries were included **Further details:** 28/55 patients in the Harrington rod group were ambulatory compared with 15/32 in the recumbency group and 5/13 in the Meurig–Williams plate group. Rest were paraplegic. 100 patients, 106 fractures	**Intervention:** Complication rate was 7%; 2 pulmonary emboli (1 fatal), 1 resolved infection, 1 failure of fixation **Intervention 2:** Not reported **Control:** Complication rate was 18%; 2 pulmonary emboli, 1 pneumonia, 1 phlebitis and 2 decubiti	**Authors' conclusions:** 1. In review of 100 patients with dorso-lumbar spine injuries Harrington rod stabilisation decreases the time required for paraplegic patients to use a wheelchair (from 10.5 to 5.3 wks) and for ambulatory candidates to walk (from 7.1 to 2.5 wks) 2. Anatomical reduction was accomplished and maintained in two-thirds of the cases treated with Harrington rods, but only rarely with other methods 3. In partial lesions neurological function was no worse, but in fact improved – 53% compared with 44% 4. The rod long-fuse short approach improved the reduction from 70% to 82% anatomical, and decreased the number of levels fused from 4.8 to 1.4 5. The posterior approach allows evaluation of posterior ligamentous injury, neurological decompression by fracture reduction, anterior decompression by the posterolateral approach, immediate stabilisation by instrumentation and permanent stabilisation by fusion

continued

Results

General comments:
Neurological improvement: evaluated by assigning numbers 1 through 5 to the Frankel classes A to E, respectively. The observed increase (observed minus initial value) was divided by the maximum improvement possible (5 minus the initial value), to give % recovery

Radiographic evaluation: <10% displacement and 15 degrees of angulation in both views (AP and lateral X-rays) were considered anatomical, >50% displacement or 45 degrees of angulation in either view were considered unsatisfactory, and all other cases considered satisfactory

Kenny Self-care Score: modified self-care score studying feeding, personal hygiene, moving in bed, dressing, bowel and bladder care, transfers and locomotion (Kelly[831])

Outcome 1

Outcome:
Neurological improvement

Intervention:
Harrington rods:
Laminectomy: 53%
No laminectomy: 53%
Both: 53%

Mevrig–Williams plates:
Laminectomy: 0%
No laminectomy: 57%
Both: 50%

Control:
Neurological improvement:
Laminectomy: 43%
No laminectomy: 46%
Both: 44%

Outcome 2

Outcome:
Radiographic evaluation

Intervention:
Harrington rods:
Unsatisfactory: 2% (1/51)
Satisfactory: 31% (16/51)
Anatomical: 67% (34/51)

Mevrig–Williams plates:
Unsatisfactory: 38% (5/13)
Satisfactory: 61% (8/13)
Anatomical: 0%

Control:
Radiographic evaluation:
Unsatisfactory: 14% (5/34)
Satisfactory: 82% (28/34)
Anatomical: 2% (1/34)

Outcome 3

Outcome:
Rehabilitation (time required to perform independent wheelchair transfers) (wks)

Intervention:
Harrington rods:
Paraplegic: 5.3 ± 0.6
Ambulatory: 2.5 ± 0.3
Total: 4.0 ± 0.4

Mevrig–Williams plates:
Paraplegic: 10.0 ± 0.5
Ambulatory: 5.4 ± 2.4
Total: 8.2 ± 0.8

Control:
Paraplegic: 10.5 ± 0.9
Ambulatory: 7.1 ± 1.3
Total: 9.1 ± 0.8

Outcome 4

Outcome:
Kenny Self-care Score

Intervention:
Operative:
4 wks: 8.00 ± 0.84
8 wks: 15.94 ± 1.92
Plateau: 19.69 ± 1.06 (13 wks)
Max: 20.30 ± 1.02

Control:
Kenny Self-care Score:
4 wks: 7.47 ± 1.82
8 wks: 8.87 ± 2.31
Plateau: 16.69 ± 1.17 (20 wks)
Max: 16.73 ± 1.15

Study details	Intervention details	Participant details	Withdrawals	Adverse events	Comments
Author (Year) Jodoin (1985)[89] **Description of study:** Review of patient records of 108 unstable thoracolumbar fractures, with follow-up examination/interview of 88, in order to assess surgical and non-surgical treatment regimes. All admissions to one Canadian hospital 1971–81	**Intervention:** Instrumentation and fusion: Harrington + fusion 42, Harrington + fusion + laminectomy 32; Knodt rods + fusion 1, Knodt + fusion + laminectomy 9 *N*: 84 **Intervention 2:** Laminectomy without instrumentation 3 with fusion, 4 without *N*: 7 Fusion *in situ* *N*: 1 **Control:** Non-surgical *N*: 16 **Duration:** Mean 4 y, range 1–10 y **Follow-up:** Not stated **Concomitant treatments:** Not reported **Comments:** Mean time to surgery was 2 days after injury (range 0–80 days)	**Age:** mean 33 y (range 14–68 y) **Sex:** 76 M, 32 F **Severity:** 53/108 neurologically intact, 10/108 complete, 45/108 incomplete *N*: 108 **Inclusion/exclusion criteria:** Unstable fracture between T11 and L12 according to White and Panjabi's criteria. 22 of 108 were lost to follow-up and were not included in final comparative evaluation	22, treatment group unknown No data on treatment groups of losses. Numbers in each treatment group in abstract (71/30/16) do not tally with those in text (Table 3). Also Harrington rods and laminectomy are not mutually exclusive treatments (32 had both)	None reported	**Authors' conclusions:** The instrumented group showed a clear tendency for earlier ambulation and discharge and pain was less severe. An increased residual deformity was found in patients treated by laminectomy, short fusion and non-surgically. Neurological recovery in laminectomy and non-laminectomy not significantly different. Spinal realignment was better where an instrumentation of five levels or more was performed and where posterior elements were not removed by laminectomy
Results					
General comments: No usable data on different treatment groups – only results of some significance tests. Patients with laminectomy had greater rate of complications ($p > 0.05$.) Average time to ambulation was 27 days for non-instrumented and 22 for instrumented – difference not statistically significant. Pain less severe in patients with instrumentation of five or more levels than with short instrumentation					

Study details	Intervention details	Participant details	Adverse events	Comments
Author (Year) Kiwerski (1982)[90] **Description of study:** A retrospective case series in Poland, comparison of conservatively and surgically treated patients	**Intervention:** Surgery *N*: 314 **Control:** Conservative treatment *N*: 249 **Duration:** 6 weeks–more than 12 months **Follow-up:** Not stated **Concomitant treatments:** Not stated **Comments:** Polish. Only one outcome reported separately for surgical and conservative patients	**Age:** 68 <18, 266 19–40, 174 41–60 and 55 >60 y **Sex:** not stated **Severity:** Frankel grade A 223; grade B 89; grade C 116, grade D 135 *N*: 563 **Patient characteristics:** Time of injury to admittance: ⩽6 hours 253 7–12 hours 80 13–24 hours 71 2–3 days 53 4–7 days 30 >7 days 76 **Inclusion/exclusion criteria:** Not stated	Both groups: decubitus ulcers 45, ossification 39, urinary complications 30, pulmonary complications 26, other complications 41, no complications 382	**Authors' conclusions:** Unclear

Results

General comments:
Results also presented for length of treatment by age of patient, time of injury to admittance and degree of neurological injury

Outcome 1

Outcome:
Length of hospitalisation

Intervention:
Up to 6 wks 57; 7–12 wks 135; 4–5 mths 96; 6–9 mths 21; 10–12 mths 4; >12 mths 1

Control:
Up to 6 wks 62; 7–12 wks 59; 4–5 mths 64, 6–9 mths 48; 10–12 mths 7, >12 mths 9

Study details	Intervention details	Participant details	Adverse events	Comments
Author (Year) Kiwerski (1986)[38] **Description of study:** Analysis of the results of treatment of 1180 patients with traumatic injury of the cervical spinal cord, admitted 1965–83 to the specialist SCI unit of a hospital in Poland within the first hours or days of injury (review of records)	**Intervention:** Surgical: decompression for burst fractures, anterior approach autogenic bone graft for dislocation without body fracture *N*: 548 **Control:** Non-surgical: skull traction for compression fractures and for fractures of anterior parts of vertebrae through flexion mechanism *N*: 632 **Duration:** Not stated but appears to be hospitalisation period, range 4 wks–1+ y **Follow-up:** Not stated **Concomitant treatments:** Not reported	**Age:** not stated **Sex:** not stated **Severity:** Degree of SCI (Frankel classes) by level of injury: 74 C1–C3 comprising 10 complete, 12 class 1, 17 class 2, 35 class 3 421 C3–C5 comprising 176 complete, 48 class 1, 96 class 2, 101 class 3 685 C5–C7 comprising 320 complete, 111 class 1, 99 class 2, 155 class 3 *N*: 1180 **Patient characteristics:** Complete/class 1/class2/class3/incomplete/death: Surgery group: 39%/17%/17%/26%/1% Non-surgery group: 46%/11%/17%/23%/4% (NB: Complete includes deaths, classes 1–3 exclude deaths) **Inclusion/exclusion criteria:** Traumatic injury to C1–C7. No data on exclusions, e.g. for incomplete records	**Intervention:** 45/548 deaths (40 with complete paralysis, 5 partial) **Control:** 136/632 deaths (112 with complete paralysis, 24 partial)	**Authors' conclusions:** Mortality largely accounted for by complete SCI. Outcome in terms of improvement is largely dependent on time of commencement of specialist treatment and clinical condition of the patient. Neither treatment method is superior. Selection of an appropriate form of treatment should be made individually

Results

General comments:	Outcome 1	Outcome 2	Outcome 3
Results show time of admission to be important (but the very late admissions may not be comparable – could include only worst cases). A much higher proportion of excellent and of good outcomes are associated with surgery. This could be a consequence of non-comparability between treatment groups in relation to the severity of injury, but there does not appear sufficient difference in terms of Frankel classes to explain the difference in outcomes	**Outcome:** Improvement for complete paralysis by 1 or more Frankel classes **Intervention:** 38/216 surgical **Control:** 13/290 non-surgical	**Outcome:** Improvement for incomplete paralysis by 1 or more Frankel classes **Intervention:** 295/332 surgical **Control:** 228/342 non-surgical	**Outcome:** Outcome by time of admission from injury **Intervention:** Excellent = no neurological disorder or improvement by 3 classes; good = improvement by 2 classes; fair = improvement by 1 class

Study details	Intervention details	Participant details	Adverse events	Comments
Author (Year) Kiwerski (1993)[39] **Description of study:** Retrospective series of patients admitted and treated in the Spinal Injury Department between 1965 and 1991	**Intervention:** Surgical treatment *N*: 963 **Control:** Conservative treatment *N*: 798 **Duration:** Not stated **Follow-up:** Not stated **Concomitant treatments:** Not reported **Comments:** Treatment decisions appeared to be based on injury type	**Age:** not reported **Sex:** not reported **Severity:** Degree of injury: Complete: 754 Frankel grade B: 252 Incomplete: Frankel grade C: 358 Frankel grade D: 397 *N*: 1761 **Patient characteristics:** Level of spinal injury: C1–C3: 107 C3–C5: 634 C5–T1: 1020 **Inclusion/exclusion criteria:** Patients admitted and treated within the first few hours of days after injury (up to 2 wks) were included in the series	**Intervention:** Mortality by spinal cord damage at baseline: Complete: 75 B: 4 C: 3 D: 1 **Control:** Mortality by spinal cord damage at baseline: Complete: 132 B: 8 C: 18 D: 2	**Authors' conclusions:** No direct comparison of the conservatively and surgically treated can be made because there was a lack of randomisation in assigning the patients to the 2 groups. The practice in our centre to assign patients to surgery or no surgery is based mainly on the mechanism of injury. In our opinion, selection of an appropriate form of treatment should be made individually and be based on a reliable analysis of possible neurological improvement and preclusion of complications

Results

General comments:	Outcome 1	Outcome 2
None	**Outcome:** Percentage improvement by spinal cord damage at baseline **Intervention:** Complete: 19 B: 93% C: 95% D: 88% **Control:** Complete: 7% B: 90% C: 78% D: 65%	**Outcome:** Neurological state: admission compared with discharge **Intervention:** Complete: complete, 256; B, 22; C, 23; D, 17; normal, 0. B: complete, 0; B, 10; C, 41; D, 93; normal, 9. C: complete, 0; B, 0; C, 9; D, 132; normal, 51. D: complete, 0; B, 0; C, 0; D, 25; normal, 192 **Control:** Complete: complete, 214; B, 6; C, 6; D, 3; normal, 0. B: complete, 0; B, 9; C, 34; D, 42; normal, 2. C: complete, 0; B, 0; C, 32; D, 102; normal, 11. D: complete, 0; B, 0; C, 0; D, 62; normal, 115

Study details	Intervention details	Participant details	Withdrawals	Adverse events	Comments
Author (Year) Kiwerski (1993)[66] **Description of study:** Study of causes of injury, neurological involvement and methods of treatment, comparing the results of operative and non-operative treatment, for 273 patients with crush or burst fractures of cervical vertebrae (patients admitted 1965–91 to Rehabilitation Centre in Poland). Earlier patients usually treated by skull traction and bed rest, later patients usually by operative decompression and fusion	**Intervention:** Surgery: anterior cervical approach with removal of central part of crushed vertebra and insertion of either a bone graft or, more recently, a corrundum ceramic implant (not stated when ceramic implant started) *N*: 203 **Control:** Non-surgical: skull traction and bed rest *N*: 70 **Duration:** Case series admitted over 26-y period. Follow-up period not stated **Follow-up:** Follow-up period not stated **Concomitant treatments:** 1965–77: 51% non-surgical, 49% surgical 1978–91: 6% non-surgical, 94% surgical	**Age:** 81<21,166 21–40, 24 41–60, 2 >60 y **Sex:** not stated **Severity:** 186 with complete SC lesion, 44 with incomplete lesion Frankel level 1 (total paralysis), 24 with incomplete lesion Frankel level 2, 14 with incomplete lesion Frankel level 3, 5 with no neurological defect (but this group is omitted from all results below as there are no data on their outcomes) *N*: 273 **Patient characteristics:** Level of fracture: C4 15; C5 123; C6 90; C7 45 **Inclusion/exclusion criteria:** Crush or burst fracture of cervical vertebrae	**Intervention group:** 5 patients with no neurological deficit were omitted from the results	**Intervention:** 20/203 died **Control:** 17/70 died	**Authors' conclusions:** None stated

Results

General comments	Outcome 1	Outcome 2	Outcome 3	Outcome 4
General comments: Results are divided into early and late parts of study but not clear if this was earlier and later surgical technique. Not stated when surgery took over from non-surgical , treatment or on what clinical basis surgery was undertaken. Difficult to analyse results as groups are almost certainly not similar	**Outcome:** Complete paralysis: improvement by one or more levels **Intervention:** 24/110 **Control:** 0/40	**Outcome:** Death **Intervention:** 20/203 **Control:** 17/70	**Outcome:** Incomplete paralysis: improvement by one or more levels **Intervention:** 64/93 **Control:** 10/30	**Outcome:** All patients: improvement by one or more levels **Intervention:** 88/203 **Control:** 10/70
	Outcome 5 **Outcome:** Complete paralysis: improvement by two or more levels or resolution **Intervention:** 14/110 **Control:** 0/40	**Outcome 6** **Outcome:** Incomplete paralysis: improvement by two or more levels or resolution **Intervention:** 35/93 **Control:** 3/30		

Study details	Intervention details	Participant details	Withdrawals	Adverse events	Comments
Author (Year) Koivikko (2000)[46] **Description of study:** Retrospective controlled study: consecutive series of patients, approximately half treated operatively and half conservatively	**Intervention:** Anterior decompression followed by iliac bone grafting and fixation by the anterior Caspar plate. Preceded by primary reduction by skull traction *N*: 35 **Control:** Skull traction (average duration 5 weeks, $n = 29$) or halo vest (average duration 8 weeks, $n = 5$) *N*: 34 **Duration:** See above **Follow-up:** At least 6 mths **Concomitant treatments:** In surgical group a collar was used for mean 11 wks, in conservative group for mean 8 wks. 2 patients in conservative group and 14 in surgical group had received high-dose methylprednisolone **Comments:** Authors claim discrepancy in numbers receiving methylprednisolone did not affect probability of neurological recovery compared with those who did not receive steroids. However, numbers were probably too small to undertake this comparison	**Age:** int mean 32.9 y (range 17–83 y); con mean 30.3 y (15–64 y) **Sex:** 56 M, 13 F **Severity:** Unstable cervical burst and teardrop fractures. On admission 22 were Frankel grade A, 12 were grade B, 7 were grade C, 3 were grade D, 25 were grade E *N*: 69 **Patient characteristics:** Surgical: Frankel A 13, B 5, C 4, D 2, E 11. Associated injuries head 5, spine 2, chest 1, abdomen 0, pelvis 2, extremities 13 Control: Frankel A 9, B 7, C 3, D 1, E 14. Associated injuries head 2, spine 0, chest 2, abdomen 1, pelvis 1, extremities 5. On admission, mean posterior displacement of posterior cortex = 24% both groups. Average kyphosis 6.6 control group and 8.0 surgical group **Inclusion/exclusion criteria:** Unstable cervical burst and teardrop fractures treated and followed up in Dept of Orthopaedics and Traumatology, Helsinki University Central Hospital during 1980–95. At least 15 y old and undergoing one of the 2 treatments detailed above. Follow-up at least 6 mths. Exclusion criteria: known malignancy, ankylosing spondylitis **Further details:** Neurological status and radiographic measures evaluated from hospital records. Average follow up 28.9 mths (range 6 mths – 14 y) in control group and 15.9 mths (range 6 mths – 3 y) in surgical group	**Intervention group n:** 1 died: 33 y, gA, of respiratory insufficiency 96 days after the injury **Control group n:** 3 died: one (53 y, grade B) of pneumonia 7 days after injury, one (83 y, gB) of MI 82 days after injury, one (43 y, gE) of pneumonia 99 days after injury	**Intervention:** Complications during hospital stay: cardiac 4, respiratory 10, urological 8, gastrointestinal 4, DVT 0, PE 0, decubitus ulcers 5, loosening of screws 0, local pain 0, other 2. Follow-up 4.5 patient-y During follow-up: cardiac 0, respiratory 1, urological 5, gastrointestinal 0, DVT 2, PE 0, decubitus ulcers 5, loosening of screws 2, local pain 1. Follow-up 39.7 patient-y **Control:** Complications during hospital stay: cardiac 2, respiratory 12, urological 7, gastrointestinal 2, DVT 4, PE 2, decubitus ulcers 3, loosening of screws 0, local pain 0, other 6. During follow-up patient-y 5.2: cardiac 0, respiratory 1, urological 6, gastrointestinal 0, DVT 0, decubitus ulcers 3, loosening of screws 0, local pain 0, other 6. During follow-up patient-y 67.4: cardiac 0, respiratory 1, urologic 6, gastrointestinal 0, DVT 0, PE 0, decubitus ulcers 6, loosening of screws 0, local pain 1, other 0.	**Authors' conclusions:** Compared with conservative methods, anterior decompression and Caspar plating provided a superior decompression and a more rigid fixation, promoting the healing of cord injuries caused by burst and flexion teardrop fractures

continued

Results				
General comments: Patients who recovered one or more Frankel grades had significantly less vertebral body displacement at the end of follow-up than those who did not recover. Similar trend seen in conservative and surgical groups. 2 patients in conservative group and 14 in operative group had received high-dose methylprednisolone therapy but authors state this did not improve the probability of neurological recovery compared with those who did not receive corticoids	**Outcome 1** **Outcome:** Frankel grade **Intervention:** Baseline: Frankel gA 12, B 5, C 4, D 2, E 11 End: 2 improved from gA to B and 2 from gA to C. 3 improved from gB to D, 1 from B to C, 3 from C to D, 1 from C to E, 1 from D to E. More improved at least 1 grade than in control ($p = 0.027$, chi-squared test) **Control:** Baseline: Frankel gA 9, B 5, C 3, D 1, E 13 End: 1 improved from B to D, 2 from C to D, 1 from C to E	**Outcome 2** **Outcome:** Reoperation **Intervention:** 2 patients had to be operated on a second time, one because of loosening of a screw and the other because excessively long screws were used in the first operation **Control:** 3 patients in conservative group underwent later surgical stabilisation (2, 5 and 10 months after injury)	**Outcome 3** **Outcome:** Size of posterior displacement of vertebral body fragments Intervention: 7.4% ($p = 0.0001$) **Control:** 21.5%	**Outcome 4** **Outcome:** Kyphosis **Intervention:** Mean 2.2 degrees of lordosis, SD 13.9 degrees, $p = 0.00003$, Mann–Whitney rank sum test. Kyphotic deformity progrediated $\geqslant$5 degrees, $n = 4$ **Control:** Kyphosis: mean 12.6 degrees, SD 10.0 degrees. Kyphotic deformity progrediated $\geqslant$5 degrees, $n = 8$

Study details	Intervention details	Participant details	Withdrawals	Adverse events	Comments
Author (Year) Koning (1989)[47] **Description of study:** Retrospective series of patients treated at the Neurological and Neurosurgical Clinic and the Rehabilitation Centre of the University of Cologne	**Intervention:** Operative group; posterior decompression + implantation of Harrington rods *N*: 5 **Intervention 2:** Operative group; posterior decompression + postural reduction *N*: 24 **Control:** Conservative group; postural reduction *N*: 47 **Duration:** Not reported **Follow-up:** Appeared to range from 2 days to 10 y **Concomitant treatments:** None reported **Comments:** Patients were operated on where there was the appearance of secondary neurological deficits or a compressive pathology	**Age:** not reported **Sex:** not reported **Severity:** Not clear *N*: 78 **Patient characteristics:** Not clear **Inclusion/exclusion criteria:** Patients with spinal cord injuries due to fractures of the thoraco-lumbar spine between 1957 and 1984 were included	**Intervention group n:** 5/20 patients with grade A died, 2 of severe head injuries, 1 of contusion of the spinal cord, and 2 pulmonary embolism **Control group n:** 7 patients died, 5 as a result of additional head injury, 1 due to secondary sepsis, 1 due to lung embolism	None reported	**Authors' conclusions:** Our results confirm those reported in the literature: improvement occurred most frequently with injuries in the lumbar region, and the worst results were to be found with injuries of the high thoracic spine. At the middle and lower thoracic levels there were also post-operative improvements. In 14 patients a CT examination was carried out. In 12 of the cases the indication for operation was provided by CT

Results

General comments	Outcome 1	Outcome 2	Outcome 3
General comments: Majority of useful data are presented in confusing diagrams and unreadable graphs!	**Outcome:** Neurological improvement **Intervention:** Grade A (Frankel): 20 patients 8 paraplegic patients improved 1–3 days or 3 wks after operation **Control:** 4/30 paraplegic patients improved by 1–3 Frankel grades	**Outcome:** Neurological improvement **Intervention:** All patients at Frankel grades B and C ($n = 9$) improved postoperatively **Control:** 12 of 17 patients with incomplete lesions improved as a result of conservative treatment	**Outcome:** Neurological change **Intervention:** $n = 29$ Improved: 17 (58%) Unchanged: 12 Worse: 0 **Control:** $n = 47$ Improved: 15 (34%) Unchanged: 22 Worse: 10

Study details	Intervention details	Participant details	Adverse events	Comments
Author (Year) Lemons (1993)[86] **Description of study:** Retrospective study over 4.5 y	**Intervention:** Surgical stabilisation: (posterior fixation and fusion); cervical corpectomies with iliac crest or fibular strut graft fusions; and anterior and posterior operations *N*: 26 **Control:** External orthosis *N*: 38 **Duration:** Not reported **Follow-up:** Mean follow-up 6 mths, minimum of 6 mths **Concomitant treatments:** None reported **Comments:** 38 patients ultimately underwent surgical stabilisation. Posterior fixation and fusion: 26 Cervical corpectomies with iliac crest or fibular strut graft fusions: 4 Anterior and posterior operations: 8	**Age:** mean 32 y (range 14–93 y) **Sex:** not reported **Severity:** Complete: 32 Incomplete: 32 *N*: 64 **Patient characteristics:** Cause of injury: Traffic accidents: 39 Diving accidents: 16 **Type of injury:** Compression: 14 Flexion–compression/distraction: 12 Unilateral facet fracture/dislocation: 12 Bilateral facet fracture/dislocation: 16 Hyperextension: 10 Severe ligamentous injury (SLI) only: 25 Severe vertebral body injury (SVBI) only: 4 SLI and SVBI: 12 No evidence of SLI or SVBI: 23 **Inclusion/exclusion criteria:** None reported	**Intervention** Two patients died within 5 wks of injury	**Authors' conclusions:** Identifying evidence of SLI or SVBI on admission roentgenograms accurately predicts the success or failure of nonoperative stabilisation. Further, identifying SLI or SVBI guides the approach for surgical stabilisation, as SLIs require posterior fixation and fusion and SVBIs require vertebrectomy and strut graft stabilisation. Injuries with both SLI an SVBI require both anterior and posterior stabilisation. Subaxial cervical fractures with neither SLI or SVBI can be successfully stabilised non-operatively

Results

General comments:
None

Outcome 1

Intervention:
Stabilisation success:
SLI:
Posterior fixation/fusion: 100%
SVBI:
Vertebrectomy + strut graft: 100%
Both SLI and SVBI:
Posterior fixation/fusion: 33%
Vertebrectomy + strut graft: 25%
Vertebrectomy + strut graft and posterior fixation/fusion: 100% ($p = 0.002$)

Control:
Initially, fracture reduction could not be maintained in 16 patients (42%)
Evidence of SLI, SVBI or both correlated strongly to non-operative stabilisation failure ($p < 0.001$, $p = 0.004$ and $p = 0.002$, respectively). Injuries without evidence of SLI or SVBI were all stabilised adequately

Study details	Intervention details	Participant details	Withdrawals	Adverse events	Comments
Author (Year) Lewis (1974)[67] **Description of study:** Retrospective study of SCI patients with unstable fracture–dislocations of thoraco-lumbar spine accompanied by paraplegia. Comparison of cases admitted to two spinal injury centres with different treatment regimes – one surgical and one non-surgical. Case histories and radiographs examined from 27-y period, with follow-up examinations at time of study	**Intervention:** Surgical: open reduction and plating: 28 Williams plate + 1 Wilson plate *N*: 29 **Control:** Non-surgical: postural reduction *N*: 12 **Duration:** Not stated **Follow-up:** Follow-up time from injury. Range 1–27 y, mean 8 y **Concomitant treatments:** None reported **Comments:** Average time from injury to operation was 14 h with maximum of 3 days	**Age:** 11–69 y **Sex:** male **Severity:** Level of injury: 13 T11–12, 22 T12–L1, 4 L1–2, 1 L2–3, 2 L3–4, 1 L4–5 21 complete lesion, 12 complete sacral cord lesion but some degree of lumbar root sparing, 3 incomplete lesion, and 4 root lesions only. 3 cases lacked initial documentation *N*: 43 **Patient characteristics:** Not stated **Inclusion/exclusion criteria:** Cases showing undoubted radiographic evidence of posterior ligament rupture. Exclusions: deaths (n = 18), those who could not be traced (n = 11) and those unable to attend for examination (n = 21) – no data on any of these and no information on treatment groups 2 plaster bed cases have been excluded from the results given here (pre-1950 treatment) **Further details:** The exclusions are not included in the numbers in each treatment group. Comparability of treatment groups is assumed due to different policies of centres. However, surgical group contained 5 with extreme initial displacement and 1 in non-surgical group	**Intervention group n:** 11 out of original 62 died 24 losses to follow-up. 2 where fixation was attempted but proved impossible **Control group n:** 7 out of original 27 died 8 losses to follow-up	**Intervention:** 1 DVT, 1 myocardial infarct, 9 removal of plates (5 loose or broken with pain, 3 loose with no pain, 1 deep sepsis) **Control:** None	**Authors' conclusions:** No evidence of improved neurological recovery with plating but less angular deformity and less pain. Open reduction and internal fixation are indicated on these grounds but more research needed with larger numbers

continued

Results				
General comments: None	**Outcome 1** **Outcome:** Reduction in kyphosis within 24 h due to operation **Intervention:** 24 excellent and 3 incomplete just after. No data on non-surgical	**Outcome 2** **Outcome:** Incidence of pain (late follow-up) No pain/aching/moderate/severe: **Intervention:** 22/5/0/0 **Control:** 4/5/1/2	**Outcome 3** **Outcome:** Clinical deformity (late follow-up) Moderate/severe gibbus: **Intervention:** 1 **Control:** 3	**Outcome 4** **Outcome:** Kyphosis (radiological assessment – late follow-up) **Intervention:** Severe kyphosis >40 degrees: 2 surgical. Moderate 20–40 degrees: 12 surgical **Control:** Severe kyphosis >40 degrees: 3 non-surgical. Moderate 20–40 degrees: 6 non-surgical
	Outcome 5 **Outcome:** Neurological improvement (late follow-up) Some degree of recovery: **Intervention:** 10/26 **Control:** 5/12	**Outcome 6** **Outcome:** Average kyphosis (late follow-up) Average displacement: **Intervention:** 20 degrees surgical **Control:** 29 degrees non-surgical	**Outcome 7** **Outcome:** Neuro deterioration (late follow-up) None in either group	

Study details	Intervention details	Participant details	Adverse events	Comments
Author (Year) Lifeso (1985)[48] **Description of study:** Spinal Cord Injuries Unit in Riyadh, Saudi Arabia. Prospective study of 98 consecutive patients presenting with neurological impairment and fractures or dislocations between 9th thoracic and 2nd lumbar vertebrae. Early patients were treated non-surgically due to unavailability of Harrington rod surgery. Later patients had Harrington rods and some of these also had further procedure of anterior decompression where necessary	**Intervention:** Harrington instrumentation (average 18 days post-injury, *n* = 21) posterior approach, plus later anterior decompression where necessary *N*: 53 **Control:** Recumbent for 10 wks followed by mobilisation with spinal support (non-surgical). This group are earlier patients when Harrington rods were not available *N*: 45 **Control 2:** Anterior decompression *N*: 21 **Duration:** 12–48 mths from surgery (average 19 months); not stated for non-surgical **Follow-up:** Not stated **Concomitant treatments:** Not stated	**Age:** mean age 35 y **Sex:** 94 M, 4 F *N*: 98 **Patient characteristics:** Paraplegia complete/incomplete: no surgery 20/25 surgery 31/22. Site of injury T9–11/T11–12–1 1/L1–2–L2: no surgery 7/31/7, surgery 2/41/10. Burst/displaced: no surgery 28/17, surgery 22/31 **Inclusion/exclusion criteria:** Included: any patient with fracture or dislocation between 9th thoracic and 2nd lumbar vertebrae bodies and neurological impairment Excluded: 2 died prior to surgery and 2 caused by gunshot wounds	**Intervention:** 2 cases of disengagement but no change in overall alignment took place. One deep infection after 3 y – treated by removal. Decubiti in 2 cases **Control:** 2 deaths. Decubiti in 8 cases of postural reduction	**Authors' conclusions:** Neurological improvement was dependent on the adequacy of spinal cord decompression and not upon Harrington rods *per se*. Rods alone were not adequate to decompress in 50% of surgical cases. Best results after anterior decompression when caused by minimally displaced wedge distal to T12

Results

General comments:
Results reported on adequacy of decompression achieved (Table 6) are difficult to mesh with overall results (Table 5) reported above. Not clear what happened to the 11 patients who underwent surgery but are not included in Table 6. It appears from Table 5 that 39/53 improved after all surgery, compared to 20/45 no surgery. Results also sub-divided between complete and incomplete paraplegia

Outcome 1

Outcome:
Frankel scale – improvement by at least one neurological grade

Intervention:
It appears that 39/53 improved after all surgery, compared with 20/45 no surgery, but see comments

Study details	Intervention details	Participant details	Withdrawals	Adverse events	Comments
Author (Year) Lifeso (2000)[55] **Description of study:** Retrospective review of cases from New York spine centre of rotationally unstable cervical spine fractures treated by brace, halo vest or posterior surgical constructs plus fusion, combined with prospective study of similar cases treated by early anterior discectomy, fusion and plating	**Intervention:** Early anterior discectomy, fusion and plating *N*: 18 **Intervention 2:** Posterior surgical constructs plus fusion *N*: 11 **Control:** Non-surgical – hard collar ($n = 14$) or halo vest ($n = 7$) *N*: 21 **Duration:** Not stated **Follow-up:** Anterior surgery group follow-up min. 2 y. Minimum follow-up 1 y for non-surgical and posterior fusion **Concomitant treatments:** Note that non-surgical group belong to retrospective study – not concurrent with anterior surgery group **Comments:** In retrospective group, surgical intervention and time to surgery at discretion of physicians with no uniformity of treatment plan	**Age:** Retrospective study mean 32 y. Prospective mean 37 y **Sex:** 43 M, 7 F **Severity:** Neurological deficit (data missing for 3 non-surgical) 0 cord complete, 9 incomplete, 17 root *N*: 50 **Patient characteristics:** 4 C3–4, 11 C4–5, 16 C5–6, 18 C6–7, 1 C7–T1 **Inclusion/exclusion criteria:** Included: rotationally unstable cervical spine fractures, classified as compression–extension stage 1 fracture (CES-1) Anterior surgery group admitted January 1993–July1994. Non-surgical and posterior fusion groups – all patients admitted 1987–93 Excluded: unilateral facet dislocations	**Control group:** 3 lost to follow-up (3 hard collar, 1 halo)	**Intervention 1** None **Intervention 2** 5 failed – 2 unreduced, 2 persistent neurological defect, 3 late kyphosis, 6 late disc collapse **Control** All failed – 17 unreduced, 5 secondary surgery, 8 persistent neurological defect, 1 death, 8 late disc collapse	**Authors' conclusions:** Early anterior fusion is recommended in CES-1 injuries. Non-operative treatment was uniformly unsuccessful. Posterior fusion was unsuccessful in 45% of cases. Anterior fusion resulted in solid union without residual deformity in all cases, and all patients with incomplete cord lesions or with radiculopathy had improved cord function

Results

General comments:
Mixture of prospective and retrospective studies done at different times but at same centre. Surgical groups have higher level of neurological deficit than non-surgical, but overall comparability of groups unclear

Outcome 1

Outcome:
Success – restoration of spinal column, no secondary surgery, complete recovery from radiculopathy, stabilisation of any cord deficit and late kyphosis no more than 10 degrees

Intervention:
Anterior surgery: 18/18
Posterior surgery: 6/11

Control:
0/18

Outcome 2

Outcome:
Improved neurological function for cord incomplete deficit

Intervention:
Anterior surgery: 4/4
Posterior surgery: 2/4

Control:
Non-surgery: 0/1

Outcome 3

Outcome:
Improved neurological function for radiculopathy (root)

Intervention:
Anterior surgery: 7/7
Posterior surgery: 0/2

Control:
Non-surgery: 2/8

Study details	Intervention details	Participant details	Adverse events	Comments
Author (Year) Loembe (1991)[144] **Description of study:** Patients with vertebral body fractures treated using a multidisciplinary approach at one hospital between 1981 and 1987	**Intervention:** 21 anterior fusion, 30 posterior fusion, 2 combined cervical; 23 thoracolumbar (2 laminectomy with graft, 16 Roy–Camille plates, 5 Harrington rods) *N*: 76 **Control:** Conservative treatment for 20 cervical (traction, collar, kinesitherapy) and 13 thoracolumbar (bed rest, orthopaedic treatment), no surgery for 8, laminectomy alone for 5 *N*: 46 **Comments:** Surgical indications depended on the osseous as well as neurological lesions. Tetraplegic patients with respiratory problems were not operated on. Most upper thoracic spine fractures were treated conservatively. Surgical intervention was increasingly possible with the availability of more material and qualified staff	**Age:** range 3–63 y **Sex:** 99 M, 23 F **Severity:** 81 had neurological deficits (44 cervical, 37 thoracolumbar) *N*: 122 **Patient characteristics:** 81 cervical fractures and 41 thoracolumbar fractures **Inclusion/exclusion criteria:** Not stated	Deaths are reported but not by intervention	**Authors' conclusions:** Despite the absence of densitomography (CAT?), conventional clinical and radiological examinations allowed us to set out our indications for surgery. Advances in ideas and surgical techniques (followed by different authors) were paralleled by improvements in instrumentation. The future uses of densitomography (CAT?) were formulated
Results				
General comments: Results are not split by intervention but by level of fracture				

Study details	Intervention details	Participant details	Adverse events	Comments
Author (Year) Lucas (1977)[68] **Description of study:** Records from the Registry's databank (not stated whose Registry or over what period) to select those with one bony level of trauma in the cervical region to assess morbidity, mortality and recovery rates	**Intervention:** Anterior fusion and/or decompressive procedures *N*: 56 **Control:** Without anterior fusion and/or decompressive procedures (WAP) *N*: not stated **Duration:** Not stated **Follow-up:** Not stated **Concomitant treatments:** Not stated	**Age:** not stated **Sex:** not stated **Severity:** Not stated *N*: not stated **Patient characteristics:** Not stated **Inclusion/exclusion criteria:** Patients with one bony level of trauma in cervical region, and follow-up examination after 1-y, and with partial lesions, i.e. evidence of motor function is at least four cord segments below the corresponding cord segment at the level of bony trauma, were included	None reported	**Authors' conclusions:** None stated

Results

General comments	Outcome 1	Outcome 2	Outcome 3	Outcome 4
General comments: Anterior fusion apparently better for cervical complete lesions. Not stated what WAP is (i.e. could be other surgical and/or non-surgical). *N* for WAP group not given, so total participants also unknown	**Outcome:** Recovery rate (RR) = (MIc – MIi)/(5-Mii), where MIi is initial motor index (average muscle strength) and MIc is motor index after 1 y. Scale 0–5 with 5 as normal **Intervention:** Complete lesions: anterior fusion RR mean 0.18 (SD 0.24) vs WAP mean 0.08 (SD 0.14), significant difference	**Outcome:** RR Partial and graded-complete lesions **Intervention:** Difference between anterior fusion and WAP not significant (means not given)	**Outcome:** Morbidity (i.e. negative RR on follow-up) **Intervention:** Anterior fusion 1.8% vs WAP 4.7%. Mean loss of initial motor function 4% vs WAP 41%	**Outcome:** Mortality within 1 y **Intervention:** 20% vs 23% WAP Immediate mortality (<2 mths) 13% vs WAP 18%

Study details	Intervention details	Participant details	Adverse events	Comments
Author (Year) Lui (1998)[92] **Description of study:** Retrospective series of patients with type III density fracture, treated with operative and non-operative methods	**Intervention:** Internal fixation: posterior C1–C2 fusion with either Halifax clamps (n = 17) or wire (n = 1) followed by 8 wks external support with Philadelphia collar. *N*: 18 **Control:** External mobilisation with halo vest for 12–16 weeks *N*: 10 **Duration:** Not stated **Follow-up:** At least 6 months **Concomitant treatments:** Not reported **Comments:** Patients were assigned to operative or non-operative treatment according to their wishes	**Age:** 18–80 y **Sex:** 22 M; 7 F **Severity:** On admission, 20 patients had normal muscle power, 5 had flaccid quadriplegia, 1 had quadriparesis and 1 had hemiparesis. 16 patients showed displacement at the fracture site, 14 anterior and 2 posterior *N*: 29 **Patient characteristics:** Cause of injury: Traffic accident, 21 Fall from height, 6 Head and neck compression, 2 **Inclusion/exclusion criteria:** Included patients with type III density fractures, according to the Anderson and D'Alonzo classification **Further details:** One patient died before any treatment was given	**Intervention:** Minor complications included loosening of one side of the Halifax clamp (n = 1) and superficial skin infection (n = 2) **Control:** Two patients were found to have purulent discharge from the halo pinhole	**Authors' conclusions:** Both external fixation with the halo vest and internal fixation are safe and effective for treating type III density fracture

Results

General comments	Outcome 1	Outcome 2	Outcome 3	Outcome 4	Outcome 5
General comments: 22 patients returned to normal daily activities, 3 were independent in spite of brachial plexus injury in 2, 1 was dependent and 2 remained bedridden due to quadriparesis	**Outcome:** Activity and/or work **Intervention:** Early return to normal **Control:** Restricted 3–6 months	**Outcome:** Discomfort **Intervention:** Short post-operative period **Control:** Long	**Outcome:** Surgical risk **Intervention:** 11% **Control:** Nil	**Outcome:** Fusion rate **Intervention:** 100% **Control:** 100%	**Outcome:** Range of motion: **Intervention:** Normal or decreased **Control:** Normal

Study details	Intervention details	Participant details	Adverse events	Comments
Author (Year) Marshall (1987)[83] **Description of study:** Prospective study of SCI patients consecutively admitted to five trauma centres participating in the Comprehensive Central Nervous System Injury Centers' program at the US National Institutes of Health	**Intervention:** (1) initial spinal stabilisation; (2) neuroradiological diagnostic procedure; (3) skeletal traction application; (4) halo vest application; (5) Stryker-frame rotation; (6) rotobed rotation; or (7) surgery *N*: 283 **Control:** *N*: 0 **Duration:** Not reported **Follow-up:** Not reported **Concomitant treatments:** None reported	**Age:** not reported **Sex:** not reported **Severity:** Complete: 141 Incomplete: 142 *N*: 283 **Patient characteristics:** Cervical (n = 154): Complete: 69 (44.8%) Incomplete: 85 (55.2%) Thoracic (n = 99): Complete: 69 (69.7%) Incomplete: 30 (30.3%) Lumbar (n = 30): Complete: 3 (10.0%) Incomplete: 27 (90.0%) **Inclusion/exclusion criteria:** None reported **Further details:** Deterioration was specifically defined as a worsening in motor function in one or more spinal nerve roots above the level of the injury or ascension of the sensory or motor level attributable to SCI. Deterioration was attributed to a specific intervention only if there was a clear temporal relationship between the two events	None reported	**Authors' conclusions:** Deterioration following hospitalisation for SCI is relatively uncommon – 4.9% in this large series. In most instances, decline in function could be attributed to specific management procedures. These changes must not be interpreted as representing failures to provide optimal care but rather should be seen as the inevitable product of an attempt to manage patients with spinal cord and column injuries, many of which are clearly unstable

Results

General comments:
134 patients underwent surgery. 4 of 26 patients who were operated on within 5 days after their injury deteriorated, whereas none of the 44 patients operated on after the 5th day but before the 10th day deteriorated (p = 0.15, Fisher's exact test). None of the 64 patients operated on at varying times after the 10th day deteriorated
Although the sample size was large, the frequency of deterioration was low. Thus, statistical differences between different subtypes of intervention are not meaningful

Outcome 1

Outcome:
No. deteriorating (375 interventions in 283 patients)

Intervention:
Surgery: 4/134

Control:
Halo vest application: 2/68
Stryker frame rotation: 2/56
Skeletal traction application: 3/60
Rotobed rotation: 1/57

Study details	Intervention details	Participant details	Adverse events	Comments
Author (Year) Meinecke (1990)[69] **Description of study:** Statistical analysis of medical records of 1 German centre for paraplegia from 1981 to 1988	**Intervention:** Spondylodesis *N*: not stated **Control:** Conservative treatment (bed rest) *N*: not stated **Duration:** Not stated **Follow-up:** Not stated **Concomitant treatments:** Not stated	**Age:** not stated **Sex:** not stated **Severity:** Not stated *N*: 626 **Patient characteristics:** *N* = 241 with polytrauma **Inclusion/exclusion criteria:** Not stated **Further details:** 70% received surgery, but in group with polytrauma more with conservative treatment. Probably all patients had paraplegia	None reported	**Authors' conclusions:** Spondylodesis provides clear advantage compared with conservative treatment in partial paraplegia, but should also be considered in complete paraplegia. Conservative treatment retains its importance in cases where surgery is not indicated

Results

General comments	Outcome 1	Outcome 2	Outcome 2
General comments: The results given here are copied from the summary, as the tables and figures do not provide any reasonable information	**Outcome:** Time until mobilisation in days **Intervention:** 21–39 days earlier than control group (dependent on locus of injury) **Control:** 21–39 days later than intervention group (dependent on locus of injury)	**Outcome:** Days of hospitalisation **Intervention:** 5 days less than control group (tetraplegia) and 34–57 days less for paraplegia	**Outcome:** Functionally valuable neurological recovery **Intervention:** 19% (complete paralysis) and 67% (partial paralysis) **Control:** 20% (complete paralysis) and 58% (partial paralysis)

Study details	Intervention details	Participant details	Adverse events	Comments
Author (Year) Murphy (1990)[40] **Description of study:** Retrospective series of patients with cervical SCI admitted to a SCI centre between 1976 and 1986	**Intervention:** Group 2 Patients with cervical instability and surgical stabilisation of the cervical spine within 2 wks of injury *N*: 44 **Intervention 2:** Group 3 Patients with cervical instability who had surgical stabilisation >2 wks after injury *N*: 14 **Control:** Group 1 Patients with cervical instability non-surgical spinal stabilisation *N*: 35 **Control 2:** Group 4 Patients admitted with stable cervical column but cervical SCI and neurologic deficits *N*: 9 **Duration:** Not stated **Follow-up:** Unclear **Concomitant treatments:** Corticosteroid usage was considered present only if such a drug had been administered to the patient in a high-dose regimen for at least a week. 64 patients were treated with high-dose dexamethasone **Comments:** Patients were selected for surgical treatment on the basis of radiographic findings. Groups were non-matched	**Age:** mean 27.9 y **Sex:** 85 M; 17 F **Severity:** Frankel classification on admission: A: 74 C: 11 D: 14 E: 3 *N*: 102 **Patient characteristics:** Neurological level: C3–C4: 64 C5: 13 C6: 22 C7: 3 Complete cord syndrome: 69 Central cord syndrome: 18 Anterior cord syndrome: 5 Brown–Sequard syndrome: 4 **Inclusion/exclusion criteria:** Not stated **Further details:** 92 patients arrived at the SCI centre <24 h after injury, 2 arrived between 24 and 28 h after injury and 8 arrived >48 h after injury	No major differences were noted among the groups with respect to complications during the acute and rehabilitative phases of management	**Authors' conclusions:** No appreciable differences in achievement in activities of daily living and mobility were noted between patients treated with surgical stabilisation of the cervical spinal column and those treated non-surgically, although no statistical comparison was possible

continued

Results				
General comments: The following categories of activities were evaluated: feeding, wheelchair mobility, transfers from bed to chair, dressing above the waist, dressing below the waist and toileting. No appreciable differences in outcome were noted among the groups or between surgically treated (groups 2 and 3) and non-surgically treated patients (groups 1 and 4) with respect to their achievements in these activities	**Outcome 1** **Outcome:** Comparison of Frankel classes at time of admission and dismissal **Intervention:** Group 2: AA, 27; AC, 1; AD, 5; CC, 1; CD, 3; CE, 1; DD, 3; DE, 2; EE, 1 Group 3: AA, 9; AD, 1; CD, 1; DD, 1; DE, 2 **Control:** Group 1: AA, 25; AD, 3; CD, 3; DD, 2; DE, 1; EE, 1 Group 4: AA, 2; AD, 1; CD, 2; DD, 3; EE, 1	**Outcome 2** **Outcome:** Duration of hospitalisation (days) **Intervention:** Group 2: 168.6 Group 3: 197.1 **Control:** Group 1: 189.4 Group 4: 110.3	**Outcome 2** **Outcome:** Voiding status (no catheter; intermittent catheter; indwelling catheter) **Intervention:** Group 2: 21; 12; 11 Group 3: 7; 4; 3 **Control:** Group 1: 23; 8; 4 Group 4: 6; 2; 1	**Outcome 2** **Outcome:** Interval until leave of absence from rehabilitation (days) **Intervention:** Group 2: 85.3 Group 3: 90.6 **Control:** Group 1: 122.9 Group 4: 72.6

Study details	Intervention details	Participant details	Withdrawals	Adverse events	Comments
Author (Year) Nikolskii (1980)[70] **Description of study:** Description of outcomes following surgery of different types	**Intervention:** Decompressive laminectomy plus posterior fixation with metal plates and paraspinal alloplasty (3); skeletal traction and closed reduction plus anterior decompression and spondylodesis (5); anterior decompression plus spondylodesis (7) Full resection with total discectomy and anterior spondylodesis (9); partial resection with total discectomy and anterior spondylodesis (11) *N*: 35 **Control:** 'Conservative' treatment (13); skeletal traction and closed reduction (5) *N*: 18 **Control 2:** Decompressive laminectomy *N*: 18 **Duration:** From <24 h to 1 mth **Follow-up:** Not stated **Concomitant treatments:** Not stated **Comments:** In Russian. 61 were treated within 1 mth and 10 after 1 mth but results are not presented separately for these 2 groups	**Age:** not stated **Sex:** not stated **Severity:** Not stated *N*: 71 **Patient characteristics:** Not stated **Inclusion/exclusion criteria:** Not stated	**Intervention group n:** 1 died in closed reduction + anterior decompression/spondylodesis group 0 deaths **Control group n:** 3 died in conservative treatment group 5 died in decompressive laminectomy group	Not reported	**Authors' conclusions:** Unclear

Results

General comments:	Outcome 1	Outcome 2	Outcome 3	Outcome 4
None	**Outcome:** No improvement **Intervention:** Laminectomy + posterior fixation 1; reduction + anterior decompression + spondylodesis 0; AD + S 1; full resection 0; partial resection 0 **Control:** Laminectomy 6; closed reduction 1; conservative treatment 3	**Outcome:** Some improvement **Intervention:** Laminectomy + posterior fixation 0; reduction + anterior decompression + spondylodesis 1; AD + S 1; full resection 0; partial resection 0 **Control:** Laminectomy 5; closed reduction 0; conservative treatment 4	**Outcome:** Significant recovery **Intervention:** Laminectomy + posterior fixation 2; reduction + anterior decompression + spondylodesis 1; AD + S 3; full resection 4; partial resection 2 **Control:** Laminectomy 2; closed reduction 2; conservative treatment 3	**Outcome:** Full recovery of neurological symptoms **Intervention:** Laminectomy + posterior fixation 0; reduction + anterior decompression + spondylodesis 2; AD + S 2; full resection 5; partial resection 9 **Control:** Laminectomy 0; closed reduction 0; conservative treatment 1

Study details	Intervention details	Participant details	Withdrawals	Adverse events	Comments
Author (Year) Odendaal (1991)[49] **Description of study:** Retrospective analysis of 48 patients with injuries of the thoracic and lumbar spine with neural involvement	**Intervention:** Surgery. See comments *N*: 41 **Control:** Postural reduction *N*: 7 **Duration:** Not stated **Follow-up:** Not stated **Concomitant treatments:** Bracing as an adjuvant to surgery was used in 5 patients (earliest cases). Revision surgery was performed in 2 patients **Comments:** Surgical procedures performed were as follows: Harrington rods (HR) + wiring + grafting (n = 22), decompression + HR + wiring + grafting (n = 7), HR + wiring (n = 5), HR + grafting (n = 3), anterior vetebrectomy and bone grafting + HR (n = 2), wiring + grafting (n = 1), posterior decompression (laminectomy) (n = 1)	**Age:** mean 30.2 y (range 10–55 y) **Sex:** 39 M; 9 F **Severity:** SCI (n = 41) Complete: 27 Incomplete: 14 (anterior cord syndrome, 13; transverse cord syndrome, 1) Cauda equina injuries (n = 7) Complete: 3 Incomplete: 4 *N*: 48 **Patient characteristics:** Mechanism of injury: Motor vehicle accident: 30 Fall from height: 10 Farm tractor accident: 2 Hit by exploding tyre: 1 Crush injury (e.g. by tree, wall, steel rods): 4 Uncertain: 1 Classification of spinal injuries (according to Denis): Compression fractures: 9 Burst fractures: 19 Flexion–dislocation injuries: 19 Fracture dislocations: 1 **Inclusion/exclusion criteria:** Patients with injuries of the thoracic and lumbar spine with associated injury to the spinal cord and/or cauda equina were included **Further details:** The interval between injury and admission for all patients ranged from 1 to 132 days (mean 6.3 days). The interval between injury and surgery ranged from 1 to 147 days (mean 21.1 days)	**Intervention group:** 1 patient did not have adequate records for follow-up	**Intervention:** Dislodgement of HR occurred in 7 patients, 1 needed reoperation. One HR fractured. There was 1 septic surgical wound and 1 patient developed meningitis post-operation (dural laceration had occurred) **Control:** One patient retained an excessive local kyphosis of 44 degrees. A boy of 10 developed a paralytic spinal deformity	**Authors' conclusions:** The author stated the following conclusions: 1. The HR system as used is effective and reliable in maintaining spinal stability. Implant failure occurred as a result of inadequate technique or errors in judgement and should be almost completely preventable. 2. Early, adequate surgical stabilisation of unstable spinal injuries eases the burden of medical and nursing care. It also permits early mobilisation in psychologically stable patients who do not have major non-spinal injuries. 3. Surgical management has not significantly reduced the period of hospitalisation in our patients. 4. No answer is forthcoming from this study as to whether surgery promotes neurological recovery

continued

Results				
General comments: General complications occurred in both groups, but were not analysed	**Outcome 1** **Outcome:** Admission to mobilisation (wks) **Intervention:** *n* = 27 Mean: 5.1 (range 1.3–14.6) **Control:** *n* = 5 Mean: 9.5 (range 7.1–15.0)	**Outcome 2** **Outcome:** Admission to discharge (wks) **Intervention:** Mean: 12.6 (range 2.1–39.3) **Control:** Mean: 15.0 (range 9.9–19.9)	**Outcome 3** **Outcome:** Neurological change **Intervention:** *n* = 40 26 patients remained unchanged, 14 patients improved 1–4 grades and 1 with a complete lesion became normal. AA, 19; AB, 2; AC, 2; AD, 1; AE, 1 BB, 4; BC, 1; BD, 1; BE, 3 CD, 1; CE, 2 DD, 3 BC, 1 **Control:** *n* = 7 3 patients remained unchanged and 4 improved 2–4 grades. AA: 3 AE: 1 BD: 2 CE: 1	**Outcome 4** **Outcome:** Final level of independence **Intervention:** *n* = 40 Walking independently: 10 Walking with crutches: 3 Wheelchair independent: 22 Wheelchair dependent: 5 **Control:** *n* = 7 Walking independently: 4 Walking with crutches: 0 Wheelchair independent: 2 Wheelchair dependent: 1

Study details	Intervention details	Participant details	Adverse events	Comments
Author (Year) Osenbach (1992)[95] **Description of study:** Retrospective series of children treated for spinal cord and/or vertebral column injuries	**Intervention:** Surgery *N*: 59 **Control:** Combination of bed rest and/or external immobilisation *N*: 122 **Duration:** Not stated **Follow-up:** Not reported **Concomitant treatments:** All patients were maintained with external spinal immobilisation **Comments:** Management of spinal injury was individualised based on the age, level and type of injury, degree of neurological dysfunction, and the presence of associated injuries 83% of the patients managed operatively were in the older age group (9–16 y)	**Age:** mean 10.2 y (range 0–16 y) **Sex:** 110 M; 69 F **Severity:** Graded according to Ducker: Intact: 86 (48%) Complete: 42 (23%) Incomplete: 51 (29%) *N*: 179 **Patient characteristics:** Cause of injury: Vehicular accidents: 100 (56%) Falls: 30 (17%) Athletics: 24 (13%) Birth trauma: 10 (5%) Penetrating injuries: 8 (4%) Miscellaneous: 7 (4%) Level of injury: Total cervical: 112 (62%) Upper cervical (O–C3): 64 (36%) Lower cervical (C4–C7): 48 (26%) Thoracic (T1–T11): 23 (13%) Thoracolumbar (T12–L1): 19 (11%) Lumbar (L1–L5): 25 (14%) Concomitant systemic injuries Closed head injury: 35 (20%) Intra-abdominal injury: 15 (8%) Long bone fractures: 15 (8%) Blunt thoracic injuries: 7 (4%) **Inclusion/exclusion criteria:** Study included patients aged 0–16 y who sustained a spinal cord and/or vertebral column injury between 1 January 1970 and 21 December 1988. Children with congenital spinal anomalies were excluded	**Intervention:** None reported **Control:** 4 patients with cervical injuries underwent surgical fusion for persistent spinal instability	**Authors' conclusions:** None stated **Results – general comments:** There was no difference in outcome between patients managed nonoperatively versus surgically

Study details	Intervention details	Participant details	Adverse events	Comments
Author (Year) Ostl (1989)[50] **Description of study:** Retrospective series of patients with cervical dislocation treated at two centres, one used conservative treatment, the other surgical	**Intervention:** Closed manipulation or skull traction using Gardner–Wells tongs. Dislocation then stabilised by single-level anterolateral fusion using the Barbour technique (dowel of iliac crest bone placed in a coronal direction, posterior to the anterior longitudinal ligament *N*: 85 **Control:** Closed manipulation under general anaesthesia or Crutchfield tong traction. Followed by postural nursing in extension in bed for an average period of 6 wks followed by mobilisation with splintage. *N*: 82 **Duration:** Not clear **Follow-up:** Control: 5.2 y (9 mths to 10 y) Surgery: 5 y (8 mths to 10 y) **Concomitant treatments:** None reported **Comments:** Six patients in the control group had late operations for symptomatic instability	**Age:** Surgery: 35.9 y (15–90 y). Control: 32.6 y (14–86 y) **Sex:** not reported **Severity:** Neurological status on admission (Frankel grade) Surgical: A 16; B 4; C 4; D1 7; D2 23; E 31 Control: A 14; B 7; C 2; D1 7; D2 19; E 33 *N*: 167 **Patient characteristics:** Level of cervical spine injury: Surgery: C3/4, 6; C4/5 23; C5/6 33; C6/7 21; C7/T1 2 Control: C3/4, 6; C4/5 18; C5/6 25; C6/7 30; C7/T1 3 **Inclusion/exclusion criteria:** Not reported **Further details:** Out of 167 patients, 30 had complete tetraplegia and 17 incomplete tetraplegia (i.e. Frankel grades A–C). The interval between injury and admission to the spinal unit ranged from under 1 h to 2 wks. The majority of patients were admitted within 24 h. The interval between injury and anterolateral dowel fusion ranged from less than 6 h to more than 1 mth. The majority had fusion within 1 wk of injury	**Intervention:** Complete injury: Death, 7; DVT, 1; UTI, 8; pressure sores, 7; pulmonary embolus, 1; wound infection, 2; Horner's syndrome, 3; recurrence of displacement, 1; dowel displacement, 1; failure of closed reduction, 0; post-traumatic syrinx, 1 Incomplete injury: Death, 0; DVT, 1; UTI, 5; pressure sores, 2; pulmonary embolus,0; wound infection, 0; Horner's syndrome, 3; recurrence of displacement, 0; dowel displacement, 2; failure of closed reduction, 0; post-traumatic syrinx, 0 **Control:** Complete injury: Death, 2; DVT, 4; UTI, 11; pressure sores, 5; pulmonary embolus, 1; respiratory infection, 3; wound infection, 0; Horner's syndrome, 0; recurrence of displacement, 3; dowel displacement, n/a; failure of closed reduction, 0; post-traumatic syrinx, 0 Incomplete injury: Death, 1; DVT, 3; UTI, 7; pressure sores, 4; pulmonary embolus, 0; respiratory infection, 2; wound infection, 0; Horner's syndrome, 0; recurrence of displacement, 2; dowel displacement, n/a; failure of closed reduction, 1; post-traumatic syrinx, 1	**Authors' conclusions:** Our results indicated that closed manipulation under general anaesthesia is a safe and effective means of reduction in the acute stage. There was a high mortality rate for acute surgery in patients with complete tetraplegia. Early surgical stabilisation by dowel fusion seemed to impair neurological recovery in patients with neurological deficit on admission

Results

General comments:
One patient with complete tetraplegia in the control group had anterior Cloward fusion, and 3 patients with incomplete tetraplegia had surgery (wiring and fusion and Cloward fusion)

Outcome 1

Outcome:
Frankel grade

Intervention:
Baseline: A 16; B 4; C 4

End:
Frankel grade A: A 5; B 4; 7 deaths
Frankel grade B: B 2; C 1; D1 1
Frankel grade C: C 1; D1 3

Control:
Baseline: A 14; B 7; C 2.

End:
Frankel grade A: A 7; B 5; 2 deaths
Frankel grade B: C 4; D1 2; one death
Frankel grade C: D1 2

Outcome 2

Outcome:
Average (range) bed and hospital stay

Intervention:
Complete: bed 50 (21–70); hospital 225.1 (180–325)
Incomplete: bed 32.5 (18–60); hospital 163 (50–395)

Control:
Complete: bed 56 (38–60); hospital 194 (120–260)
Incomplete: bed 41 (26–56); hospital 212 (90–310)

Study details	Intervention details	Participant details	Adverse events	Comments
Author (Year) Petitjean (1995)[71] **Description of study:** Retrospective series of patients admitted to the Emergency Department at Le Tripode (Bordeaux, France) over a 30-mth period (1990–3)	**Intervention:** Early surgery (first 24 h after injury): open reduction and internal stabilisation. Mean delay of 12 h (5–22 h) *N*: 10 **Intervention 2:** Late surgery: open reduction and internal stabilisation. Mean delay of 9 days *N*: 22 **Control:** Conservative treatment by postural reduction *N*: 17 **Duration:** Not stated **Follow-up:** Not stated **Concomitant treatments:** All patients underwent plain X-ray at admission, 24 had spinal CT and 4 had MRI **Comments:** Open reduction and internal stabilisation of the cervical spine was performed within a delay of 22 h after injury	**Age:** mean 37.3 y (SD 17.3 y) **Sex:** 78% M; 22% F **Severity:** Complete paraplegia: 39 Incomplete paraplegia: 10 Mean ISS (SD) 33 (9.4) *N*: 49 **Patient characteristics:** Cause of injury: Road accidents: 53% Domestic: 16% Work-related accidents: 16% Suicide attempts: 10% Other: 5% Thoracic spinal injury: Burst fracture: 16 Flexion distraction: 3 Shear fracture: 7 Luxation: 23 Upper thoracic spine: 35 Lower thoracic spine: 14 **Inclusion/exclusion criteria:** Patients with thoracic spinal trauma with neurological impairment were included. Cases of SCI due to gunshots were excluded **Further details:** Secondary transfer accounted for 78% of admissions. Mean time elapse between injury and admission to the Emergency Dept was 4.48 h (30 min–14 h) Mean Injury Severity Score (ISS) in the early surgery group (27 SD 6.4) was statistically different compared with ISS (35.5 SD 7.8) of the patients not operated on or operated on later ($p < 0.01$)	**Intervention:** One patient with complete tetraplegia died of refractory hypoxemia (day 3) **Control:** One patient who was too ill to be operated on died on day 4 of refractory hypoxemia. Another patient died of multiple organ failure on day 12	**Authors' conclusions:** In our opinion, early spine decompression and internal stabilisation should be performed in partial paraplegia to enhance neurological recovery, unless severe blunt chest trauma or a potential haemorrhagic lesion is present. In contrast early surgery has no indication in complete paraplegia, but we think that surgery with internal fixation is of value for nursing care and prevention of kyphotic deformities. The timing of such surgery will essentially depend on associated injuries

continued

Results				
General comments: None	**Outcome 1** **Outcome:** Mean time of surgery **Intervention:** 130 min (75 min to 4 h) in early group and 190 min in the late group	**Outcome 2** **Outcome:** Mean stay in intensive care **Intervention:** 7.9 days (SD 8.9 days) **Control:** For patients who had either late surgery or conservative treatment, 16.2 days (SD 14 days), not significantly different compared to early surgery	**Outcome 3** **Outcome:** Neurological improvement, complete SCI **Intervention:** Early surgery None of the complete paraplegic patients ($n = 5$) made a neurological improvement **Control:** Of 34 complete paraplegic patients, neurological recovery was observed in 2 patients: one recovered some sensory function and the other had motor improvement (locomotion without assistance)	**Outcome 4** **Outcome:** Neurological improvement, incomplete SCI **Intervention:** Early surgery: 4 out of 5 incomplete patients made a good neurological recovery Late surgery: none of the incomplete patients ($n = 2$) made a partial neurological recovery **Control:** None of the incomplete patients ($n = 2$) made a partial recovery
	Outcome 5 **Outcome:** Mean blood loss **Intervention:** 1000 ml (SD 424 ml) in the early group and 1508 ml (SD 800 ml) in the late group	**Outcome 6** **Outcome:** Mean injury severity score **Intervention:** Early surgery 27 (6.4, $p < 0.01$) Control: Late surgery + conservative treatment 35.5 (7.8)		

Study details	Intervention details	Participant details	Adverse events	Comments
Author (Year) Place (1994)[85] **Description of study:** Retrospective inpatient and outpatient chart review	**Intervention:** Surgical stabilisation and fusion *N*: 46 **Control:** Non-operative *N*: 48 **Control 2:** Laminectomy *N*: 19 **Duration:** Not stated **Follow-up:** Average 8.4 y (min. 5 y) **Concomitant treatments:** Not stated	**Age:** mean 24.3 y **Sex:** 79% M; 21% F **Severity:** All patients had complete paraplegia at the level of their fracture and were graded as Frankel A *N*: 116 **Patient characteristics:** Cause of injury: Motor vehicle accident: 61 (52.6%) Motorcycle accident: 19 (16%) Fall from height: 19 (16%) Gunshot wounds: 9 (8%) Other: 8 (7%) Level of injury: T2 6; T3 16; T4 25; T5 16; T6 19; T7 16; T8 15; T9 6 Time from injury to date of admission: mean 70 days, SD 13.6 days (range 2–86 days) **Inclusion/exclusion criteria:** Patients with complete spinal paralysis due to fracture of the upper thoracic spine (T2–T9), who had been admitted within 3 months of injury and had minimum 5 y follow-up were included	**Intervention:** Operative (n = 65): Wound healing: 3 Scoliosis: 3 Lumbar charcot: 1 Reoperation: 6 Pulmonary embolism: 2 Death: 0 CSF leak: 1 Spasticity: 1 Severe back pain: 1 Head injury: 0 Total: 18 (27.7%)* Control: Non-operative (n = 48): Wound healing: 0 Scoliosis: 2 Lumbar charcot: 0 Reoperation: 0 Pulmonary embolism: 0 Death: 1 CSF leak: 0 Spasticity: 0 Severe back pain: 3 Head injury: 1 Total: 7 (14.5%) ($p < 0.10$)*	**Authors' conclusions:** The surgical stabilisation of thoracic (T2–T9) spine fractures with complete paraplegia tends to decrease initial rehabilitation days but is associated with increased overall complications. The treatment of this patient group clearly must be individualised

Results

General comments:
*The difference in rehabilitation hospital days between the surgical stabilisation group and the laminectomy group was statistically significant ($p < 0.05$). The difference between surgical stabilisation and non-operative group approached significance.

Outcome 1

Outcome:
Mean rehabilitation hospital stay (days)

Intervention:
Fusion: 52.2

Control:
No surgery: 64
Laminectomy: 64.2*

Study details	Intervention details	Participant details	Adverse events	Comments
Author (Year) Prasad (1995)[41] **Description of study:** Retrospective series of 51 patients from a developing SCI centre in India	**Intervention:** Surgical treatment: transpedicular screw-plate fixation (n = 26), posterior decompression and interlaminar wire fixation (n = 2) and laminectomy alone (n = 2) *N*: 29 **Control:** Conservative treatment *N*: 22 **Duration:** Not stated **Follow-up:** Not reported **Concomitant treatments:** Methylprednisolone therapy was given to those who reached the hospital early **Comments:** Reasons for non-operative treatment included delay in arrival (n = 7), focus of sepsis (n = 8), osteoporosis (n = 3), medical illness (n = 2) and stable spinal injury (n = 2)	**Age:** 80.4% were in 20s and 30s **Sex:** 43 M; 8 F **Severity:** Not reported, but all patients had SCI *N*: 51 **Patient characteristics:** Cause of injury: Road traffic accident: 55% Falls: 35%. Other: 10% Type of injury: Thoracic: 25 Lumbar: 26 Location of bony injury: L1: 31% T12: 25% T11: 15% L2: 12% L3: 12% Type of lesion: Wedge compression fracture: 53% Fracture dislocation: 29% **Inclusion/exclusion criteria:** Patients admitted with thoracolumbar spinal injury during the first 8 mths in which the centre opened were included **Further details:** Of 51 patients, only 11 (21.5%) reached hospital within 24 h; 66.7% of acute injuries arrived within the first wk of trauma	**Intervention:** Haemothorax: 2 Minor wound sepsis: 1 **Control:** None reported	**Authors' conclusions:** Although there was no statistically significant difference in the neurological outcome, between a patient treated by a surgical or by non-surgical methods, the 95% CI method favours surgical management. Reduction of any complications from immobilisation, reduced duration of hospital stay and reduced hospital expenses, positive psychological influences and early integration of the patients into the family in our country where compliance and follow-up of patients is poor, appear to favour treatment by early operative stabilisation of the unstable spine whenever appropriate

continued

Results			
General comments: Frankel grading at the time of admission and at the last follow-up were compared between the operative and non-operative groups	**Outcome 1** **Outcome:** No. of patients with improvements in Frankel grading **Intervention:** 11 (37.9%) **Control:** 3 (13.6%) Using Fisher's exact test this result was not significantly different between the two groups	**Outcome 1** **Outcome:** Psychological assessment The operated group of patients were found to brighter than the non-operative group, who had predominantly feeling of unworthiness depression and suicidal tendencies	**Outcome 1** **Outcome:** Length of stay/complications Operated cases had a shorter hospital stay and complications of immobilisation were limited

Study details	Intervention details	Participant details	Adverse events	Comments
Author (Year) Rockswold (1990)[72] **Description of study:** Retrospective study of patients treated by halo immobilisation and/or surgical fusion	**Intervention:** Surgical fusion either as a primary procedure or after halo failure. Posterior cervical fusion was the usual procedure of choice. Sublaminar wiring, usually with autologous bone grafting, was used in 80% *N*: 22 **Control:** Halo immobilisation for an average of 12.2 wks *N*: 48 **Duration:** Not stated **Follow-up:** At least 6 mths **Concomitant treatments:** None reported **Comments:** Data extracted includes only those patients with neurological deficit	**Age:** (*n* = 140) mean 36 y (range 7–88 y) **Sex:** (*n* = 140) 75% M **Severity:** Radiculopathy: 15 Incomplete spinal lesions: 34 (central cord syndrome: 12; monoparesis: 11; Brown–Sequard: 8; anterior cord: 2; quadriparesis: 1) Complete quadriplegia: 21 *N*: 70 **Patient characteristics:** Cause of injury (*n* = 140): Motor vehicle accident: 49% Fall: 28% Diving: 13% Miscellaneous: 7% Assault: 3% Other injuries/illnesses (*n* = 140): Multiple trauma: 15% Major medical problems: 9% **Inclusion/exclusion criteria:** None reported	None reported	**Authors' conclusions:** 1. Halo immobilisation brings about satisfactory healing for most fracture types 2. Both halo immobilisation and surgical fusion have relatively high failure rates in the treatment of hyperflexion–anterior subluxation injury, with or without bilaterally locked facets 3. If halo immobilisation injury is elected as the primary treatment for hyperflexion–anterior subluxation injuries, close monitoring is mandatory. Surgical fusion with postoperative immobilisation may be needed to achieve stability

Results

General comments:
None

Outcome 1

Outcome:
Neurological status: admission and outcome

Intervention:
Deficit improved: 10 (25%)
Deficit unchanged: 11 (25%)
Deficit worse: 1 (2%)

Control:
Deficit improved: 50 (35%0
Deficit unchanged:19 (14%)
Deficit worse: 1 (1%)

Study details	Intervention details	Participant details	Adverse events	Comments
Author (Year) Senegas 1976[73] **Description of study:** Series of 412 traumatic cervical fractures (not C1 or C2) admitted and treated at traumatology centre in Bordeaux between 1961 and 1975. 197 had SCI	**Intervention:** Anterior fixation with Cloward plates (?57); posterior fixation (19) *N*: 76 **Control:** Orthopaedic (skull traction) *N*: 121 **Duration:** Not stated for operation; traction 45 days **Follow-up:** Not stated	**Age:** not stated **Sex:** not stated **Severity:** 79 complete tetraplegia, 118 incomplete tetraplegia *N*: 197 **Patient characteristics:** Cervical fractures caused by trauma (not C1 or C2)	**Intervention:** 18/76 died (15 complete, 3 incomplete) **Control:** 61/121 died (37 complete, 24 incomplete)	**Authors' conclusions:** Anterior fixation by arthrodesis and plates and screws has given better results with minimal risk of neurological complications or infection. Worst orthopaedic results with this technique were attributable to a bad reduction of articular processes (2 cases). In all cases, neurological recovery was rapid and more complete than with the other 2 methods. This technique, carried out within 12 hours of injury, is the only method which has allowed us to obtain recovery of motor function in cases of complete tetraplegia

Results

General comments:
None

Outcome 1

Outcome:
Neurological improvement

Intervention:
52/76 (4 complete, 48 incomplete)

Control:
37/121 (0 complete, 37 incomplete)

Study details	Intervention details	Participant details	Withdrawals	Adverse events	Comments
Author (Year) Volker (1981)[75] **Description of study:** Review of 15 cases of bilateral locked facets of the cervical spine	**Intervention:** Operation for reduction and stabilisation *N*: 5 **Intervention 2:** Operation for stabilisation after reduction *N*: 4 **Control:** Non-operative, manual reduction (traction, flexion) *N*: 6 **Duration:** Not stated **Follow-up:** Average 2.7 y **Concomitant treatments:** All patients received external mobilisation (range 4–12 wks) with either Somi brace ($n = 3$), Camp brace ($n = 1$), Camp brace + Philadelphia brace ($n = 1$), halo vest ($n = 3$), two poster + tongs ($n = 1$), Philadelphia brace ($n = 1$), tongs + four poster ($n = 1$) or collar ($n = 1$)	**Age:** average 26 y (range 16–63 y) **Sex:** 11 M; 4 F **Severity:** Neurological condition Complete deficit: 13 Incomplete deficit: 2 *N*: 15 **Patient characteristics:** Not stated **Inclusion/exclusion criteria:** Patients with bilateral locked facets were included	**Intervention group n:** 1 patient died of pulmonary complications **Control group n:** 2 patients were lost to follow-up	None reported	**Authors' conclusions:** Stabilisation after reduction was successful irrespective of the methods used
Results					
General comments:	**Outcome 1** **Outcome:** Neurological improvement **Intervention:** Surgery: 1 patient had improved root function (improved wrist flexion), 1 patient had an ascending neurological deficit while closed reduction was attempted **Control:** 1 patient had increasing neurological deficit, 1 patient had improved root function (increased bilateral triceps strength)				

Study details	Intervention details	Participant details	Withdrawals	Adverse events	Comments
Author (Year) Soreff (1982)[59] **Description of study:** The study included 20 consecutive patients with vertebral fractures and neurological injuries compared with those in a series of 18 patients who were operated upon at the Dept of Orthopaedic Surgery, Karolinska Hospital during 1976–9	**Intervention:** Stabilisation was achieved by Harrington distraction rods in 16 patients, by compression rods in 1 patient and by combination of two methods in 1 patient *N*: 18 **Control:** Conservative treatment. All patients received bed rest and physiotherapy. Decompressive laminectomy without fusion in 10 patients, closed reduction in 1 patient, and 12 patients treated in a plaster cradle *N*: 20 **Duration:** Not stated **Follow-up:** At least 60 days **Concomitant treatments:** None reported **Comments:** Stabilisation was completed by a fusion comprising one segment below and one segment above the level of injury. 1 patient received anterolateral and 1 patient posterolateral decompression in addition to stabilisation. 4 patients in the surgery group received laminectomy	**Age:** average (range), surgery 33 y (16–70 y), conservative 28 y (16–53 y) **Sex:** surgery 9 M; 9F. Conservative 16 M; 4 F **Severity:** surgery: complete 2/18, incomplete 10/18, paresthesia 4/18, none 2/20. Conservative: complete 10/20, incomplete 9/20, para-paresis cauda equina syndrome 1/20 *N*: 38 **Patient characteristics:** Fracture classification (according to Roberts and Curtiss) Surgery: Type 2 (compression burst fractures): 3 Type 3 (rotational dislocation fractures): 15 Conservative: Type 2: 2 Type 3: 18 Cause of injury: Surgery: Traffic accidents: 9 Falls: 8 Direct violence: 1 Conservative: Traffic accidents: 11 Falls: 8 Direct violence: 1 7 patients had serious associated injuries **Inclusion/exclusion criteria:** Patients operated on for progressive kyphosis in vertebral fractures were excluded	**Intervention group:** 1 patient was lost to follow-up	**Intervention:** Asystolia: 1 Lung abscess: 1 Pseudarthrosis: 1 Sciatic pain: 1 **Control:** Pulmonary embolism: 1 DVT: 4 Severe UTI: 2 Severe orthostatic reactions: 2 Severe decubitus: 2	**Authors' conclusions:** Surgical reduction and stabilisation of dislocated and unstable vertebral fractures shortens the period of immobilisation, hospitalisation and rehabilitation. It also decreases the risk of complications and to a greater extent reduces the residual spinal deformity

continued

Results				
General comments: Neurological restitution was classified as follows: 0 no restitution 1 somewhat increased sensory or motor function 2 increased sensory or motor function, 1–2 segments 3 increased sensory or motor function, 3 or more segments	**Outcome 1** **Outcome:** Time of immobilisation **Intervention:** Horizontal position (wks): average 1.1 (range 0–4) Upright position: average 4.2 (range 1–10) ADL activities: average 5.7 (range 2–12) **Control:** Horizontal position (wks): average 5.7 (range 4–14) Upright position: average 13.6 (range 10–12) In wheelchair: average 13.8 (range 6–20) ADL activities: average 16.8 (range 12–20)	**Outcome 2** **Outcome:** Healing time **Intervention:** <3 mths: 7 3–6 mths: 9 **Control:** <6 mths: 3 6–9 mths: 6 9–12 mths: 3 >12 mths: 3	**Outcome 3** **Outcome:** Deformity **Intervention:** Preoperative kyphosis varied between slight kyphosis (<5 degrees) and a kyphosis of 38 degrees, average 18 degrees Postoperative kyphosis varied between 0 and 20 degrees, average 7 degrees **Control:** Slight kyphosis (<5 degrees) to kyphosis of 38 degrees, average 20 degrees In 10 patients treated with laminectomy, the average was 27 degrees	**Outcome 4** **Outcome:** Neurological restitution **Intervention:** Grade 1: 1 Grade 2: 0 Grade 3: 9 None: 2 **Control:** Grade 1: 2 Grade 2: 1 Grade 3: 9 None: 8

Study details	Intervention details	Participant details	Withdrawals	Adverse events	Comments
Author (Year) Sved (1997)[93] **Description of study:** Prospective longitudinal study of 100 patients with traumatic SCI with and without surgery to compare pain in the year following injury. Patients recruited at 1 SI Unit over 3 y	**Intervention:** Surgery for SCI: 52 with metal rods/plates, 14 decompression and fusion with bone graft, 3 posterior decompression and laminectomy *N*: 69 **Control:** No surgery *N*: 31 **Duration:** 1 y follow-up for each participant **Follow-up:** Not stated **Concomitant treatments:** Not stated	**Age:** not stated **Sex:** not stated **Severity:** 37 complete lesions *N*: 100 **Patient characteristics:** Level: 52 cervical, 24 thoracic, 22 lumbar, 2 sacral. The level of injury is also reported for each treatment group . The only significant difference was in lumbar injuries (22 surgery, 0 no surgery.) Others not significantly different **Inclusion/exclusion criteria:** Admitted to Spinal Injuries Unit within 3 mths of acute traumatic SCI. Excluded: age under 18 y, previous psychiatric disorder, brain injury resulting in neuropsychological deficit, or significant communication difficulty (e.g. deafness, confusion). Also excluded patients requiring ventilation and those discharged with no motor or sensory defect. 97 patients were not enrolled – 3 refused to participate and 94 did not qualify	Unclear. Only 45% in total (both groups) followed up at 52 wks; 67% at 26 wks. States that different patients were available at different dates but does not give mean or range follow-up time	None reported	**Authors' conclusions:** Apart from increased musculoskeletal pain at 2 weeks for surgery group, there is no significant relationship between surgery and SCI pain

Results

General comments	Outcome 1	Outcome 2	Outcome 3	Outcome 4
General comments: Cannot extract any numbers for results between treatment groups – only possible to estimate % from bar charts, but the base numbers change at each point in time and do not always refer to the same patients, so are not clearly reliable trends. (Although most differences between groups non-significant because of small numbers, there is a consistent difference towards increased musculoskeletal pain in the surgery group at all time points)	**Outcome:** % reporting severe pain **Intervention:** Only reported for whole group – not separately for surgery group. Musculoskeletal 26% 2 wks–8% 1 y Neuropathic at level 28% 2 wks–28% 1 y Neuropathic below level 20% 2 wks–50% 1 y	**Outcome:** % reporting any musculoskeletal pain **Intervention:** Surgery group reported significantly more at 2 wks (69% vs 47%). No significant difference thereafter, but surgery group always greater than non-surgery	**Outcome:** % reporting neuropathic at level pain **Intervention:** No significant difference at any stage. However, non-surgery greater up to 6 months, but surgery greater at 1 y	**Outcome:** % reporting neuropathic below level pain **Intervention:** No significant difference at any stage. Greater in surgical group up to 3 months and greater in non-surgical 6 mths–1 y

Study details	Intervention details	Participant details	Adverse events	Comments
Author (Year) Takayanagi (1995)[98] **Description of study:** Study of sitting balance and trunk muscle strength in paraplegic patients	**Intervention:** Harrington instrumentation. 4–7 vertebrae fixed (mean 5.3) *N*: 6 **Control:** Conservative treatment *N*: 6 **Control 2:** Healthy adults *N*: 6 **Duration:** Not stated **Follow-up:** Not stated **Concomitant treatments:** None reported	**Age:** mean intervention 32.0 y; conservative 33.5 y; conservative 2 33.5 y **Sex:** 100% M **Severity:** All of the patients in the conservative therapy and Harrington instrumentation groups were paraplegic *N*: 18 **Patient characteristics:** X-ray assessment of both conservative therapy and Harrington instrumentation cases revealed that all of them sustained instable dislocations and fractures; there was no difference in the degree of instability **Inclusion/exclusion criteria:** None reported **Further details:** Data from the weight balance analyser were recorded with regard to 9 parameters, i.e. time required to stand, tilting force, repellent force, number of failures, trembling in the initial stage (error 1), trembling in the intermediate stage (error 2), trembling in the late stage (error 3), the time required to respond and time to reverse response. Of the 9 parameters, errors 1, 2 and 3 were compared with each other in terms of transfer back and forth and transfer from right to left	None reported	**Authors' conclusions:** With the recent progress of spinal surgery, types of spinal instrumentation surgery including the Harrington method have been selected for the treatment of thoracolumbar injuries. It is true that the patients on spinal instrumentation are able to initiate rehabilitation procedure in the training room at earlier stages when compared with those treated with strong internal fixation. However, stiffness of the spinal column becomes conspicuous during the course of prognosis, which impairs acquisition of ADL. In patients treated with Harrington instrumentation, sway is increased with shifting centre of gravity and sway during anterior shift is especially great and associated with poor dynamic sitting balance. One of the causes for poor dynamic balance in Harrington instrumentation is a decrease in torque at the time of isokinetic contraction of the abdominal and back muscles. It may be that although muscular strength is maintained, the trunk muscles are unable to move because of the stiffness of the spinal column, causing poor dynamic balance with deteriorating ADL and even lesser ability to perform in wheelchair sports

continued

Results			
General comments: None	**Outcome 1** **Outcome:** Sitting balance Transfer from right to left **Intervention:** Error 1: 8.26 ± 3.25%* Error 2: 5.96 ± 4.04% Error 3: 4.55 ± 4.62% **Control:** Error 1: 7.34 ± 3.16%* Error 2: 4.40 ± 3.76% Error 3: 3.21 ± 4.50% *$p < 0.005$	**Outcome 2** **Outcome:** Sitting balance Transfer back and forth **Intervention:** Error 1: 12.21 ± 4.21%* Error 2: 9.79 ± 5.26%* Error 3: 4.46 ± 4.98%* **Control:** Error 1: 9.23 ± 3.16%* Error 2: 6.40 ± 3.94%* Error 3: 3.78 ± 2.85%* *$p < 0.001$	**Outcome 3** **Outcome:** Strength of abdominal and back muscles **Intervention:** Abdominal muscles peak torque: isometric: 30–91 (mean 70) ft-lb isokinetic: 17–60 (mean 30) ft-lb Back muscles peak torque: isometric: 47–95 (mean 72) ft-lb isokinetic: 15–61 (mean 31) ft-lb **Control:** Abdominal muscles peak torque: isometric: 53–105 (mean 71) ft-lb isokinetic: 40–81 (mean 61) ft-lb Back muscles peak torque: isometric: 53–111 (mean 80) ft-lb isokinetic: 46–89 (mean 70) ft-lb

Study details	Intervention details	Participant details	Adverse events	Comments
Author (Year) Tator (1987)[145] **Description of study:** Prospective data collection of series of patients admitted to the Acute SCI Unit at Sunnybrook Medical Centre, Toronto, between 1974 and 1981	**Intervention:** Operated group. Posterior (n = 87): fusion (38), reduction + fusion (27), laminectomy + fusion (12), laminectomy (5), laminectomy + reduction + fusion (5) Anterior (n = 29): decompression + fusion (25), fusion (4) *N*: 116 **Control:** Non-operated group *N*: 92 **Duration:** Not stated **Follow-up:** 12 months **Concomitant treatments:** In general, cervical injuries were initially treated by halo traction followed by immobilisation in a halo vest. Thoracic, thoracolumbar or lumbosacral injuries were treated with bed rest with postural reduction **Comments:** In general, treated initially by conservative methods. Operation was considered for patients showing neurological deterioration or lack of improvement who had radiological evidence of compromise of the spinal canal or malalignment of the vertebral column	**Age:** mean operated 32.5 y; non-operated 37.0 y **Sex:** Operated 81% M; non-operated 76.1% M **Severity:** Grade on admission (operated, non-operated, total) 1 (complete) n = 93: 44.8%, 44.6%, 44.7% 2–10 (incomplete) n = 115: 55.2%, 55.4%, 55.3% The mean ISS for the operated group was 24.6 and for the non-operated group 24.8, and these were not significant (2-tailed t-test, pooled var estimate, p = 0.88) *N*: 208 **Patient characteristics:** Cause of injury (operated, non-operated): Motor vehicle: 86 (41.4%, 41.3%) Sport and recreation: 47 (19.0%, 27.2%) Work: 29 (19.0%, 7.5%) Domestic: 25 (12.1%, 12.0%) Other: 21 (8.5%, 12.0%) Level of injury (% operated): Cervical: 127 (43.3%) Thoracic: 34 (70.6%) Thoracolumbar: 40 (77.5%) Lumbosacral: 7 (85.7%) Type of bony injury (% operated): Normal: 15 (26.7%) Dislocation only: 6 (0%) Fracture–dislocation: 88 (63.6%) Compression: 13 (76.9%) Burst: 72 (58.3%) Other: 14 (28.6%) **Inclusion/exclusion criteria:** For inclusion, patients must have been admitted to the unit within 30 days of injury and have had no operative treatment in other institutions before referral. Patients sustaining spinal column injury without cord involvement or with nerve root injury only were excluded. One patient with penetrating injury was also excluded **Further details:** There was a highly significant relationship between the level of injury and treatment (χ^2, $p < 0.001$). There was also a highly significant association between the type of bony injury and the treatment modality (χ^2, $p < 0.001$) 35 patients had pre-existing spinal conditions: 22 (62.9%) were treated non-operatively and 13 (37.1%) underwent surgery (χ^2, p = 0.025) 56 (48.2%) of operations were performed in the first week following injury. By the end of the fourth week after injury 100 (86.2%) had had surgery	21 patients died before full follow-up and 8 patients were lost to follow-up	**Authors' conclusions:** Overall, there was no difference between operated and non-operated patients in length of stay or neurological recovery. Surgical management of patients with acute SCI appears safe in terms of mortality rate and neurological recovery, but it has not been proved to improve the latter

continued

Results				
General comments: Multiple regression: the treatment regime, whether the patient was treated surgically or conservatively, was not associated with mortality, length of stay or neurological recovery	**Outcome 1** **Outcome:** Complications **Intervention:** Respiratory 19.8%, thromboembolic 23.3%*, gastrointestinal 5.2%, urinary 62.9%, pressure sore 16.4% **Control:** Respiratory 32.6%, thromboembolic 9.8%*, gastrointestinal 9.8%, urinary 56.5%, pressure sore 10.9% *$p = 0.018$ **Outcome 5** **Outcome:** Neurological improvement **Intervention:** Mean change 32.7% **Control:** Mean change 35.0%	**Outcome 2** **Outcome:** Mortality in hospital **Intervention:** Overall 3.5%*; respiratory failure 0.9%; pulmonary embolism 1.7%; cardiovascular 0.9%; renal failure 0 **Control:** Overall 13.0%*; respiratory failure 9.7%; pulmonary embolism 1.1%; cardiovascular 1.1%; renal failure 1.1% *$p = 0.026$	**Outcome 3** **Outcome:** Mortality after discharge **Intervention:** Overall 2.6%; respiratory failure 1.7%; pulmonary embolism 0; suicide 0.9% **Control:** Respiratory failure 1.1%; pulmonary embolism 1.1%; suicide 0	**Outcome 4** **Outcome:** Length of hospital stay (days), in patients surviving to first discharge (minus 16 deaths) **Intervention:** 51.3 **Control:** 45.9

Study details	Intervention details	Participant details	Adverse events	Comments
Author (Year) Vaccaro (2001)[56] **Description of study:** Retrospective study of 24 consecutive patients with distraction extension injury of the cervical spine, admitted to US regional SCI centre	**Intervention:** Surgical: anterior cervical discectomy and autologous iliac crest fusion with anterior plate fixation (n = 9). Anterior corpectomy and posterior stabilisation (n = 4). Other 3 various procedures detailed in paper *N*: 16 **Control:** Non-surgical: halo vest immobilisation *N*: 8 **Duration:** Not stated **Follow-up:** 14 months average follow-up. Surgery range 1 day–14 mths. Non-surgery range 6 days–57 mths **Concomitant treatments:** Not stated **Comments:** More details of operative procedures and outcomes by individual in tables. Non-surgical group includes 4 too ill for surgery. Decision whether to operate based on surgeon preference at time of admission	**Age:** mean 65 y **Sex:** 20 M; 4 F Severity: ASIA grade on admission (details of level also given in Table 4): Surgical: A 3, B 2, C 4, D 4, E 3 Non-surgical: A 2, B 1, C 0, D 1, E 4 *N*: 24 **Patient characteristics:** 9 had diffuse idiopathic skeletal hyperostosis and 2 ankylosing spondylitis. Injuries resulted from 16 falls and 8 motor vehicle accidents. Levels of injury (between C3 and C7) reported in tables. Non-surgical: 4 DES Type 1 bony injury and 4 too ill to be able to undergo surgery. Surgical: 9 DES 1 or significant cervical stenosis. 4 DES-1 with thecal sac compression, 2 DES-2, 1 cervical stenosis **Inclusion/exclusion criteria:** Consecutive admissions with distraction extension injury of the cervical spine 1993–7	**Intervention:** 5 deaths **Control:** 5 deaths; includes the 4 too ill to undergo surgery	**Authors' conclusions:** Anterior cervical graft and plate acting as a tension band is the ideal treatment method for acute distraction extension injury involving primarily soft tissue structures. Type 2 injuries may need to be approached initially posteriorly to obtain alignment, followed by anterior reconstruction. Great care needed during anterior graft placement to avoid over-distraction of spine. If non-surgical intervention is selected, close regular radiographic follow-up is necessary to detect early vertebral malalignment

Results

General comments:	Outcome 1	Outcome 2	Outcome 3
See tables for more details of outcomes by individual	**Outcome:** Radiological: satisfactory alignment of cervical spine at latest follow-up **Intervention:** 16/16 **Control:** 3/4 (discounting 4 too ill for surgery; of these, 2 had stable alignment at time of death)	**Outcome:** Improvement 1+ grade ASIA scale **Intervention:** 6/16 **Control:** 1/4 (discounting 4 too ill for surgery, one of whom improved)	**Outcome:** Deterioration by 1 or more grades **Intervention:** 1/16 **Control:** 0/4

Study details	Intervention details	Participant details	Adverse events	Comments
Author (Year) Waters (1996)[76] **Description of study:** Retrospective study, patients assigned to 5 categories: no surgery; spine fusion with instrumentation; anterior decompression with or without spine fusion and instrumentation; laminectomy/posterior decompression with or without internal instrumentation and fusion; and bullet removal	**Intervention:** Anterior decompression (n = 23), fusion only (n = 74), laminectomy/posterior decompression (n = 16), bullet removal (n = 14) *N*: 127 **Control:** No surgery including bed rest, closed reduction, and/or external immobilisation *N*: 142 **Duration:** Not stated **Follow-up:** Not stated **Concomitant treatments:** None reported	**Age:** not reported **Sex:** not reported **Severity:** On admission: 177 were paraplegic (127 complete, 50 incomplete); 92 were tetraplegic (46 complete; 46 incomplete) *N*: 269 **Patient characteristics:** Paraplegia: Cause of injury (n): gunshot wound, 84; motor vehicle crash, 38; falls, 24; motorcycle accidents 16; stabs, 3 Fracture pattern (n): fracture dislocation, 35; burst fracture, 31; compression fracture, 14; unclear, 10 Tetraplegia: Cause of injury (n): gunshot wound, 21; motor vehicle crash, 34; falls, 14; motorcycle accidents 5; stabs, 2; miscellaneous (sports injuries, blunt injuries), 16 Injury pattern (non-penetrating) (n): distractive flexion-type facet dislocation, 27; bilateral facet dislocation, 16; compressive flexion, 14; vertical compression, 12; compressive extension, 5; distractive extension, 1; spondylosis, 10; unclassified, 5 **Inclusion/exclusion criteria:** Only patients who underwent surgery in the first 3.5 mths following injury were included **Further details:** Allen classification was used for cervical spine injuries and the Denis system for injuries to the thoracic and lumbar spine. Gunshot injuries classified based upon bullet location relative to the spinal canal	None reported	**Authors' conclusions:** Motor recovery did not significantly differ between patients categorised in various surgical subgroups or between those having surgery and those treated non-operatively. Additionally, although the sample size was small, motor recovery among tetraplegic individuals did not depend on whether unilateral and bilateral facet dislocations were reduced and in patients with incomplete lesions, those with reductions actually had a poorer outcome than those who were left in a dislocated position

continued

Results				
General comments: Surgeries were performed by a variety of surgeons at different hospitals. Therefore, the investigators were not able to perform a controlled study of the effects of surgery	**Outcome 1** **Outcome:** Paraplegia: ASIA motor score increase (mean, SD) Complete SCI **Intervention:** Anterior decompression (n = 5): 1.8, 4.0 Fusion only (n = 35): 1.0, 3.4 Laminectomy/posterior decompression (n = 7): 3.3, 5.8 Bullet removal (n = 3) 0.0 All surgery (n = 50): 1.32, 3.8 **Control:** (n = 77) 0.4, 1.8; incomplete (n = 23) 13.3, 8.8	**Outcome 2** **Outcome:** Paraplegia: ASIA motor score increase (mean, SD) Incomplete SCI **Intervention:** Anterior decompression (n = 7): 9.0, 5.4 Fusion only (n = 10): 11.2, 10.7. Laminectomy/posterior decompression (n = 3): 12.7, 7.8 Bullet removal (n = 7): 12.1, 5.8 All surgery (n = 27): 11.03, 7.7	**Outcome 3** **Outcome:** Tetraplegia: ASIA motor score increase (mean, SD) Complete SCI **Intervention:** Anterior decompression (n = 18): 8.3, 6 Fusion only (n = 18): 7.3, 3.5 Laminectomy/posterior decompression (n = 2): 10.5, 3.5 Bullet removal (n = 2): 10.0, 2.8 All surgery (n = 28): 7.9, 4.1 **Control:** (n = 18) 8.3, 5.8; incomplete (n = 24) 21.6, 9.9	**Outcome 4** **Outcome:** Tetraplegia: ASIA motor score increase (mean, SD) Incomplete SCI **Intervention:** Anterior decompression (n = 24): 21.0, 13.5 Fusion only (n = 11): 21.7, 13.1. Laminectomy/posterior decompression (n = 4): 24.8, 12.2 Bullet removal (n = 2): 29.5, 12.0 All surgery (n = 22): 22.8, 12.3

Study details	Intervention details	Participant details	Adverse events	Comments
Author (Year) Wilberger (1993)[80] **Description of study:** Examined the NASCIS II experience of surgical treatment in SCI	**Intervention:** Surgery: 45 had anterior surgery and 250 posterior surgery *N*: 295 **Control:** No surgery *N*: 192 **Duration:** Not stated **Follow-up:** Not stated **Concomitant treatments:** Some patients received methylprednisolone protocol, given within 8 h of SCI **Comments:** Majority of patients (61.5%) undergoing anterior surgery had incomplete injuries while most of the patients (64.1%) undergoing posterior surgery had complete injuries. Bone fragments and/or disc material were compromising the spinal canal in 77% of those patients with anterior surgery. Fracture/dislocation or dislocation only was the primary indication in 79% of those with posterior surgery. Mean time interval between accident and surgery was 284.5 h for anterior surgery and 184 h for those with posterior surgery	**Age:** not stated **Sex:** not stated **Severity:** Not reported *N*: 487 **Patient characteristics:** Not reported **Inclusion/exclusion criteria:** None reported	None reported	**Authors' conclusions:** None reported. See comments below **General comments:** The following results were noted: (1) Methylprednisolone protocol, given within 8 h of SCI, improved neurological recovery irrespective of other surgical and non-surgical approaches or the timing of other treatments. (2) While not reaching statistical significance, neurological recovery was improved in those patients undergoing surgery <25 h or >200 h after SCI. Poorer neurological recovery tended to occur when surgery took place 26–50 h after SCI. (3) Regardless of the indication for surgery, the adjusted odds ratio for increasing the changed motor scores 5 points or greater at 1 y post-SCI were not statistically significantly different in the patients undergoing surgery <25 h or >200 h after SCI. (4) Irrespective of surgical timing, complications rates were slightly lower in the surgical group (8.4% vs 10.29%)

Study details	Intervention details	Participant details	Withdrawals	Adverse events	Comments
Author (Year) Willen (1983)[77] **Description of study:** Comparison of treatments for 37 patients with unstable thoracolumbar fractures and paraplegia – retrospective review of case records and follow-up examination (Swedish hospital)	**Intervention:** Open reduction, fusion and stabilisation with Harrington distraction rods and early mobilisation (HG) *N*: 12 **Intervention 2:** Laminectomy with or without fusion followed by bed-rest (LFG) *N*: 14 **Control:** Non-surgical – bed-rest for 9–10 weeks with tilting (CG) *N*: 11 **Duration:** 2 y for all **Follow-up:** Follow-up examination at time of study 2–10 y after injury **Concomitant treatments:** Not stated **Comments:** CG and LG used in 1971–7. All HG took place in 1977–81 (only 1 LG and 1 CG in this period)	**Age:** mean 27 y (range 15–60 y) **Sex:** 25 M; 12 F **Severity:** Modified Frankel scale; Complete paraparesis/ severe/moderate/slight: CG 2/3/3/3 HG 2/5/3/2 LG 8/3/3/0 *N*: 37 **Patient characteristics:** Severe associated injuries: CG 4, LG 2, HG 3 **Inclusion/exclusion criteria:** Admissions to Swedish hospital (Sahlgren) 1971–81. Patients with unstable thoracolumbar fractures and paraplegia (excluding those with fractures but no neurological impairment) **Further details:** High incidence of complete and severe paraparesis in the LG group compared with the others	5 did not undergo re-examinations. Treatment groups not stated	**Intervention:** HG 2 complications related to insertion or removal; 1 DVT; 5 urinary bladder infections; 1 pressure sores. Deformity at follow-up (2–10 y) 1/12 **Intervention 2:** LG 5 DVT (2 thrombectomies), 10 urinary bladder infections with 3 cysto-pyelonephritis (1 nephrectomy), 3 pressure sores, 1 heterotopic bone formation. Deformity at follow-up (2–10 y) 5/11 **Control:** CG 2 DVT (1 with pulmonary embolism), 8 urinary bladder infections with 3 cysto-pyelonephritis. Deformity at follow-up (2–10 y) 4/9	**Authors' conclusions:** The treatment of open reduction, fusion and stabilisation with Harrington rods considerably reduced immobilisation and hospitalisation time. The complications were few and rehabilitation was earlier. There was no difference between the three treatments regarding neurological improvement after 2 y. Study confirms the disadvantage of laminectomy followed by non-surgical treatment reported by other authors

continued

Results				
General comments: Treatment switched from CG or LG to HG, so could compare LG + CG with HG, although not concurrent. Numbers very small. Detailed results by treatment can be extracted on urinary and bowel function, walking, outdoor transportation, employment, psychiatric status after 2 y. The rehabilitation score is an aggregate of these. Also on progress in motor function from 1 month to 2 y in those patients with severe paraparesis	**Outcome 1** **Outcome:** Immobilisation time before walking/wheelchair (days) **Intervention:** Mean (SD): HG 19 (18.6), CG 74 (8.7), LG 90 (16.8) **Control:** Hospitalisation time (days) Mean (SD): HG 146 days (125) CG 209(87) LG 244(99)	**Outcome 2** **Outcome:** Neurological improvement – complete parapesis ($n = 12$) **Intervention:** None improved in any treatment group	**Outcome 3** **Outcome:** Neurological improvement 1 mth – rehabilitation score Mean rehabilitation score (SD) **Intervention:** All patients: HG 29.1 (14.4); CG 17.2 (9.0); LG 11.4 (6.4) Incomplete: HG ($n = 9$) 36 (6.7); CG ($n = 7$) 20 (8.2); LG ($n = 4$) 12 (19.6). HG score significantly different from other groups ($p < 0.001$)	**Outcome 4** **Outcome:** Neurological improvement 3 mths – incomplete parapesis – rehabilitation score **Intervention:** Mean rehabilitation score (SD): HG 44.3 (15.1); CG 42.8 (11.2); LG 24.9 (8.1). LG scores lower than the other groups ($p < 0.001$)
	Outcome 5 **Outcome:** Neurological improvement 2 y – incomplete parapesis – rehabilitation score **Intervention:** Mean rehabilitation score: HG 64; CG 64; LG 58 (approx. from graph)	**Outcome 6** **Outcome:** Pain at follow-up (2–10 y) – scale 0–9 **Intervention:** Mean (SD) HG 3.8 (2.5); CG 4.0 (2.4); LG 4.9 (3.1)	**Outcome 7** **Outcome:** Increasing pain during day at follow-up (2–10 y) – No. with pain **Intervention:** HG 7/12; CG 5/9; LG 9/11	**Outcome 8** **Outcome:** Daily thoracolumbar fatigue (2–10 y) **Intervention:** HG 7/12; CG 4/9; LG5/11

Study details	Intervention details	Participant details	Withdrawals	Adverse events	Comments
Author (Year) Willen (1985)[81] **Description of study:** Retrospective study comparing conservative treatment and Harrington instrumentation	**Intervention:** Paired Harrington rods and localised fusion *N*: 26 **Control:** Conservative treatment *N*: 24 **Follow-up:** Intervention: average 26 mths (range 22–44 mths Conservative: average 74 mths (range 44–122 mths) **Concomitant treatments:** Not stated	**Age:** mean 27 y **Sex:** 28 M; 22 F **Severity:** Neurological status total (intervention, conservative): Grade 1: 4 (2, 2) Grade 2: 7 (4, 3) Grade 3: 7 (4, 3) Grade 4: 4 (2, 2) Grade 5: 28 (14, 14) *N*: 50 **Patient characteristics:** Cause of trauma (intervention, conservative): Fall: 14, 15 Traffic accident: 10, 7 Direct trauma: 2, 2 Fracture level (intervention, conservative): T11: 1, 0 T12: 6, 9 L1: 13, 12 L2 6, 3 Associated injury: Severe: 6, 9 Slight: 3, 5 **Inclusion/exclusion criteria:** Not stated **Further details:** Neurological status was evaluated using a modified Frankel classification: Grade 1: complete absence of motor and sensory function Grade 2: function a single muscle group and/or some preserved sensory function Grade 3: function in several muscle groups and varying sensory disturbance Grade 4: paresis of single muscle groups combined with varying sensory disturbance Grade 5: normal neurological status	**Intervention group n:** 0 **Control group n:** Originally $n = 28$ but 4 patients lost to follow-up	**Intervention:** Thoracolumbar fatigue: 16 Recurring thoracolumbar pain: 11 Increasing back pain: 18 Skin tenderness/pain at fracture site: 5 UTI: 12 DVT: 1 Instrumentation complications: 5 (hook dislodgement 4, extensive bleeding 1) **Control:** Thoracolumbar fatigue: 10 Recurring thoracolumbar pain: 14 Increasing back pain: 13 Skin tenderness/pain at fracture site: 8 UTI: 12 DVT: 2	**Authors' conclusions:** The Harrington operation of unstable thoracolumbar fractures results in early mobilisation, which shortens the rehabilitation and hospitalisation times. Moreover, the fracture reduction is significantly improved by this type of surgery. However, there are no apparent differences between conservative treatment and Harrington instrumentation regarding the final neurological and rehabilitation status

continued

Results

General comments:
None

Outcome 1

Outcome:
Gibbus angle (in degrees) (mean, SD)

Intervention:
Admission: 19.0, 9.7
Mobilisation: 6.8, 5.3
Int2: 17.1, 7.7

Control:
Admission: 19.5, 9.0
Mobilisation: 22.0, 7.2
C2: 27.4, 11.7

Outcome 2

Outcome:
Sagittal displacement (%) (mean, SD)

Intervention:
Admission: 8.5, 10.6
Mobilisation: 2.0, 4.1
Int 2: 1.8, 4.5

Control:
Admission: 8.8, 16.3
Mobilisation: 5.5, 9.6
C2: 4.5, 8.6

Outcome 3

Outcome:
Immobilisation time (days) (mean, SD)

Intervention:
Paraparetic (n = 11): 19, 9
Intact neurology (n = 15): 17, 7
Average: 18, 8

Control:
Paraparetic (n = 8): 73, 9*
Intact neurology (n = 16): 64, 11*
Average: 67, 11*
*$p < 0.001$ compared with intervention

Outcome 4

Outcome:
Hospitalisation time (days) (mean, SD)

Intervention:
Paraparetic (n = 11): 157, 127
Intact neurology (n = 15): 30, 29*
Average: 81, 103
*$p < 0.001$ compared with conservative treatment

Control:
Paraparetic (n = 8): 207, 95
Intact neurology (n = 16): 81, 21
Average: 123, 82

Outcome 5

Outcome:
Functional status (rehabilitation index, score 0–75) (mean, SD)

Intervention:
(n = 11)
1 mth: 29, 15
3 mths: 44, 16
6 mths: 51, 17
24 mths: 59, 18

Control:
(n = 8)
1 mth: 18, 10
3 mths: 43, 12
6 mths: 51, 10
24 mths: 61, 18

Outcome 6

Outcome:
Neurological function

Intervention:
Grade 1: 2
Grade 2: 4
Grade 3: 4
Grade 4: 2
Grade 5: 14

Improved:
1 to 2: 1
2 to 3: 2
2 to 4: 2
3 to 4: 2
3 to 5: 2
4 to 5: 2
No improvement:
1: 1
5: 14

Control:
Neurological function:
Grade 1: 2
Grade 2: 3
Grade 3: 3
Grade 4: 2
Grade 5: 14

Improved:
1 to 2: 2
2 to 4:3
3 to 5: 2
4 to 5: 2
No improvement:
1: 2
3: 1
5: 14

Study details	Intervention details	Participant details	Adverse events	Comments
Author (Year) Wilmot (1986)[42] **Description of study:** Retrospective study conducted over two years (1981–3)	**Intervention:** Harrington rod alone (*N* = 1); Harrington rod placement with posterior fusion (*n* = 50); laminectomy with or without rodding or fusion (*n* = 21) *N*: 72 **Control:** No surgery *N*: 23 **Duration:** Not stated **Follow-up:** Not reported **Concomitant treatments:** None reported **Comments:** Indications for surgical interventions are based upon stability vs instability of the fractures	**Age:** average 32 y **Sex:** 75 M; 20 F **Severity:** Complete neurological lesions: 56/95 *N*: 95 **Patient characteristics:** Cause of injury: Motor vehicle accident: 52% Fall: 25% Gunshot wound: 11% **Inclusion/exclusion criteria:** Paraplegic SCI patients	**Intervention:** Internal fixation (*n* = 65); No. at SCVMC in parentheses: Thrombophlebitis: 11 (5) PE: 5 (1) Pneumonia: 2 (2) Other respiratory: 3 (2) Decubiti: 1 (0) Pneumothorax: 3 (1) No difference in the proportion of complications was seen between SCVMC and elsewhere **Control:** No. at SCVMC in parentheses: Thrombophlebitis: 1 (1) PE: 1 (0) Pneumonia: 1 (0) Other respiratory: 1 (0) Decubiti: 0 (0) Pneumothorax: 0 (0) % difference was statistically significant ($z = 1.85$, $p < 0.05$, one-tailed)	**Authors' conclusions:** Neurological/function status does not appear to be jeopardised by rodding and fusion, as the percentage improvement is comparable to that for those not receiving surgery. Those receiving other types of spinal surgery did not show the same degree of improvement

Results

General comments:
None

Outcome 1

Outcome:
Length of stay (rehabilitation)

Intervention:
For those with rodding and/or fusion (*n* = 65), the rehabilitation stay was average 70 days

Control:
Average rehabilitation stay (*n* = 23) was 81 days

Outcome 2

Outcome:
Days of hospital from injury to rehabilitation

Intervention:
SCVMC (*n* = 35)
Mean: 89.3, SD 40.3
Median 132, range 52–274

Elsewhere (*n* = 37)
Mean 99.5, SD 46.7
Median 87, range 36–218

Control:
Mean 136.1, SD 61.9 ($p = 0.001$)
Median 132, range 52–274

Outcome 3

Outcome:
Improvement in Frankel grade

Intervention:
5 patients who had rodding and fusion and 1 who had laminectomy and fusion improved in Frankel class.

Control:
3 patients improved in Frankel class

Study details	Intervention details	Participant details	Withdrawals	Adverse events	Comments
Author (Year) Wilmot (1986)[51] **Description of study:** Retrospective study of 106 tetraplegic patients admitted consecutively to the Santa Clara Valley Medical Center (SCVMC) between August 1981 and September 1983. This paper also has some results for the referral question	**Intervention:** Surgical treatment at SCVMC: Posterior fusion (PF) (n = 17), anterior fusion (AF) (n = 1), laminectomy alone (n = 1) *N*: 19 **Intervention 2:** Surgical treatment elsewhere PF (n = 18), AF (n = 7), PF and AF (n = 2), PF and laminectomy (n = 1), AF and laminectomy (n = 2), laminectomy alone (n = 3) *N*: 33 **Control:** No surgery *N*: 54 **Duration:** Not stated **Follow-up:** Not reported **Concomitant treatments:** None reported **Comments:** No surgery was indicated where the fracture/ dislocation was reduced by traction, and the patients' general condition was stable	**Age:** average 28 y **Sex:** 81% M **Severity:** 53% had complete lesions. 2 died while undergoing rehabilitation. On admission, Frankel grades were A 55, B 26, C 15, D 11 *N*: 106 **Patient characteristics:** Cause of injury: Motor vehicle accident: 46% Motorcycle accident: 19% Diving: 19% Falls: 9% **Inclusion/exclusion criteria:** Tetraplegic patients admitted to the SCVMC rehabilitation programme between 1981 and 1983 were included **Further details:** Average days from injury to admission for those who had surgery at SCVMC was 11.5 days and elsewhere 60 days. For those who had no surgery, mean was 31 days	**Intervention group n:** 0? **Control group n:** 2 patients had missing data for days of hospitalisation. Authors state that 2 people died during rehabilitation	**Intervention:** No. of complications: PF only: 15/35 All other: 11/17 All surgical patients (n = 52): Pneumonia: 7 Atelectasis: 12 Decubiti: 15 Thrombophlebitis: 0 Pulmonary embolism: 1 Wound infection: 2 Spontaneous pneumothorax: 0 GI haemorrhage: 0 Cardiopulmonary arrest: 4 Haemothorax: 0 Respiratory distress: 0 Pulmonary congestion: 3 37% of surgical patients with complications had surgery at SCVMC and 58% elsewhere. 7/7 SCVMC patients had no multiple complications, whereas 9/19 patients having surgery elsewhere had multiple complications **Control:** No. of complications: 24/54 Pneumonia: 9 Atelectasis: 7 Decubiti: 7 Thrombophlebitis: 8 Pulmonary embolism: 2 Wound infection: 0 Spontaneous pneumothorax: 2 GI haemorrhage: 1 Cardiopulmonary arrest: 2 Haemothorax: 1 Respiratory distress: 2 Pulmonary congestion: 1	**Authors' conclusions:** None reported

continued

Results			
General comments: The authors remark that the major difference in surgical approach between SVMVC and elsewhere is that SVMVC uses more posterior and less anterior surgery	**Outcome 1** **Outcome:** Rehabilitation stay **Intervention:** (*n* = 49): mean 133 days (SD 59) **Control:** (*n* = 53): mean 119 days (SD 61). No statistical significance compared with surgery	**Outcome 2** **Outcome:** Acute hospitalisation and rehabilitation stay (days) **Intervention:** At SCVMC (*n* = 17): Mean 144.1 (SD 58.6) Median 146 (range 22–252) Elsewhere (*n* = 33): Mean 194.6 (SD 102.0)* Median 166 (range 83–588) **Control:** (*n* = 52) Mean 151.5 (SD 81.2)* Median 130.5 (range 27–404) **t* = –2.157, *p* = 0.05	**Outcome 3** **Outcome:** Neurological improvement (Frankel grade) **Intervention:** 18/106 patients improved in Frankel classification between admission and discharge from rehabilitation, 88 did not change and 0 worsened. Of 18 who improved, 9 had no surgery, 6 had PF and 3 had other surgery

Study details	Intervention details	Participant details	Adverse events	Comments
Author (Year) Yablon (1989)[94] **Description of study:** Study of acute form of ascending myelopathy that occurred 24 h to 4 wks after injury to the cervical spine	**Intervention:** Surgery, decompression followed by rigid internal fixation *N*: 80 **Control:** Non-operative, spine immobilisation by skull tongs with bed rest for 4–6 wks, followed by Philadelphia collar (6–12 wks) or halo immobilisation (average 12 wks) *N*: 54 **Duration:** Not stated **Follow-up:** Average 9 y **Concomitant treatments:** Not stated **Comments:** Indications for surgery were (1) unstable injury such as a burst fracture or rupture of the posterior longitudinal ligaments, (2) a dislocation of the spine resulting in compression of the cord and (3) cord obstruction by a disc or fracture fragment	**Age:** average 24 y **Sex:** surgery: 58 M; 22 F. Conservative: 37 M; 17 F **Severity:** Not reported, but all patients had SCI *N*: 134 **Patient characteristics:** All patients sustained injuries to their cervical spines that consisted of burst fractures, extension–dislocations and anterior dislocations involving rupture of the posterior ligament complex with either unilateral or bilateral jumped facets **Further details:** 14 cases lost neurological function, 3 ascended one level, 8 two levels, 2 three levels, and 1 four levels. One patient developed ascending paralysis within 24 h, 11 within 2 wks, 1 at 3 wks and 1 at 4 wks	None reported	**Authors' conclusions:** Thorough decompression of the cord with rigid internal fixation markedly reduced the incidence of acute ascending myelopathy of the spine

Results

General comments:
The only factor that was of significance was whether or not the patient had a surgical decompression or reduction of the dislocation and at what point surgery was performed. Those patients who underwent surgery within the first 2 wks of their injury showed a significantly lower incidence of ascending myelopathy

Outcome 1

Outcome:
Ascending neuropathy

Intervention:
4/80 patients (5%) ascended 1–4 levels

Control:
The neurological deficit in 10/54 patients (19%) ascended 1–4 levels. $p < 0.005$ compared with surgery

Study details	Intervention details	Participant details	Adverse events	Comments
Author (Year) Yablon (1991)[78] **Description of study:** Retrospective review of all patients with complete sensorimotor paralysis secondary to closed injuries of the lower cervical spine	**Intervention:** Surgery, anterior decompression + fusion (n = 9), or reduction + stabilisation with a posterior approach (n = 13) *N*: 22 **Control:** Conservative management, either in skull tongs with bed rest for 6 wks, followed by Philadelphia collar (6 wks) or by halo vest immobilisation (average 3 mths) after initial period of cervical traction (10 days) *N*: 14 **Duration:** Not stated **Follow-up:** 3 mths to 10 y (average, 3.3 y) **Concomitant treatments:** All patients were subjected to extensive evaluation, including conventional anteroposterior and lateral radiographs, myelography, CT scanning with or without metrizamide and MRI **Comments:** Patients in the surgery group were initially immobilised in 10–15 lb of cervical traction. Immediate surgery was performed in patients with complete spinal canal block	**Age:** average 24.3 y (range 15–46 y) **Sex:** 88% M **Severity:** All patients had complete quadriplegia *N*: 36 **Patient characteristics:** Motor vehicle and diving accidents were the most frequent cause of injury Vertebral body burst fractures: 11 Also 22 flexion and 3 extension injuries resulting in anterior or posterior subluxation, respectively The most commonly fractured structure was the body of C4, whereas C5–6 was the most frequent site of dislocation **Inclusion/exclusion criteria:** Patients with complete sensorimotor paralysis secondary to closed injuries of the lower cervical spine admitted to the New England Regional SCI Center from 1977 to 1989 were included. Only osseous and ligamentous injuries that were confined to C3–C7 were included **Further details:** Approx. 1/3 patients admitted directly to ICU at University Hospital, Boston, remainder were transferred to the SCI centre from another institution. The average interval from injury to admission was 5.3 days for those in the surgery group and 30 days for those managed conservatively	**Intervention:** Transient dysphagia lasting up to 5 days was common after anterior fusion procedures. Thrombophlebitis and pulmonary problems occurred in 5% of patients **Control:** Thrombophlebitis and pulmonary problems were the most common complications and occurred in 8% of patients	**Authors' conclusions:** The results strongly suggest that in cases of cervical spine trauma with complete quadriplegia, meticulous decompression and rigid internal fixation afford the best opportunity for the functional return of one or more segmental levels

Results

General comments:	Outcome 1	Outcome 2
None	**Outcome:** Descending neuropathy **Intervention:** 7 (32%) descended one level and 4 (18%) descended two levels, i.e. 50% showed functional return of at least one nerve root **Control:** 1 (7%) gained one level. The difference in segmental level recovery between the two groups was significant ($p < 0.01$)	**Outcome:** Ascending neuropathy **Intervention:** No patient lost sensorimotor function **Control:** 3 (21%) ascended one to three levels during the early stages of hospitalisation

Study details	Intervention details	Participant details	Adverse events	Comments
Author (Year) Young (1978)[52] **Description of study:** Comparison of neurological recovery distal to the zone of injury in closed traumatic SCI cases admitted to a specialist centre in Arizona 1970–75 with those reported by Frankel admitted to Stoke Mandeville 1951–68	**Intervention:** Treatment at Southwest Regional System (SWRS) – postural reduction *N*: 99 **Intervention 2:** Treatment at SWRS – surgical 37/64 laminectomy and/or fusion 27/64 had fusion alone *N*: 64 **Control:** Treatment at Stoke Mandeville (SM) – all non-surgical *N*: 589 **Duration:** Not stated **Follow-up:** Minimum 12 weeks follow-up **Concomitant treatments:** SWRS Almost all patients were immobilised for 4–8 wks and then fitted in a brace or collar maintained to 12–15th wk. Steroids (usually dexamethasone) given to 102 patients (majority admitted <24 h after injury) **Comments:** Halo traction and immobilisation used in patients with unstable fractures associated with poorly incomplete lesions	**Age:** not stated **Sex:** not stated **Severity:** Complete injuries as % of all within each category (Frankel grade A): Cervical SWRS 52%, SM 56%; dorsal SWRS 87%, SM 81%; dorso-lumbar SWRS 70%, SM 62%. Frankel grades C, D, E as %: cervical SWRS 32%, SM 28%; dorsal SWRS 8%, SM 20%; dorso-lumbar SWRS 20%, SM 27% *N*: 752 **Patient characteristics:** SWRS 55% cervical, 40% dorsal and dorso-lumbar, 5% cauda equina (not included in *N*) SM 35% cervical, 61% dorsal and dorso-lumbar, 4% cauda equina (not included in *N*) Road accidents: SWRS 63%, SM 50% (would have been about 50% at SWRS if gunshot wounds had not been excluded). SM had higher proportion of falls and of falling/moving objects **Inclusion/exclusion criteria:** Excluded: those admitted over 14 days after injury, those with penetrating injuries or who died and those with cauda equina **Further details:** Time from injury to admission at SWRS: 18% >72 h, 70% within 24 h	None reported	**Authors' conclusions:** The demography of the two study groups was amazingly similar. Average neurological improvement at both centres was relatively small, particularly amongst those with complete injury. SM's better results cannot be attributed to non-surgical treatment being superior to surgical. Could have resulted from SM's greater experience, from differences in time from injury to admission (no data for SM), in extent and duration of skeletal traction or in organisational differences between two systems (SM more specialised care in rehabilitation stage)

continued

Results				
General comments: NB. The detailed results of before and after grade are given in the paper for each category, so other results could be computed (e.g. No. improving by 1+ grade for incomplete injuries). The net average recovery for SM patients was slightly greater within each neurological category than in SWRS and statistically significant for cervical cases. When non-surgical treatment was compared, SM did significantly better for cervical cases. Comparison between SWRS surgical and non-surgical treatments showed no significant difference in any category	**Outcome 1** **Outcome:** Cervical: net average change in Frankel grades **Intervention:** Mean (SD, N) SWRS 0.34 (0.96,95), SM 0.67 (0.98, 218). Difference significant, $p < 0.01$	**Outcome 2** **Outcome:** T1–T10: net average change in grades **Intervention:** Mean (SD, N) SWRS 0.24 (0.70,38), SM 0.41 (0.85, 166). Difference not significant	**Outcome 3** **Outcome:** T11–L1: net average change in grades **Intervention:** Mean (SD, N) SWRS 0.30 (1.19, 30), SM 0.56 (0.92, 205). Difference not significant	**Outcome 4** **Outcome:** Complete injuries (grade A): improvement to C/D/E **Intervention:** Cervical: SWRS 2/49 (4%) vs SM 21/123 (17%) T1–T10: 1/33 (3%) vs SM 10/135 (7%) T11, T12, L1: 2/21 (10%) vs SM 12/126 (10%)
	Outcome 5 **Outcome:** Cervical non-surgical cases: net average improvement **Intervention:** SWRS vs SM : SM significantly better $p < 0.001$ (means not given)	**Outcome 6** **Outcome:** **Intervention:** SWRS: net average improvement Surgical vs non-surgical: no significant difference within any category (means not given)		

Appendix 3

Data extraction sheets for referral studies

Study details	Intervention details	Participant details	Withdrawals	Adverse events	Comments
Author (Year) Aito (2000)[124] **Country:** Italy **Focus of study:** Both **Description of study:** Study of complications in SCI and their possible association with late referral to specialist units. Cases drawn from Italian national database of SCI patients admitted (1997–9) to specialist SCI Units, to general rehabilitation centres (post-acute) and to SCI Services without dedicated beds (not clearly defined – later in paper described as rehabilitation services)	**Intervention:** Treated at specialist SCI Unit *N*: 233 **Intervention 2:** SCI Service without dedicated beds (unclear whether only post-acute rehabilitation or whether also acute) *N*: 44 **Control:** General Rehabilitation Centre (post-acute) *N*: 311 **Duration:** Follow-up not stated. **Follow-up:** Not stated **Concomitant treatments:** Not stated	**Age:** mean 39 y **Sex:** 476 M; 112 F **Severity:** 322 paraplegics and 238 tetraplegics. Neurological ASIA classification: 291 complete (class A 49%) and 297 incomplete (class B 11%, C 23%, D 13%, E 2%) *N*: 588 **Patient characteristics:** % with at least one complication on admission: SCIU 25%, rehabilitation 40%, service 25%. (NB. 18% unknown for SCIU and 20% unknown for service) % with individual complication on admission: Paraosteoarthropathies: SCIU 7%, Rehabilitation 1%, Service 0% (NB. >20% unknown for SCIU and Service) Urinary complications: SCIU 2%, Rehabilitation 8%, Service 2% (NB. >20% unknown for SCIU and Service) Pulmonary embolism: SCIU 1%, Rehabilitation 2%, Service 0% DVT: 2%, Rehabilitation 6%, Service 0% **Inclusion/exclusion criteria:** Patients with traumatic SCI with admission within 60 days of injury to a centre in the study **Further details:** There are no data on comparability of groups by type of treatment institution They are not cross-tabulated by severity of injury or time to admission. Rehabilitation and possibly Service centres may well be receiving all patients at a late stage, with no indication of their initial treatment (possibly at an SCIU). There is no breakdown by number or % by time from injury to admission	Not stated	Not stated	**Authors' conclusions:** Optimal rehabilitation care, at least with regard to prevention of complications during the acute phase, entails early admission to a specialised multidisciplinary spinal unit

continued

Results			
General comments: Data on time to admission are unusable – no numbers. Not available by type of centre. Not defined whether the outcome is pre-existing complications only or includes those arising during hospitalisation. Not clear where patients have been previously treated when admitted late	**Outcome 1** **Outcome:** Incidence of complications by time to admission **Intervention:** % with 1+ complication by time to admission: <48 h 8.9%, 48 h–7 days no data, 7–14 days 15.5%, 15–30 days 38.6%, 30–60 days 49.8% (no group total numbers) Percentages for individual complications by time only shown on graph	**Outcome 2** **Outcome:** Incidence pressure sore(s) during hospitalisation **Intervention:** On admission: SCIU 25%, Rehabilitation 30%, Service 21% During: SCIU 3.4%, Rehabilitation 7.4%, Service 13.6%	**Outcome 3** **Outcome:** Incidence respiratory comp during hospitalisation **Intervention:** On admission: Respiratory complications (diagnosed by X-ray/CT) SCIU 9%, Rehabilitation 12%, Service 12% (NB. >20% unknown for SCIU and Service.) During: SCIU 9.9%, Rehabibilitation 7.4%, Service 22.7%

Study details	Intervention details	Participant details	Withdrawals	Adverse events	Comments
Author (Year) Aung (1997)[5] **Country:** UK **Focus of study:** Delay **Description of study:** Retrospective review of cases (1985–8) to compare hospitalisation time and secondary complications for early and delayed admissions to Midlands SCI centre	Intervention: Group 1: admission to Centre within 1 week of injury *N*: 155 Group 3: admission to Centre over 2 months from injury *N*: 19 **Control:** Group 2: admission to Centre within 1 week–2 months of injury *N*: 45 **Duration:** Follow-up 2–5 y **Follow-up:** Not stated **Concomitant treatments:** Not stated	**Age:** mean M 35.5 y, F 44.2 y **Sex:** 173 M; 46 F **Severity:** Paraplegic: Group 1 67, Group 2 25, Group 3 11 Tetraplegic: Group 1 88, Group 2 20, Group 3 8 *N*: 219 **Patient characteristics:** Level of bony injury: cervical 53%, thoracic 33%, lumbar 14% **Inclusion/exclusion criteria:** Included: patients admitted to Midlands Centre for SI in 1985–8 with traumatic cord injury with paralysis Excluded: bony injury with intact neurology, conversion reaction, non-traumatic spinal lesion **Further details:** Group 3 late admission usually due to late referrals. Group 2 delayed admission due to difficulties of transfer or unavailability of beds. 9 patients died during follow-up but their groups are not stated. Prior deaths in Groups 2 and 3 unknown	None stated	None stated	**Authors' conclusions:** The results show a significant reduction in the incidence of pressure sores in the early admissions and demonstrate the lowered incidence of both preventable and non-preventable complications, as well as reduction of hospitalisation time

continued

Results

General comments:
Very little on comparability of groups – delayed and late admissions may have been more severe/complex cases. No data on complications resolved before admission. Appears that data relate only to any complication at time of admission or during follow-up. A total of 14 complications were compared and only pressure sores reached statistical significance. Bladder stones, broncho-pneumonia and contractures showed an excess of >5% in Groups 2 + 3 over Group 1 in one of tetrapl or paraplegic, but numbers are very small. There was an excess of cardiac arrests in Group 1 ($n = 2$) over 2 + 3 ($n = 0$) but if cardiac arrest occurs soon after injury, it would have occurred elsewhere for 2 + 3

Outcome 1

Outcome:
Median hospitalisation (weeks)

Intervention:
Group 1: paraplegic 19, tetraplegic 22

Control:
Group 2: paraplegic 22, tetraplegic 25,
Group 3: paraplegic 74, tetraplegic 42

Outcome 2

Outcome:
Pressure sores

Intervention:
Group 1: paraplegic 1, tetraplegic 1

Control:
Group 2: paraplegic 5, tetraplegic 1
Group 3: paraplegic 3, tetraplegic 4

Outcome 3

Outcome:
DVT

Intervention:
Group 1: paraplegic 3, tetraplegic 2

Control:
Group 2: paraplegic 1, tetraplegic 0
Group 3: paraplegic 0, tetraplegic 0

Outcome 4

Outcome:
Heterotopic ossification

Intervention:
Group 1: paraplegic 1, tetraplegic 2

Control:
Group 2: paraplegic 0, tetraplegic 1
Group 3: paraplegic 1, tetraplegic 0

Outcome 5

Outcome:
Broncho-pneumonia

Intervention:
Group 1: paraplegic 2, tetraplegic 5

Control:
Group 2: paraplegic 0, tetraplegic 3
Group 3: paraplegic 0, tetraplegic 0

Outcome 6

Outcome:
Urological (bladder stone, hydroneph. epididym.)

Intervention:
Group 1: paraplegic 3, tetraplegic 1

Control:
Group 2: paraplegic 2, tetraplegic 2
Group 3: paraplegic 4, tetraplegic 0

Outcome 7

Outcome:
Contracture

Intervention:
Group 1: paraplegic 0, tetraplegic 0

Control:
Group 2: paraplegic 0, tetraplegic 0
Group 3: paraplegic 0, tetraplegic 2

Outcome 8

Outcome:
Pulmonary embolism

Intervention:
Group 1: paraplegic 0, tetraplegic 1

Control:
Group 2: paraplegic 0, tetraplegic 0
Group 3: paraplegic 0, tetraplegic 0

Outcome 9

Outcome:
Respiratory failure

Intervention:
Group 1: paraplegic 0, tetraplegic 1

Control:
Group 2: paraplegic 0, tetraplegic 0
Group 3: paraplegic 0, tetraplegic 0

Outcome 10

Outcome:
Cardiac arrest

Intervention:
Group 1: paraplegic 0, tetraplegic 6

Control:
Group 2: paraplegic 0, tetraplegic 0
Group 3: paraplegic 0, tetraplegic 0

Outcome 11

Outcome:
Perforated duodenal ulcer

Intervention:
Group 1: paraplegic 0, tetraplegic 1

Control:
Group 2: paraplegic 0, tetraplegic 0
Group 3: paraplegic 0, tetraplegic 0

Outcome 12

Outcome:
Septicaemia

Intervention:
Group 1: paraplegic 0, tetraplegic 0

Control:
Group 2: paraplegic 1, tetraplegic 1
Group 3: paraplegic 0, tetraplegic 0

Outcome 13

Outcome:
Depression needing treatment

Intervention:
Group 1: paraplegic 3, tetraplegic 4

Control:
Group 2: paraplegic 2, tetraplegic 1
Group 3: paraplegic 0, tetraplegic 0

Study details	Intervention details	Participant details	Withdrawals	Adverse events	Comments
Author (Year) Bravo-Payno (1992)[125] **Country:** Spain **Focus of study:** Delayed referral **Description of study:** Case control study to identify risk factors for heterotopic ossification (HO). Cases drawn from first-time admissions to Hospital Nacional de Paraplejicos	**Intervention:** With HO *N*: 44 **Control:** Without HO *N*: 44 **Duration:** Not stated **Follow-up:** Not stated	**Age:** mean (range): HO 29.7 (18–56); without HO 33.3 (17–64) **Sex:** Not stated *N*: 88 **Patient characteristics:** HO group: 24 with 1 HO, 17 with 2, 1 with 3, 2 with 4. Sites of HO: 41% one hip only, 41% both hips, 9% knees, 7% shoulders, 2% elbows **Inclusion/exclusion criteria:** Included: patients with traumatic aetiology admitted for the first time to the Hospital Nacional de Paraplejicos in 1988–9 identified as with and without HO. One random sample drawn from 85 with HO and one from 569 without HO. Excluded: over 180 days from injury to admission	Not stated	Not stated	**Authors' conclusions:** Non-significant association between presence of HO and age, lesion level, DVT, urinary tract complications, associated trauma and time to admission. Three factors were significantly associated with HO: complete lesion, presence of pressure sores and spasticity. These three risk factors for HO appeared to be cumulative. Pressure sores are significantly associated with longer time to admission (over 15 days)

Results

General comments:
As a case control study examining risk factors, the group definitions are not treatments but outcomes. Outcomes in bold are relevant to this review

Outcome 1

Outcome:
HO by type of lesion

Intervention:
With HO/without HO: complete 40 with/31 without; incomplete 4 with/13 without ($p < 0.05$)

Outcome 2

Outcome:
HO by pressure sore incidence

Intervention:
With HO/without HO: sores 27 with HO/12 without; no sores – 17 with HO/32 without ($p < 0.01$)

Outcome 3

Outcome:
HO by spasticity

Intervention:
With HO/without HO: spasticity 30 with HO, 15 without; no spasticity 14 with HO, 29 without ($p < 0.01$)

Outcome 4

Outcome:
HO by time to admission

Intervention:
With HO/without HO: mean days injury to admission 40.79 (45.2) with, 32.84 (38) without. Difference non-significant

Outcome 5

Outcome:
Pressure sores by time to admission

Intervention:
<15 days/>15 days: 7 with sores, 32 without/32 with sores, 17 without ($p < 0.001$)

Study details	Intervention details	Participant details	Adverse events	Comments
Author (Year) Carvell, (1989)[6] **Country:** UK **Description of study:** Examined pattern of treatment and transfer of patients admitted to the Duke of Cornwall Spinal Treatment Centre, Salisbury **Focus of study:** Delayed referral and SIU versus non-SIU	Total participants not reported	**Age:** not stated **Sex:** not stated **Severity:** Not stated **Level of injury:** Not stated **Inclusion/exclusion criteria:** Patients admitted to Duke of Cornwall Spinal Treatment Centre, Salisbury, UK	No pressure sores were seen in patients admitted within 48 hours after injury, but if transfer was delayed by 8 days the incidence of pressure sores was 14% in patients who had been treated conservatively and 29% in those who had had an operation. Other complications were also common. Some of these were the result of inappropriate treatment, e.g. inadequate bone grafting or spinal instrumentation. These technical failures made a further operation necessary in 15 out of 77 patients (19.5%). Analysis of all patients who had both primary and revision operations in the spinal treatment centre showed a rate of complication of zero	**Authors' conclusions:** If surgeons are to avoid the many potential pitfalls in operating on patients with acute spinal injuries the initial appraisal should be made by a team of doctors who are fully conversant with the modern techniques of stabilisation and instrumentation. Doctors at the district hospital where the patient is treated initially should consult with the nearest supraregional spinal unit so that joint decisions can be made about initial management and transfer of the patient to the specialist centre
Results				
General comments: 37% of patients who had been treated conservatively and 4% of those who had undergone a stabilising operation before transfer were admitted to the centre within 48 hours after injury. In those who had been operated on the commonest reasons for delay were related to spinal operations and their complications (36% of patients). 9% of patients underwent multiple transfers, being moved firstly to a hospital where spinal surgery was available and then to the spinal treatment centre				

Study details	Intervention details	Participant details	Withdrawals	Adverse events	Comments
Author (Year) Carvell (1994)[7] **Country:** UK **Focus of study:** Both **Description of study:** Results of spinal surgery were studied in 420 consecutive patients with SCI admitted to the Duke of Cornwall Spinal Treatment Centre. For full study details see Carvell (1994) in Appendix 2	**Intervention:** Surgical stabilisation before transfer *N*: 127 **Intervention 2:** Surgical stabilisation at the Duke of Cornwall Spinal Treatment Centre *N*: 31 **Control:** No surgery *N*: 262 **Duration:** Not stated **Follow-up:** Not stated **Concomitant treatments:** None reported **Comments:** Indications for surgery were an unreduced dislocation or spinal stability	**Age:** not reported **Sex:** not reported **Severity:** All patients had SCI *N*: 420 **Patient characteristics:** Site of injury: Cervical: 208 Thoracic: 121 Thoracolumbar: 69 Lumbar: 22 **Inclusion/exclusion criteria:** Patients admitted to the centre between 1984 and 1991 with an acute SCI were included	Not stated	Not stated	**Authors' conclusions:** The authors make suggestions as to how complications can be avoided in future

Results

General comments:
Note

Outcome 1

Outcome:
Main reason for delay in admission (n = 158)

Intervention:
Surgery and its complications: 55 (35%)
Multiple injuries: 17 (10.5%)
Other complications: 9 (5.5%)
Distance: 17 (11%)
Multiple transfers: 18 (11.5%)
Difficulty in admission to a spinal centre: 3 (2%)
No specific reason: 5 (3%)
No delay (admitted within 48 h of injury): 34 (21.5%)

Outcome 2

Outcome:
Development of pressure sores
Intervention:
No sores were seen in patients admitted to the centre within 48 h of injury, but if transfer was delayed by >8 days, incidence was 14% in conservative patients and 29% in surgical patients

Study details	Intervention details	Participant details	Withdrawals	Adverse events	Comments
Author (Year) Dalyan (1998)[126] **Country:** USA **Focus of study:** Delayed referral **Description of study:** Study was undertaken to examine the occurrence of contractures in acute SCI and clarify possible contributing factors including early versus late admission	**Intervention:** Early admission (<24 h of SCI) *N*: 382 **Control:** Late admission (24 h to 60 days of SCI) *N*: 100 **Duration:** Not stated **Follow-up:** Not reported **Concomitant treatments:** None reported	**Age:** not reported **Sex:** not reported **Severity:** All patients had acute SCI, 256 were paraplegic and 226 were tetraplegic. 362 had ASIA grade A, B or C and 120 were ASIA grade D *N*: 482 **Inclusion/exclusion criteria:** Patients admitted between 1990 and 1995 with acute SCI to University of Washington's Northwest Regional SCI System, Seattle, WA were included **Further details:** Contracture was defined as a 'reduction in joint range of motion severe enough to have warranted or recommended specific stretching exercises'	Not stated	None stated	**Authors' conclusions:** This study is one of the first to demonstrate a significant association of contractures in acute SCI with pressure ulcers and co-existent head injury and reaffirms the importance of early admission to a coordinated SCI centre in the prevention of contracture

Results

General comments:
None

Outcome 1

Outcome:
n (%) with contractures

Intervention:
29 (7.6)

Control:
15 (15)*

*$p = 0.05$ compared with early admission

Study details	Intervention details	Participant details	Withdrawals	Adverse events	Comments
Author (Year) DeVivo (1990)[123] **Country:** USA **Focus of study:** SIU vs non-SIU **Description of study:** Retrospective review of records 1973–85 to compare outcomes for patients admitted to SCI Centre within one day of injury with those who received their acute care elsewhere	**Intervention:** Early admission to SCI centre within 1 day of injury *N*: 315 **Control:** Late admission – acute care elsewhere, admitted to Centre for rehabilitation care *N*: 401 **Duration:** Not stated, but until discharge **Follow-up:** Not stated **Concomitant treatments:** Spinal fusion: early 41%, late 33% Halo traction: early 31%, late 19% Other operative procedures: similar levels in both groups	**Age:** mean: early 29.5 y, late 32.0 y **Sex:** not stated **Severity:** No data on level of lesion or neurological deficit. Numbers not given for complete/incomplete and paraplegic/quadriplegic although analysed by these categories *N*: 716 **Patient characteristics:** Complete quadriplegics not comparable because early group contains higher proportion with lesions at third cervical segment, requiring a ventilator. Groups stated to be otherwise comparable **Inclusion/exclusion criteria:** Included: traumatic SCI admitted to Centre within 1 day of injury, or admitted for rehab. phase only Excluded: incomplete data ($n = 15$), admitted for acute care but >1 day from injury ($n = 78$), neurological recovery during acute phase **Further details:** Deaths ($n = 26$) and complete recoveries ($n = 14$) before completion of rehabilitation analysed separately. Analyses exclude them, so are based on: early ($n = 284$), late ($n = 377$)	Not stated	None stated	**Authors' conclusions:** Between comparable patient groups, there was a statistically significant reduction in acute care and total length of stay, coupled with a highly significant reduction in the incidence of pressure ulcers for patients admitted within 1 day of injury. Mortality rates for early admissions were lower than reported previously for patients not admitted to an SCI care system

continued

Results				
General comments: None	**Outcome 1** **Outcome:** Mean hospitalisation time (days) **Intervention:** Early (n = 284) – acute/rehabilitation (days): paraplegia incomplete 22.0/46.3; paraplegia complete 19.5/62.2; quadriplegia incomplete 19.5/59.7 quadriplegia complete 31.2/90.4 **Control:** Late (n = 387) – acute/rehabilitation (days): paraplegia incomplete 30.7/50.6; paraplegia complete 32.6/62.9; quadriplegia incomplete 36.7/71.3; quadriplegia complete 38.4/83.8	**Outcome 2** **Outcome:** Pressure sores (Grade 2 or worse) during acute care phase **Intervention:** Early (n = 284) – % incidence: paraplegia incomplete 4.8%; paraplegia complete 10.3%; quadriplegia incomplete 2.8%; quadriplegia complete 14.5%; all 8.1% **Control:** Late (n = 387) – % incidence: paraplegia incomplete 5.3%; paraplegia complete 26.6%; quadriplegia incomplete 25.5%; quadriplegia complete 45.6%; all 25.5%	**Outcome 3** **Outcome:** Neurological recovery during rehabilitation phase **Intervention:** Early 10/315 **Control:** Late 4/401	**Outcome 4** **Outcome:** Mortality during rehabilitation phase **Intervention:** Early 5/315 (315 includes 15 deaths during acute phase, who should be excluded for comparability) **Control:** Late 6/401

Study details	Intervention details	Participant details	Withdrawals	Adverse events	Comments
Author (Year) Donovan (1984)[127] **Country:** Australia and USA **Focus of study:** Both **Description of study:** Comparison of complications by time of admission to a specialist unit for SCI patients initially treated in non-specialist hospitals in USA, compared with patients admitted early to a specialist centre in Australia. Retrospective review of records	**Intervention:** Initially treated in non-specialist hospitals (USA) before admission to specialist centre *N*: 1606 **Control:** Admitted early to specialist centre (Australia) *N*: 66 **Duration:** Follow-up variable according to time from injury to admission **Follow-up:** Not stated **Concomitant treatments:** USA admissions subdivided by time initially spent in non-specialist hospital (i.e. time from injury to specialist unit admission): 1–15 days 840, 16–30 days 342, 31–45 days 260, 46–60 days 164	**Age:** not stated **Sex:** not stated **Severity:** Australia: incomplete tetraplegia 31, complete tetraplegia 17, incomplete paraplegia 13, complete paraplegia 5 USA: no data *N*: 1672 **Patient characteristics:** Australia: all patients included were admitted within 48 hours of injury, and 95% within 24 hours **Inclusion/exclusion criteria:** Included: Australia: all patients admitted to SCI Unit 1979–80 (i.e. all spinal injuries in Region) Excluded: deaths within 60 days of injury ($n = 4$); those with no neurological deficit ($n = 44$)	Not stated	Not stated	**Authors' conclusions:** The data suggest that system care is preferable to non-system care in its capacity to prevent costly complications and the sooner the spinal cord injured patient is referred to a spinal cord centre capable of meeting all his needs, the less likely will he be exposed to complications that could slow the rehabilitation effort

continued

Results				
General comments: None	**Outcome 1** **Outcome:** Urinary tract infection **Intervention:** USA: occurrences before admission by injury–adm time: 1–15 days 24/840, 16–30 days 99/342, 31–45 days 100/260, 46–60 days 82/164 **Control:** Australia: occurrences by period of first incidence: 1–15 days 5/66, 16–30 days 3/66, 31–45 days 6/66, 46–60 days 4/66	**Outcome 2** **Outcome:** Decub. ulcer **Intervention:** USA: occurrences before admission by injury–admission time: 1–15 days 13/840, 16–30 days 59/342, 31–45 days 65/260, 46–60 days 58/164 **Control:** Australia: occurrences by period of first incidence 1–15 days 0/66, 16–30 days 0/66, 31–45 days 0/66, 46–60 days 0/66	**Outcome 3** **Outcome:** Atelectasis **Intervention:** USA: occurrences before admission by injury–admission time: 1–15 days 21/840, 16–30 days 42/342, 31–45 days 40/260, 46–60 days 29/164 **Control:** Australia: occurrences by period of first incidence 1–15 days 4/66, 16–30 days 0/66, 31–45 days 0/66, 46–60 days 0/66	**Outcome 4** **Outcome:** Pneumonia **Intervention:** USA: occurrences before admission by injury–admission time: 1–15 days 16/840, 16–30 days 43/342, 31–45 days 30/260, 46–60 days 20/164 **Control:** Australia: occurrences by period of first incidence 1–15 days 2/66, 16–30 days 0/66, 31–45 days 1/66, 46–60 days 0/66
	Outcome 5 **Outcome:** Pulmonary embolism **Intervention:** USA: occurrences before admission by injury–admission time: 1–15 days 0/840, 16–30 days 5/342, 31–45 days 9/260, 46–60 days 8/164 **Control:** Australia: occurrences by period of first incidence 1–15 days 1/66, 16–30 days 2/66, 31–45 days 0/66, 46–60 days 0/66	**Outcome 6** **Outcome:** Gastrointestinal ulcer **Intervention:** USA: occurrences before admission by injury–admission time: 1–15 days 1/840, 16–30 days 6/342, 31–45 days 9/260, 46–60 days 6/164 **Control:** Australia: occurrences by period of first incidence 1–15 days 0/66, 16–30 days 0/66, 31–45 days 0/66, 46–60 days 0/66	**Outcome 7** **Outcome:** Heterotopic ossification **Intervention:** USA: occurrences before admission by injury–admission time: 1–15 days 0/840, 16–30 days 0/342, 31–45 days 1/260, 46–60 days 0/164 **Control:** Australia: occurrences by period of first incidence 1–15 days 0/66, 16–30 days 0/66, 31–45 days 0/66, 46–60 days 0/66	

Study details	Intervention details	Participant details	Withdrawals	Adverse events	Comments
Author (Year) Gardner (1986)[128] **Country:** UK **Focus of study:** SIU vs non-SIU Description of study: Case series of 44 ventilated spinal cord damaged patients treated at Mersey Regional SIU prior to 1985	**Intervention:** Ventilated patients *N*: 44 **Control:** *N*: 0 **Duration:** Not stated **Follow-up:** Not stated **Concomitant treatments:** Not reported	**Age:** majority 20–29 y (*n* = 12) **Sex:** not reported **Severity:** Not stated *N*: 44 **Patient characteristics:** Initial neurological level: majority of patients were injured at C4 (*n* = 20) Day following injury ventilation commenced: majority ventilated on day 1 (*n* = 24, 6/24 prior to transfer), 6 patients were ventilated >6 days after injury Weeks on ventilator after weaning commenced (*n* = 38): majority weaned after 2 wks (*n* = 10), 5 patients were weaned after >9 days on the ventilator **Inclusion/exclusion criteria:** Not stated	**Intervention group:** 20 patients died (14 during first admission and 6 after discharge) **Causes:** Respiratory: 16 Cardiovascular: 10 Renal: 1 Hepatic: 1 Insominate artery erosion: 1 Septicaemia: 1	**Intervention:** Significant infection: 5 Cardiovascular: 4 Pulmonary collapse: 4 Failure of spontaneous closure of tracheostomy: 3 Excessive tracheal granulation tissue: 2 Major haemothorax: 1	**Authors' conclusions:** Spinal cord damaged patients should be transferred to a specialised comprehensive centre as soon as possible after injury so that the requirement for ventilation can be minimised, the incidence of cardiac and respiratory arrest reduced, optimal methods of ventilation and weaning employed and global emotional and educational support provided from the outset for the patient and his/her family

Results

General comments:
Patients who received ventilation prior to transfer are not described as a subgroup

Outcome 1

Outcome:
Patients ventilated prior to transfer

Intervention:
Inappropriate early management before or during transfer to the spinal injuries centre led to the need for ventilation in several cases

Outcome 2

Outcome:
Time on ventilator

Intervention:
Patients whose ventilation was initiated before transfer and who survived ventilation spent almost twice as long on the ventilator as those treated in the SIU

Study details	Intervention details	Participant details	Withdrawals	Adverse events	Comments
Author (Year) Heinemann (1989)[129] **Country:** USA **Focus of study:** SIU vs non-SIU **Description of study:** Retrospective study of admissions to Rehabilitation Centre 1981–5 and outcomes at discharge, comparing their prior acute treatment according to whether at a specialist centre or elsewhere	**Intervention:** Acute treatment at specialist SCI Centre *N*: 185 **Control:** Acute treatment at non-specialist hospitals *N*: 153 **Duration:** Not stated **Follow-up:** Not stated **Concomitant treatments:** Not reported	**Age:** mean 31.2 y Centre, 29.7 y non-Centre **Sex:** 82% M; 18% F Centre; 81% M; 19% F non-Centre **Severity:** Paraplegia/quadriplegia: Centre 45%/55%, non-Centre 48%/52%. Complete/incomplete: Centre 48%/52%, non-Centre 49%/51%. Frankel grade A/B/C/D: Centre 48%/19%/4%/29%, non-Centre 49%/14%/10%/27% *N*: 338 **Patient characteristics:** Groups were comparable in terms of incidence of DVT, tracheotomy, mean No. of pressure sores, mean No. of surgical procedures, internal injuries and long-bone fractures. There were significant differences between spine instability (Centre 0.5%, non-Centre 5%, $p = 0.02$) and mean time from injury to Rehabilitation Centre admission (see baseline outcome 3, $p < 0.001$) **Inclusion/exclusion criteria:** Admitted to Rehabilitation Centre (part of Regional SCI Care System) with SCI 1981–5	Not stated	Not stated	**Authors' conclusions:** Duration from injury to admission to rehabilitation significantly longer for non-Centre patients. While Centre patients were discharged at equivalent functional skill rates as non-Centre patients, their daily rate of functional gains was significantly greater. These results support the practice of specialised short-term SCI care to enhance rehabilitation outcomes

continued

Results				
General comments: Initial comparison of groups shows no significant differences in condition (except spinal instability) or in incidence of complications – indicates that the two treatment groups are comparable in effectiveness. Very complex 'efficiency score' is used to measure rate of improvement – appears to be an attempt to prove superiority of Centre treatment. Conclusions about superiority only seem justified in relation to duration of hospitalisation. Sub-group results over-complex – not supported by numbers in sub-groups (which are not always given e.g. for outcomes 1 and 2)	**Outcome 1** **Outcome:** Paraplegic independence – modified Barthel index **Intervention:** Centre – mean MBI score on admission by Frankel grade: A 31.5, B 33.8, C 36.0, D 40.0, all 34.8 Centre – mean MBI score on discharge by Frankel grade: A 68.4, B 72.7, C 80.0, D 81.5, all 73.7 **Control:** Non-Centre – mean MBI score on admission by Frankel grade: A 33.6, B 46.1, C 31.9, D 55.8, all 40.0 Non-Centre – mean MBI score on discharge by Frankel grade: A 68.1, B 77.5, C 70.0, D 86.0, all 73.5	**Outcome 2** **Outcome:** Quadriplegic independence – modified Barthel index **Intervention:** Centre – mean MBI score on admission by Frankel grade: A 9.2, B 12.0, C 27.0, D 22.9, All 14.2 Centre – mean MBI score on discharge by Frankel grade: A 33.9, B 42.2, C 61.0, D 71.4, all 46.5 **Control:** Non-Centre – mean MBI score on admission by Frankel grade: A 10.8, B 18.4, C 15.2, D 22.2, all 16.0 Non-Centre – mean MBI score on discharge by Frankel grade: A 30.1, B 41.6, C 42.8, D 60.3, all 42.4	**Outcome 3** **Outcome:** Mean length of rehabilitation stay **Intervention:** Centre: mean time injury to rehabilitation admission 27.5 days Centre: paraplegic 68.7 days, quadriplegic 98.0 days, all 84.9 days **Control:** Non-Centre: mean time injury to rehabilitation admission 60.8 days Non-Centre: paraplegic 70.7 days, quadriplegic 103.4 days, all 87.7 days	**Outcome 4** **Outcome:** Improvement by 1+ functions levels MRSCICS **Intervention:** Centre admission: Levels 1–6 dependent–independent: level 1 $n = 95$, 2 $n = 76$, 3 $n = 13$, 4 $n = 1$ Centre discharge: 33 unchanged level, 91 improved by 1 level, 61 by 2+ levels. Level 1 $n = 24$, 2 $n = 58$, 3 $n = 51$, 4 $n = 18$, 5 $n = 28$, 6 $n = 6$ **Control:** Non-Centre admission: Levels 1–6 dependent–independent: 1 $n = 69$, 2 $n = 70$, 3 $n = 11$, 4 $n = 1$, 5 $n = 2$ Non-Centre discharge: 40 unchanged level, 77 improved by 1 level, 36 by 2+ levels. Level 1 $n = 24$, 2 $n = 46$, 3 $n = 49$, 4 $n = 12$, 5 $n = 17$, 6 $n = 5$

Study details	Intervention details	Participant details	Withdrawals	Adverse events	Comments
Author (Year) Kiwerski (1981)[130] **Country:** Poland **Focus of study:** Delayed referral **Description of study:** Series of patients with complete or severe cervical SCI (motor paralysis) admitted to a hospital in Poland 1964–78, split by time from injury to arriving at the hospital	**Intervention:** Early admission (up to 24 h from trauma) *N*: 385 **Control:** Late admission (after 24 h) *N*: 83 **Duration:** 1964–78 **Follow-up:** Not stated **Concomitant treatments:** Not stated **Comments:** Can also be divided into early surgery (up to 3 days $n = 126$), late surgery ($n = 55$) and conservative treatment ($n = 287$). With dislocations in the lower part of the spine, anterior open reduction of fractures may be undertaken. The form of spinal stabilisation depends on the nature of the trauma. In compression, flexion or extension fractures, patients are treated with skull traction for 6–8 wks and an orthopaedic collar. Anterior fusion may take place if there is obvious instability. Early surgical stabilisation is applied in patients with burst fractures and in flexion dislocations	**Age:** 76 <20 y, 168 21–40 y, 136 41–60 y, 88 >60 y **Sex:** not stated **Severity:** 333 complete injury (71%), 135 incomplete injury *N*: 468 **Patient characteristics:** Injury caused by fall from a cart 128, diving into water 121, fall from a height 111, road accident 83, crush 16, others 9 **Inclusion/exclusion criteria:** Cervical spine injury complicated by SCI (in the Rehabilitation Institute of Konstancin 1964–78)	Not stated	Not stated	**Authors' conclusions:** Not stated

continued

Results			
General comments: Included patients do not fit with inclusion criteria (incomplete should be excluded!)	**Outcome 1** **Outcome:** Death (by time to admission) **Intervention:** up to 24 h: 109/385 **Control:** after 24 h: 13/83	**Outcome 2** **Outcome:** Neurological status (by time to admission) **Intervention:** Complete: improved 3 grades 6, improved 2 grades 17, improved to incomplete 15 Incomplete: recovered 9, improved 3 grades 58, improved 2 grades 31 Unchanged 140 (complete 135, incomplete 5) **Control:** Complete: improved to incomplete 1 Incomplete: improved 3 grades 8, improved 2 grades 11 Unchanged 50	**Outcome 3** **Outcome:** Neurological status (by time to surgery) **Intervention:** *N*: 55 Late, complete: 1 improved to incomplete. Incomplete: improved 3 grades 8, improved 2 grades 10, unchanged 30, died 6 Early surgery (up to 3 days, $n = 126$) complete: improved 3 grades 5, improved 2 grades 12, improved to incomplete 9. Incomplete: recovered 7, improved 3 grades 30, improved 2 grades 6. Unchanged: 41, died 16 **Control:** No surgery $n = 287$, complete: improved 13 grades 1, 2 grades 5, to incomplete 6. Incomplete: recovered 2, improved 3 grades 28, 2 grades 26. Unchanged 119, died 100

Study details	Intervention details	Participant details	Adverse events	Comments
Author (Year) Meyer (1987)[137] **Country:** USA **Description of study:** Review of Midwest Regional Spinal Cord Injury Care System (MRSCICS) Acute Spine Injury Centre data between 1972 and 1985 **Focus of study:** Delayed referral	**Interventions:** Total participants $n = 2403$	**Age:** median 26 y **Sex:** not reported **Severity of injury:** Incidence of complete neurological injury: 34% **Time to admission:** The median admission time for all newly injured spinal cord patients was 9 h, and the mode time from injury to admission was 6 h. 78% of all patients were admitted to the Acute Spine Injury Centre in under 72 h. 67% were transferred to the acute unit in under 24 h **Inclusion/exclusion criteria:** Not reported	None reported	**Authors' conclusions** None reported
Results				
General comments: The patient group admitted in under 24 h (67%) had the highest rate of neurological improvement (10.9%) and the lowest rate of neurological deterioration (0.9%) ($p < 0.05$)				

Study details	Intervention details	Participant details	Withdrawals	Adverse events	Comments
Author (Year) Oakes (1990)[131] **Country:** USA **Focus of study:** Delayed referral **Description of study:** Study of the effects of early admission to a specialised SCI Centre. Retrospective review of cases admitted to specialised level I Trauma centre	**Intervention:** Early admission to Centre (≤11 days for quadriplegic $n = 51$; ≤21 days for paraplegics $n = 47$) *N*: 98 **Control:** Late admission to Centre (>11 days for quadriplegic $n = 51$; >21days for paraplegic $n = 48$) *N*: 99 **Duration:** 1 y from admission to Centre **Follow-up:** Not stated **Concomitant treatments:** Spinal surgery at Centre or elsewhere by early/late admission. (a) Quadriplegics: Early ($n = 51$): Centre 13/elsewhere 4 Late ($n = 51$): Centre 4/elsewhere 28 (b) Paraplegics: Early ($n = 47$): Centre 30/elsewhere 12 Late ($n = 48$): Centre 7/elsewhere 23 **Comments:** Early and late admission defined by median time of admission	**Age:** mean (range): quadriplegics 28 y (12–68 y); Paraplegics 31 y (5–77 y) **Sex:** 158 M; 39 F **Severity:** Quadriplegics $n = 102$: average Frankel scores (A complete = 1 to E normal = 5): early 3.51, late 3.31 (difference not significant) Paraplegics $n = 95$: average Frankel scores (A = 1 to E = 5): early 4.02, late 3.81 (difference not significant) *N*: 197 **Patient characteristics:** Laminectomy (alone or combined with rods/fusion) at Centre/elsewhere: (a) Quadriplegics: Centre 1, elsewhere 6 (b) Paraplegics: Centre 4, elsewhere 13 Rods and/or fusion, without laminectomy, at Centre/elsewhere: (a) Quadriplegics: at Centre 16, elsewhere 26 (b) Paraplegics: at Centre 33, elsewhere 19 **Inclusion/exclusion criteria:** Included: admissions to Centre 1981–3 with traumatic SCI, admitted within 1 y of injury and followed up for at least 1 y Excluded: deaths within 1 y of admission to Centre ($n = 4$)	Not stated	Not stated	**Authors' conclusions:** Patients with acute SCI benefit from early admission (11 days for quadriplegics and 21 days for paraplegics) to a comprehensive trauma centre. Early admission leads to decreased total hospitalisation. Medical complications are lessened by early admission and more appropriate surgical care is received. When admissions were defined as being within 24 h, identical results were obtained

continued

Results				
General comments: Not clear that early and late groups are comparable – successes from other hospitals may be excluded if only difficult patients are transferred	**Outcome 1** **Outcome:** Acute hospitalisation time **Intervention:** Mean No. of days from injury to start of rehabilitation: (a) Quadriplegics: early 3, late 75 ($p < 0.01$) (b) Paraplegics: early 6, late 59 ($p < 0.01$)	**Outcome 2** **Outcome:** Acute rehabilitation time **Intervention:** Mean No. of days from start to finish of rehabilitation: (a) Quadriplegics: early 128, late 123 (b) Paraplegics: early 77, late 67	**Outcome 3** **Outcome:** Total hospitalisation time **Intervention:** Median days injury to discharge: (a) Quadriplegics: early 125, late 166 (b) Paraplegics: difference 38.5 days less for early (mean: early 83, late 126)	**Outcome 4** **Outcome:** Incidence of complications by treating hospital **Intervention:** Complications occurring at Centre or elsewhere by early/late admission: (a) Quadriplegics: early: Centre 28/elsewhere 12; late: Centre 16/elsewhere 42 (b) Paraplegics: early: Centre 8/elsewhere 4; late: Centre 5/elsewhere 12

Study details	Intervention details	Participant details	Withdrawals	Adverse events	Comments
Author (Year) Ohry (1983)[132] **Country:** Israel **Focus of study:** Delayed referral **Description of study:** Review of 18 cases of gibbus formation in patients admitted to a rehabilitation centre 1973–81	**Intervention:** Patients with gibbus formation *N*: 18 **Control:** Other traumatic cases *N*: 110 **Duration:** Not stated **Follow-up:** Not reported **Concomitant treatments:** None reported	**Age:** range 19–37 y (gibbus group) **Sex:** not reported **Severity:** Not reported *N*: 128 **Patient characteristics:** Data for gibbus formation group ($n = 18$) Cause of injury: Motor vehicle accident: 8 Gunshot wound: 1 Fall from a height: 5 Work accident: 4 Level of injury: Dorsal vertebrae: 3 D12: 3 D12 + L1: 3 L1: 6 L1 + L2: 1 L2: 1 L3–L4: 1 **Inclusion/exclusion criteria:** Patients with traumatic injury to the dorso-lumbar spinal cord were included **Further details:** 44% of patients required surgical intervention as result of their deformities Time elapsed between injury and admission Range: 5 days–3 y Majority did not have a primary operation (laminectomy, $n = 2$ and laminectomy with stabilisation + POP, $n = 1$)	Not stated	Not stated	**Authors' conclusions:** None of the non-operated patients who developed a gibbus received their non-operative care in a specialised SCI centre. The authors conclude that where effective non-operative treatment cannot be instituted, internal fixation should be seriously considered as a means of preventing deformity

Results

Outcome 1

Outcome:
Gibbus formation
Intervention:
The common denominator was the time that had elapsed between injury and transfer to the Spinal Treatment centre. 18 patients were transferred either from an orthopaedic ward or neurosurgical ward

Study details	Intervention details	Participant details	Withdrawals	Adverse events	Comments
Author (Year) Richardson (1981)[133] **Country:** USA **Focus of study:** Delayed referral **Description of study:** Consecutive series of all patients entering MidWest Regional Spinal Cord Injury Care System from 1973 until June 1978. Retrospective	**Intervention:** Entered 'system' less than 72 hours from time of injury *N*: 219 **Control:** Entered 'system' 72 hours or more from time of injury *N*: 330 **Duration:** 1973–78 **Follow-up:** Not stated **Concomitant treatments:** Not stated **Comments:** System = acute phase of injury at North Western Hospital Acute Spinal Cord Unit; chronic phase at the Rehabilitation Institute of Chicago	**Age:** not stated **Sex:** not stated **Severity:** Complete 302, incomplete 247 *N*: 549 **Patient characteristics:** Not stated **Inclusion/exclusion criteria:** All patients entering the MidWest Regional Spinal Cord Injury Care System	Not stated	Not stated	**Authors' conclusions:** The overall prevalence of pressure sores is greater in non-system than in system patients in all six categories, varying from a minimal 9.6% difference (thoracic incomplete) to a maximal 49.7% difference (lumbar complete). Highest prevalence of pressure sores developed in complete cervical cord injuries instead of thoracic or thoracolumbar cord injuries. Both findings correlate that most common site of single pressure sore development is sacral. Multiple pressure sores in cervical cord injured patients are more common than pressure sores at a single site. Calculated values showed that quadriplegics were more prone to develop pressure sores at a single site and at multiple sites than paraplegics. The fact that system entry patients develop more pressure sores during acute hospitalisation is related to associated medical and systemic trauma (>50% had multiple-system trauma). Over 70% of non-system patients who had pressure sores on admission had healing or conversion of pressure sores from multiple sites to a different single site. No system patient had a pressure sore on admission (due to rapidity and competence of transport system)

continued

Results				
General comments: Authors state that cost analysis for the treatment of a single pressure sore based on Edberg's 1973 statistics is approx. US$15,000. With inflation and the cost of increased hospitalisation taken into account for a present cost analysis these figures would double	**Outcome 1** **Outcome:** Prevalence of pressure sores **Intervention:** On admission: 0 During stay: 81; cervical complete 33, incomplete 19, thoracic complete 19, incomplete 4, lumbar complete 1, incomplete 5 **Control:** On admission: 134; cervical complete 34, incomplete 32, thoracic complete 46, incomplete 9, lumbar complete 6, incomplete 7 During stay: 42; cervical complete 8, incomplete 9, thoracic complete 17, incomplete 1, lumbar complete 3, incomplete 4	**Outcome 2** **Outcome:** Prevalence of multiple pressure sores **Intervention:** On admission: 0 During stay: 27; cervical complete 16, incomplete 4, thoracic complete 5, lumbar incomplete 2 **Control:** On admission: 62; cervical complete 16, incomplete 16, thoracic complete 22, incomplete 4, lumbar complete 2, incomplete 2 During stay: 13; cervical complete 3, incomplete 1, thoracic complete 7, incomplete 0, lumbar complete 1, incomplete 1	**Outcome 3** **Outcome:** Pressure sore sites for complete injuries **Intervention:** On admission: 0 During stay: gluteal-sacral 17, trochanteric-ischial 4, other sites 11 **Control:** On admission: gluteal-sacral 26, trochanteric-ischial 7, other sites 13 During stay: gluteal-sacral 10, trochanteric-ischial 2, other sites 6	**Outcome 4** **Outcome:** Pressure sore sites for incomplete injuries **Intervention:** On admission: 0 During stay: gluteal-sacral 12, trochanteric-ischial 2, other sites 8 **Control:** On admission: gluteal-sacral 11, trochanteric-ischial 5, other sites 10 During stay: gluteal-sacral 3, trochanteric-ischial 4, other sites 5

Study details	Intervention details	Participant details	Adverse events	Comments
Author (Year) Selecki (1986)[134] **Country:** Australia **Focus of study:** Delayed referral **Description of study:** Retrospective survey of spinal injuries admitted to various types of hospital in New South Wales between 1977 and 1978	**Interventions:** Total participants, *n* = 202 **Group 1** (*n* = 133) Patients who survived **Group 2** (*n* = 69) Patients who died while still in hospital, 34 occurred <24 h after injury, 26 died during first month in hospital and 9 died >1 mth 15 additional deaths occurred before transfer in small country hospitals (these were excluded)	**Age:** reported in graph (mode 15–24 y) Sex: M:F 4.3:1 **Severity of injury:** All cases, except 2, exhibited neurological damage on admission (*n* = 150), at a later time (*n* = 27) or died within 6 h of injury (*n* = 23) Total transport time to the hospital of first admission Time (h) — No. of patients <1 — 118 (58%) 1–2 — 50 (25%) 2–4 — 16 (8%) 4–6 — 3 (2%) 6–12 — 5 (3%) >12 — 4 (2%) **Inclusion/exclusion criteria:** Included: (a) all spinal injury cases associated with death and (b) all spinal injury cases with record of a neurological deficit expressing damage to the spinal cord and/or cauda equina. Excluded: (a) injuries where damage was confined to individual nerve roots; (b) patients who died or recovered in small country hospitals of first admission; (c) <2 y of age; and (d) had sustained gunshot wounds	None reported	**Authors' conclusions** This study suggests that preventable delay in transport, inappropriate treatment, and failure to correct shock may have been causative factors in 16 deaths in this series. Reduction of the time lag between accident and institution of definitive treatment will save lives, and may avoid some crippling neurological deficits. To achieve this, there is an urgent and overdue need to integrate ambulance and hospital services and to establish efficient multidisciplinary trauma centres

continued

Results

General comments:
Only 41 (20%) patients were directly admitted to hospitals with neurosurgical and/or spinal units; 6 of these cases went to units which were not considered to offer full neurosurgical services. The other patients went first either to metropolitan surgical hospitals ($n = 61$), country based hospitals ($n = 45$) or small country hospitals ($n = 55$). Only 3 patients were directly admitted to spinal unit wards; 45 (22%) went first to Intensive Care Units

Of 181 inter-hospital transfers, 170 (94%) of patients were effected because facilities in the referring hospital were inadequate. In 37 transferred cases, the diagnosis of spinal injury was substantially changed after transfer – in 5, after arrival at a third hospital. As a result of these logistic systems, 139 transferred patients eventually reached hospitals with adequate facilities, but they did so after a mean time of 22 h after first hospital admission (median approx. 9 h). In 28 cases who were never transferred to a special centre, there were 24 deaths

Multivariate relation to mortality by hospital type:

			Fatality rate (%)	
	No. of cases	No. of deaths	Observed	Adjusted
Teaching	35	16	46	40
City surgical	58	23	40	28
Country base	45	11	24	30
Small country and other	60	16	27	38

The higher fatality rate in the teaching hospitals compared with the other types was not significant. On average, patients admitted to the teaching hospitals were in more severe condition than those admitted to other hospitals

Initial admission to an inappropriate hospital was the rule rather than the exception for both deaths and survivors, delay for more than 6 h was common in both groups. More of the deaths than survivors had a delay to admission of more than 24 h, although the difference was not significant. Inappropriate treatment occurred significantly more frequently in deaths than in survivors ($p < 0.05$)

Study details	Intervention details	Participant details	Adverse events	Comments
Author (Year) Smith (1999)[3] **Country:** UK **Description of study:** Research project undertaken on behalf of the Spinal Injury Association (SIA) to compare the efficacy of specialist and non-specialist management of SCI. Readers of the SIA newsletter were asked to complete a questionnaire	**Interventions** Total participants, *n* = 800 Intervention (*n* = 702) Patients who had received the opportunity to access one of the spinal injury units following injury (SIU) Control (*n* = 98) Patients who had not utilised specialist services (non-SIU)	**Age:** (mean) SIU 47 y; non-SIU 48 y **Sex:** SIU 71% M; non-SIU 51% M Severity of injury: % (SIU; non-SIU) Complete: 61; 39 Incomplete: 39; 61 Level of injury: % (SIU; non-SIU) C1–3: 3.3; 5.1 C4–5: 20.5; 13.3 C6–8: 23.5; 17.3 T1–12: 47.9; 39.8 L1–5: 4.7; 24.5 Injury date: % (SIU; non-SIU) Pre-1950: 0.4; 2.1 1950s: 5.3; 8.4 1960s: 11.1; 9.5 1970s: 23.7; 16.8 1980s: 32.5; 37.9 1990s: 27.0; 25.3 Cause of injury: % (SIU; non-SIU) Injury: 88.9; 54.1 Illness: 11.1; 45.9 **Comments:** There was no significant difference between the groups on age, level and injury date **Inclusion/exclusion criteria:** Any person with neurological deficit resulting from spinal cord damage, either from non-traumatic or traumatic origin, was included	The complications having a statistically significant lower incidence in the SIU cohort as a whole, or for one/both groups comprised skin mark, superficial sore, chest infection, urinary tract infection, problematic spasm, uncontrolled autonomic dysreflexia, sleep, abdominal pain, severe depression, problems in relationships with relatives	**Authors' conclusions** The key question of this study was to ascertain if there was any evidence of improved outcome for those who had access to SIUs, compared with those who had received management of initial injuries in a non-specialist centre. This study has provided conclusive, statistically significant evidence that those who have access to SIUs have improved health, function and social outcomes, albeit to varying degrees

continued

Results

Personal assistance required with living activities

Eating: There was a statistically significant positive outcome in the SIU whole tetraplegic cohort ($p = 0.01$) and in the high tetraplegic group ($p = 0.05$)
Drinking: A statistically significant positive outcome was demonstrated in the SIU high and low tetraplegic cohorts ($p = 0.024$ and 0.02, respectively), and was highly significant in the SIU
Showering/bathing: A high statistically significant positive outcome was demonstrated in the SIU paraplegic cohort ($p < 0.001$)
Grooming: High statistically significant positive outcomes were demonstrated in the SIU paraplegic cohort ($p < 0.001$) and in the SIU whole tetraplegic group with complete injuries ($p = 0.004$)
Dressing/undressing (upper and lower): There was a highly statistically significant positive outcome in the SIU paraplegic cohort ($p < 0.001$)
Managing bladder: Despite differences between cohorts, statistical significance in outcomes was not demonstrated
Managing bowels: A statistically significant positive outcome was shown in non-SIU low tetraplegic cohort ($p = 0.02$) and in the SIU paraplegic cohort ($p = 0.014$)
Bed–chair transfer: A statistically significant positive outcome was demonstrated in the SIU paraplegic cohort ($p = 0.016$)
Toilet transfer: Despite descriptive differences between cohorts, statistical significance in outcomes was not demonstrated
Car transfer: A statistically significant positive outcome was demonstrated in the SIU paraplegic cohort ($p = 0.014$).
Wheelchair mobility (indoors): A highly statistically significant positive outcome was demonstrated in the SIU whole tetraplegic cohort ($p = 0.001$) and low tetraplegic group ($p < 0.001$). Also, there was a highly statistically significant positive outcome in the SIU paraplegic cohort ($p < 0.001$)
Wheelchair mobility (outdoors): A statistically significant positive outcome was demonstrated in the SIU paraplegic cohort ($p = 0.007$)
Driving/transportation: A statistically significant positive outcome was demonstrated in the SIU paraplegic cohort ($p = 0.005$)
Shopping: A statistically significant positive outcome was demonstrated in the SIU paraplegic cohort ($p = 0.043$)
Laundry: A statistically significant positive outcome was demonstrated in the SIU paraplegic cohort ($p = 0.011$)
Housework: Despite descriptive differences between cohorts, statistical significance in outcomes was not demonstrated
Entering/leaving home: There was a statistically significant positive outcome in the SIU paraplegic cohort ($p = 0.04$)

Social activities

Hours out of bed per day: Despite descriptive differences no statistical significance was demonstrated between the two cohorts using the Mann–Whitney *U*-test for analysis
Hours out of the house per week: There was statistically significant positive outcome in the SIU cohort paraplegic group ($p = 0.05$) using the Mann–Whitney *U*-test for analysis
Driving: Despite descriptive differences no statistical significance was demonstrated between the two cohorts using chi-squared analysis
Employment: A statistically significant positive outcome was demonstrated in the SIU cohort as a whole ($p = 0.017$) and in the SIU paraplegia group ($p = 0.045$) (Mann–Whitney *U*-test). Overall rate of paid employment was poor in both groups. For voluntary employment a significant difference was demonstrated in favour of the SIU cohort as a whole
Education: No statistical significance between the cohort was demonstrated using chi-squared for analysis
Having a partner: More of the SIU cohort had a partner to an extent which demonstrated statistical significance ($p = 0.012$)
Happiness with sex: Using a chi-squared analysis, no statistical difference was demonstrated between the two cohorts as a whole. For male happiness with sex alone, there was a statistically significant difference within the tetraplegic ($p = 0.006$) and paraplegic ($p = 0.05$) in favour of the SIU cohort
Contact with and visiting others: No statistically significant differences were demonstrated (Mann–Whitney *U*-test)

Life satisfaction

Overall satisfaction level: No statistical difference was demonstrated between the two cohorts
How satisfaction has changed: No statistical difference was demonstrated between the two cohorts

Study details	Intervention details	Participant details	Withdrawals	Adverse events	Comments
Author (Year) Soopramanien (1994)[138] **Country:** Romania **Focus of study:** Delayed referral **Description of study:** Study included both retrospective and prospective data on spinal cord injuries in Romania	**Intervention:** *N*: not stated **Control:** *N*: not stated **Duration:** Not stated **Follow-up:** Not stated **Concomitant treatments:** Not stated	**Age:** reported in graph (median approx. 40 y) **Sex:** male:female ratio: 3.35:1 **Severity:** 262 patients had neurological damage *N*: 412 **Patient characteristics:** Falls from heights, especially from horse-drawn carts, caused 59% of the injuries and road traffic accidents 13%. Diving accidents accounted for 7% of injuries **Inclusion/exclusion criteria:** Patients with spinal injuries admitted from Jan. 1992 to Jan. 1993 were included **Further details:** Retrospective data included patients admitted from 1975 to Dec. 1991. Prospective data (collected daily) included patients admitted between Jan. 1992 and Jan. 1993	Not stated	Not stated	**Authors' conclusions:** A programme is needed in Romania to prevent accidents that cause spinal injuries and to improve clinical management. As a result of this study, 3 films were made to aid the prevention of accidents and to train staff and relatives in the care of those with spinal cord injuries

Results

General comments:
None

Outcome 1

Outcome:

Intervention:
45% of patients were admitted within a day of injury,
31% within the first week and 10% between weeks 1 and 2.
By that time pressure sores had developed in 26 patients (44% of all sores)

Study details	Intervention details	Participant details	Withdrawals	Adverse events	Comments
Author (Year) Tator (1995)[135,139] **Country:** Canada **Focus of study:** SIU vs non-SIU **Description of study:** Based on epidemiological data from 2 populations of patients with acute SCI to evaluate the effectiveness of management in a regionalised, specialised acute SCI unit (ASCIU)	**Intervention:** Patients selected from admission to the ASCIU between 1974 and 1981 *N*: 201 **Control:** Patients admitted between 1947 and 1973. (pre-ASCIU) *N*: 351 **Duration:** Not stated **Follow-up:** Pre-ASCIU: complete 12 mths; incomplete 18 mths ASCIU: complete 6 mths; incomplete 12 mths **Concomitant treatments:** None reported	**Age:** median ASCIU 27.0 y; pre-ASCIU 32.0 y **Sex:** approx. 80% M (both groups) **Severity:** Not stated *N*: 552 **Patient characteristics:** Approx. 60% of spinal injuries were at the cervical level in both groups. Level of the SCI and the level of the most significant vertebral column injury were identical in most patients **Inclusion/exclusion criteria:** Intervention group inclusion: patients admitted within 30 days following closed SCI and had received no definitive management of acute SCI at another institution prior to transfer. Control group inclusion: patients records contained complete documentation of SCI, associated injuries, treatment, neurological status at discharge, plus same criteria as for intervention group. Exclusion: patients with penetrating injuries, injuries below L2, or spinal column injury without cord involvement or with nerve root involvement only. Also patients who died at the accident scene, or during transfer or dead-on-arrival **Further details:** In the ASCIU group there was a significantly higher frequency of motor vehicle and sports/recreational accidents, and a lower incidence of work-related injuries (chi-squared, $p = 0.001$). The ASCIU group was admitted much sooner after injury, with the time interval from admission to a study hospital decreasing from a median time of 13–5 h (2-tailed *t*-test, $p < 0.001$)	**Intervention group:** 8 (4.0%) patients were lost to follow-up Mortality rate: 15 (7.5%) died **Control group:** 20 (5.6%) patients were lost to follow-up Mortality rate: 49 (14%) died (chi-squared, $p = 0.022$ compared with ASCIU)	None stated	**Authors' conclusions:** The results suggest that outcome from ASCI can be optimised by early referral to an ASCIU with a multidisciplinary surgical, medical, nursing and paramedical staff possessing specialised training in the diagnosis and treatment of the acute phase of SCI including the initiation of rehabilitation measures as soon as possible after admission. It has been estimated that an ASCIU should treat a minimum of 25 new patients per year to establish and maintain proficiency

continued

Results			
General comments: Multiple regression model: Higher neurological recovery was strongly associated with less severe ASCI and less total trauma burden (ISS). Improved neurological recovery was also associated with management in the ASCIU and with more cephalad injuries. The effect of level of injury on neurological recovery appears to have been mediated through ISS, which showed a high correlation with level of injury (ISS increased with more caudal injuries, correlation $p = 0.0009$). There was not a significant correlation between severity of ASCI and anatomic level of injury (correlation, $p = 0.1571$)	**Outcome 1** **Outcome:** Length of stay **Intervention:** Mean 48.2 days, excluding patients who died during first hospitalisation ($n = 186$): 48.9 days **Control:** Mean 86.9 days (2-tailed *t*-test, $p < 0.001$ compared with ASCIU), excluding patients who died during first hospitalisation ($n = 302$): 97.3 days (2-tailed *t*-test, $p < 0.001$ compared with ASCIU)	**Outcome 2** **Outcome:** Mortality rate *n* (%) classified by time of death and severity of injury **Intervention:** Time of death: Hospital: 15 (7.5%) Follow-up: 4 (2.1%) Total: 19 (9.8%) Severity of injury: Complete: 11 (12.1%) Incomplete: 8 (7.8%) **Control:** Time of death: Hospital: 49 (14.0%) Follow-up: 11 (3.3%) Total: 60 (18.1%) Severity of injury: Complete: 49 (22.1%) Incomplete: 11 (10.1%)	**Outcome 3** **Outcome:** Neurological recovery (based on 17 patient CINRI) **Intervention:** $n = 173$ Mean recovery: 28.8% **Control:** $n = 262$ Mean recovery: 13.0% (2-tailed *t*-test, $p < 0.001$ compared with ASCIU group)

Study details	Intervention details	Participant details	Withdrawals	Adverse events	Comments
Author (Year) Wang (2001)[140] **Country:** UK **Focus of study:** Both **Description of study:** Study of relationship between time of operation and mobilisation and between type of centre, mobilisation and complications. Review of cases of acute SCI admitted to National SI Centre (1990–4), some of whom had previously been operated on in non-specialised facilities	**Intervention:** Group A – initially seen at NSIC *N*: 34 **Intervention 2:** Group C – initially seen at non-specialised hospitals in continental Europe *N*: 23 **Control:** Group B – initially seen at non-specialised hospitals in UK *N*: 45 **Duration:** Not stated, but until mobilisation **Follow-up:** Not stated **Concomitant treatments:** Time to operation – mean (median) No. of days from injury to operation: Group A 12 (9), Group B 6 (2), Group C 1.5 (1) Time to admission to NISC – mean (median) No. of days from injury to admission: Group A 4 (1, range 24 h–5 days), Group B 33 (22, range 2–222 days), Group C 72 (24, range 9–729 days) All 102 patients had had internal fixation Fixation + fusion with bone graft 68, fixation only 22, fixation + fusion with graft + laminectomy 6, fixation + laminectomy 5	**Age:** Group A, B, C medians: 27, 35, 25 (difference not significant) Range 8–72 **Sex:** not stated **Severity:** Paraplegic/tetraplegic: Group A 12/22, Group B 17/28, Group C 10/13 (difference between groups not significant $p > 0.05$) Neurological level of tetraplegic patients – below C5/above C5: Group A 30/4, Group B 39/6, Group C 16/7 (difference between groups not significant $p > 0.05$) With associated injuries: Group A 3, Group B 9, Group C 2 (difference between groups not significant $p > 0.05$) *N*: 102 **Inclusion/exclusion criteria:** Included: patients admitted to NSIC 1990–4 with acute SCI who underwent internal spinal fixation there or in UK/Europe. Excluded: 12 decompressive laminectomy without stabilisation not aimed at early mobilisation Excluded: Eastern Europe, Asia, Africa, America and Oceania **Further details:** Although distribution of tetraplegia, neurological deficit and age were all similar (and not significant) between groups, it is not clear what the criteria are for initial admission or for transfer to NSIC. Does NSIC only initially admit difficult cases? Are only difficult cases transferred from elsewhere? (i.e. cases of early mobilisation achieved elsewhere may be omitted)	Not stated	None stated	**Authors' conclusions:** A trend of negative correlation was found between time to operation and time to mobilisation, and positive correlation between time to admission to SSIU and time to mobilisation. Long stay in bed was associated with complications, especially pressure sores. Early operation alone does not guarantee early mobilisation. To ensure early mobilisation, early spinal surgery must be supported by specialised comprehensive care

continued

Results				
General comments: Questionable whether groups are comparable, as it is not stated on what criteria transfer to NSIU is made. Statistical analysis is inadequate – regression analysis with time to mobilisation as outcome with all other factors as dependent variables would have yielded more information and allowed better investigation of inter-relationships	**Outcome 1** **Outcome:** Mean/median time to wheelchair mobilisation **Intervention:** Mean No. of days from injury: Group A 36, Group B 46, Group C 73 Median (IQ range) No. of days from injury: Group A 26 (22–24), Group B 35 (22–52), Group C 46 (27–60). Difference between groups not significant, $p > 0.05$	**Outcome 2** **Outcome:** Median time from operation to mobilisation **Intervention:** Median (IQ range) No. of days from operation: Group A 19 (9–35), Group B 31 (18–50), Group C 44 (25–67). Significant difference between groups, $p < 0.001$	**Outcome 3** **Outcome:** Mobilisation time over 77 days **Intervention:** Group A 0, Group B + C 13. Significant difference between A and B + C combined (chi-squared, $p = 0.02$)	**Outcome 4** **Outcome:** Incidence of 1+ complications **Intervention:** Group A 6, Group B 15, Group C 7. Difference not significant, $p > 0.05$
	Outcome 5 **Outcome:** Incidence of respiratory complications **Intervention:** Group A 3, Group B 2, Group C 2	**Outcome 6** **Outcome:** Incidence of pressure sores **Intervention:** Group A 0, Group B 11, Group C 3. Significant difference between A and B + C combined, $p < 0.03$		

Study details	Intervention details	Participant details	Withdrawals	Adverse events	Comments
Author (Year) Yarkony (1985)[136] **Country:** USA **Focus of study:** Both **Description of study:** Incidence of contractures following SCI: comparison between patients treated in their acute phase at an SCI specialist centre and in general hospitals. Comparison based on retrospective review of records of admissions over 2 y to a Rehabilitation Centre in the SCI Regional Care System	**Intervention:** Acute treatment at SCI centre *N*: 90 **Control:** Acute treatment elsewhere (not at a specialised SCI centre.) *N*: 91 **Duration:** Review of admissions over 2 y – no follow-up **Follow-up:** Not stated **Concomitant treatments:** Mean time from injury to admission to rehabilitation centre – SCI centre 30 days, non-centre 66 days ($p < 0.01$); overall 48 days (SD 42.25, median 35) **Comments:** Admission to an acute unit within 24 h of injury: SCI centre 86% (10% no data), non-centre no data	**Age:** mean 29 **Sex:** 149 M; 32 F **Severity:** 54% tetraplegic, 46% paraplegic 58% incomplete lesions, 42% complete *N*: 181 **Patient characteristics:** Average contractures per patient 7.5 (SD 6.22, median 6.0). Incidence of contractures for tetraplegics significantly greater ($p < 0.01$), particularly of elbow, wrists, thumb and index fingers **Inclusion/exclusion criteria:** SCI patients admitted to one Rehabilitation Centre over 2 y following acute treatment	Not stated	Not stated	**Authors' conclusions:** Patients treated in general hospitals had statistically significant increased incidence of contractures. SCI Centre treated patients were transferred sooner. An increased time from injury to rehabilitation admission correlated significantly with increased incidence of contractures. Contracture development was not related to fractures of the extremities. This evidence further supports the need for SCI Centres

continued

Results				
General comments: No data on level of lesion, completeness or Frankel by treatment group (Centre/non-Centre) so it is not clear whether groups are comparable, given that tetraplegics had higher rates of contractures. Data is given (Table 3 in text) for % incidence of abnormalities by sites in shoulder joint, shoulder complex and elbow, where no significant difference in score was found	**Outcome 1** **Outcome:** Normal range of motion on admission **Intervention:** 78% Centre **Control:** 68% non-Centre ($p < 0.05$)	**Outcome 2** **Outcome:** Incidence of significant joint abnormalities on admission **Intervention:** Significant (i.e. loss of 15% of passive motion in one key range or loss of several degrees in multiple joint planes) – 13% Centre; (no data 2% centre) **Control:** Significant – 17% non-Centre; (no data 5% centre)	**Outcome 3** **Outcome:** Incidence of mild joint abnormalities on admission **Intervention:** Mild –7% Centre; (no data 2% Centre) **Control:** Mild –10% non-Centre; (no data 5% non-Centre)	**Outcome 4** **Outcome:** Abnormality score for hip, knees and ankles. Mean score (0 for a normal joint, 1 for mild in a joint, 2 for significant) **Intervention:** Non-Centre greater than Centre ($p < 0.001$) using outcomes 5 and 6
	Outcome 5 **Outcome:** Significant abnormalities of hips, knees and ankles, % incidence right/left: **Intervention:** Centre – hip 22%/29%, knee 3%/4%, ankle 40%/32% **Control:** Non-Centre – hip 36%/33%, knee 11%/9%, ankle 56%/57%	**Outcome 6** **Outcome:** Mild abnormalities of hips, knees and ankles, % incidence right/left: **Intervention:** Centre – hip 34%/27%, knee 6%/2%, ankle 7%/8% **Control:** Non-Centre – hip 35%/36%, knee 12%/10%, ankle 7%/9%	**Outcome 7** **Outcome:** Significant abnormalities of shoulder joint (abduction; internal rotation; external rotation), shoulder complex (extension; flexion; abduction) and elbow, % incidence right/ left: **Intervention:** Centre – shoulder joint 12%/16%; 24%/22%; 18%/19% Shoulder complex 4%/7%; 30%/28%; 30%/30% Elbow 1%/1% **Control:** Non-Centre – shoulder joint 9%/10%; 29%/23%; 15%/19% Shoulder complex 7%/2%; 34%/33%; 26%/32% Elbow 1%/1%	**Outcome 8** **Outcome:** Mild abnormalities of shoulder joint (abduction; internal rotation; external rotation), shoulder complex (extension; flexion; abduction) and elbow, % incidence right/ left: **Intervention:** Centre – shoulder joint 2%/4%; 11%/8%; 6%/4% Shoulder complex 2%/1%; 8%/10%; 6%/3% Elbow 8%/6% **Control:** Non-Centre – shoulder joint 7%/3%; 8%/8%; 9%/3% Shoulder complex 1%/0; 8%/13%; 12%/9% Elbow 15%/12%

Appendix 4

Validity assessment

Check-list for assessing economic evaluations

1. **Was a well-defined question posed in answerable form?**
   - 1.1 Did the study examine both costs and effects of the service(s) or programme(s)?
   - 1.2 Did the study involve a comparison of alternatives?
   - 1.3 Was a viewpoint for the analysis stated and was the study placed in any particular decision-making context?

2. **Was a comprehensive description of the competing alternatives given? (i.e. can you tell who? did what? to whom? where? and how often?)**
   - 2.1 Were any important alternatives omitted?
   - 2.2 Was (should) a *do-nothing* alternative (be) considered?

3. **Was the effectiveness of the programmes or services established?**
   - 3.1 Was this done through a randomised, controlled clinical trial? If so, did the trial protocol reflect what would happen in regular practice?
   - 3.2 Was effectiveness established through an overview of clinical studies?
   - 3.3 Were observational data or assumptions used to established effectiveness? If so, what are the potential biases in results?

4. **Were all the important and relevant costs and consequences for each alternative identified?**
   - 4.1 Was the range wide enough for the research question at hand?
   - 4.2 Did it cover all relevant viewpoints? (Possible viewpoints include the community or social viewpoint, and those of patients and third-party payers. Other viewpoints may also be relevant depending upon the particular analysis.)
   - 4.3 Were capital costs, as well as operating costs, included?

5. **Were costs and consequences measured accurately in appropriate physical units? (e.g. hours of nursing time, number of physician visits, lost work-days, gained life-years)**
   - 5.1 Were any of the identified items omitted from measurement? If so, does this mean that they carried no weight in the subsequent analysis?
   - 5.2 Were there any special circumstances (e.g. joint use of resources) that made measurement difficult? Were these circumstances handled appropriately?

6. **Were costs and consequences valued credibly?**
   - 6.1 Were the sources of all values clearly identified? (Possible sources include market values, patient or client preferences and views, policy-makers' views and health professionals' judgements.)
   - 6.2 Were market values employed for changes involving resources gained or depleted?
   - 6.3 Where market values were absent (e.g. volunteer labour), or market values did not reflect actual values (such as clinic space donated at a reduced rate), were adjustments made to approximate market values?
   - 6.4 Was the valuation of consequences appropriate for the question posed? (i.e. Has the appropriate type or types of analysis – cost-effectiveness, cost–benefit, cost–utility – been selected?)

7. **Were costs and consequences adjusted for differential timing?**
   - 7.1 Were costs and consequences which occur in the future 'discounted' to their present values?
   - 7.2 Was any justification given for the discount rate used?

8. **Was an incremental analysis of costs and consequences of alternatives performed?**
   - 8.1 Were the additional (incremental) costs generated by one alternative over another compared to the additional effects, benefits or utilities generated?

9. **Was allowance made for uncertainty in the estimates of costs and consequences?**
   - 9.1 If data on costs or consequences were stochastic, were appropriate statistical analyses performed?

9.2 If a sensitivity analysis was employed, was justification provided for the ranges of values (for key study parameters)?
9.3 Were study results sensitive to changes in the values (within the assumed range for sensitivity analysis, or within the confidence interval around the ratio of costs to consequences)?

10. Did the presentation and discussion of study results include all issues of concern to users?
10.1 Were the conclusions of the analysis based on some overall index or ratio of costs to consequences (e.g. cost-effectiveness ratio)? If so, was the index interpreted intelligently or in a mechanistic fashion?
10.2 Were the results compared with those of others who have investigated the same question? If so, were allowances made for potential differences in study methodology?
10.3 Did the study discuss the generalisability of the results to other settings and patient/client groups?
10.4 Did the study allude to, or take account of, other important factors in the choice or decision under consideration (e.g. distribution of costs and consequences, or relevant ethical issues)?
10.5 Did the study discuss issues of implementation, such as the feasibility of adopting the 'preferred' programme given existing financial or other constraints, and whether any freed resources could be redeployed to other worthwhile programmes?

Quality checklist for RCTS (based on CRD Report No. 4[14])

1. Was the method used to assign participants to the treatment groups really random? (Computer-generated random numbers and random number tables will be accepted as adequate, while inadequate approaches will include the use of alternation, case record numbers, birth dates or days of the week).
2. Was the allocation of treatment concealed? (Concealment will be deemed adequate where randomisation is centralised or pharmacy-controlled, or where the following are used: serially numbered containers, on-site computer-based systems where assignment is unreadable until after allocation, other methods with robust methods to prevent foreknowledge of the allocation sequence to clinicians and patients. Inadequate approaches will include the use of alternation, case record numbers, days of the week, open random number lists and serially numbered envelopes even if opaque.)
3. Was the number of participants who were randomised stated?
4. Were details of baseline comparability presented in terms of duration of illness, diagnosis, age, gender?
5. Were the eligibility criteria for study entry specified?
6. Were any co-interventions identified that may influence the outcomes for each group?
7. Were the outcome assessors blinded to the treatment allocation?
8. Were the individuals who were administered the intervention blinded to the treatment allocation?
9. Were the participants who received the intervention blinded to the treatment allocation?
10. Was the success of the blinding procedure assessed?
11. Were at least 50% of the participants originally included in the randomisation process followed up in the final analysis?
12. Were the reasons for any withdrawals stated?
13. Was an intention to treat analysis included?
14. Was an appropriate dose of the comparator drug given?
15. Did the trial include an adequate washout period?

Items will be graded in terms of ✓ yes (item properly addressed), × no (item not properly addressed), ✓-× partially (item partially addressed), **?** unclear or not enough information, or **NA** not applicable.

Quality assessment of cohort studies (based on Crombie 1996[832])

Is the group studied clearly stated?
Was there any control group and, if not, was this appropriate?
Was the follow-up adequate?
Were the aims clearly stated?
Was the study design appropriate?
Was the sample size appropriate?
Were the measurements valid and reliable?
Were the outcome measures appropriate?
Were all participants accounted for?
Were the statistical methods appropriate and well described?

Validity of fixation studies

Study	Groups described?	Groups similar at baseline?	Treatment details reliable?	Comparable on confounding factors?	Adjust for confounding factors?	Dose response?	Outcomes blind?	Follow-up long enough?	Follow up? (%)	Drop-out rates?	Control group?	Comments
Ahn, 1984[96]	No	Yes	No	Unclear	Not stated	Not stated	Not stated	Unclear	100	Not stated	Unclear	Unclear whether the groups were matched
An 1991[57]	Yes	No	Yes	No	No	Not stated	Not stated	Yes	87	Unclear	No	Dropout rate reported over all groups, treatment determined by type of injury
Argenson 1989[97]	Yes	No	Yes	No	No	Not stated	Not stated	Yes	59	Yes	No	Treatment determined by type of injury. Not all had SCI
Arima, 1994[35]	Yes	Yes	Partially	Unclear	Not stated	Not stated	Not stated	Yes	100	Not stated	Unclear	Only 3 patients in the comparison group
Asazuma, 1996[34]	Partially	Yes	Yes	Unclear	Not stated	Not stated	Not stated	Yes	100	Not stated	Unclear	
Bohlman, 1985[43]	Partially	Yes	Yes	Unclear	Not stated	Not stated	Not stated	Yes	85	Unclear	Unclear	Some patients were not operated on until months/years later
Bucci, 1988[82]	Yes	Yes	Partially	Unclear	Not stated	Not stated	Not stated	Unclear	100	Not stated	Unclear	
Bucholz, 1989[79]	Yes	No	Yes	No	Not stated	Not stated	Not stated	Unclear	Not reported	Not stated	Unclear	Patients only received surgery if they failed halo immobilisation
Burke, 1976[60]	Yes	Yes	Yes	Yes	Not stated	Not stated	Not stated	Unclear	100	Not stated	Not stated	
Carvell, 1994[7]	Partially	Yes	No	Unclear	Not stated	Not stated	Not stated	Not stated	100	Not stated	Unclear	

continued

Study	Groups described?	Groups similar at baseline?	Treatment details reliable?	Comparable on confounding factors?	Adjust for confounding factors?	Dose response?	Outcomes blind?	Follow-up long enough?	Follow up? (%)	Drop-out rates?	Control group?	Comments
Chahal, 1990[61]		Unclear						Yes	Not stated			
Chen, 1997[62]												Difficult to extract data from this study – mainly narrative
Daneyemez, 1999[36]	No	Unclear	No	No	Not stated	Not stated	Not stated	Unclear	90	Not stated	Unclear	Pretty useless study!
Denis, 1982[54]	Not stated	Not stated	Not stated	Not stated	Not stated	Not stated	Not stated	Yes	100	Not stated	Unclear	Abstract – very little detail and results reported
Donovan, 1987[44]												
Donovan, 1992[37]	Yes	Yes	Partially	Unclear	Not stated	Not stated	Not stated	Yes	100	Not stated	Unclear	
Dosen 1972[63]	Yes	Yes	Yes	Unclear	No	Not stated	Not stated	Yes	99	Unclear	Unclear	
Duh, 1994[64]	No	Yes	Unclear	Yes	Yes	Not stated	Unclear	Yes	Unclear	Not stated	Yes	Unclear how many patients underwent surgery. Patient demographics are not reported
Ectors 1971[142]	Partially	Unclear	Yes	Unclear	No	Not stated	Not stated	Yes	Not stated	Not stated	Unclear	Most results not reported separately for operative and non-operative groups
Fang, 1982[53]	Partially	Yes	Yes	Unclear	Not stated	Not stated	Not stated	Yes	100	Not stated	Unclear	Small groups, lack of expertise in SI, so results are of limited applicability

continued

Study	Groups described?	Groups similar at baseline?	Treatment details reliable?	Comparable on confounding factors?	Adjust for confounding factors?	Dose response?	Outcomes blind?	Follow-up long enough?	Follow up? (%)	Drop-out rates?	Control group?	Comments
Gardner, 1988[88]	No	Unclear	No	No	Not stated	Not stated	Not stated	Unclear	100	Not stated	No	No patient characteristics were reported
Gerard 1977[143]	No	Unclear	Yes	Unclear	No	Not stated	Not stated	Yes	Unclear	Unclear	Unclear	
Guthkelch, 1987[58]	No	Yes	Partially	Unclear	Not stated	Not stated	Not stated	Unclear	100	Not stated	Unclear	Only included 25 SCI patients and very little information was reported for this subgroup
Hamel, 1977[87]	No	Yes	No	Unclear	Not stated	Not stated	Not stated	Not stated	100	Not stated	Unclear	Old study – type of surgery may be outdated
Hardcastle, 1987[91]												
Heiden, 1975[65]												
Jacobs, 1980[45]	Yes	No	Partially	Unclear	Not stated	Not stated	Not stated	Unclear	100	Not stated	Unclear	Patient characteristics were not well described
Jodoin, 1985[89]												
Kiwerski, 1993[39]	Yes	Yes	No	No	Not stated	Not stated	Not stated	Not stated	100	Not stated	Not stated	Groups are not comparable

continued

Study	Groups described?	Groups similar at baseline?	Treatment details reliable?	Comparable on confounding factors?	Adjust for confounding factors?	Dose response?	Outcomes blind?	Follow-up long enough?	Follow up? (%)	Drop-out rates?	Control group?	Comments
Kiwerski, 1993[66]												Problem of switch of treatment regime over time, so group comparability questionable. Perhaps can compare early non-surgery with later surgery on basis that nearly all were allocated these treatments in these periods
Kiwerski, 1986[38]												
Koivikko, 2000[46]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	100			Probable confounding by higher proportion receiving high-dose steroid therapy in treatment group
Koning, 1989[47]	No	Unclear	No	Unclear	Not stated	Not stated	Not stated	Partially	Unclear	Not stated	Unclear	Very few data reported. Some useful data were not extractable from graphs and diagrams
Lemons, 1993[86]	Yes	Yes	Partially	Unclear	Not stated	Not stated	Not stated	Yes	100	Not stated	Unclear	Does not properly compare surgical and non-surgical treatments
Lewis, 1974[67]	Partially								66			

continued

Study	Groups described?	Groups similar at baseline?	Treatment details reliable?	Comparable on confounding factors?	Adjust for confounding factors?	Dose response?	Outcomes blind?	Follow-up long enough?	Follow up? (%)	Drop-out rates?	Control group?	Comments
Lifeso, 1985[48]												Controls were treated earlier than surgical patients (before introduction of Harrington rods) so there may have been other differences in care
Lifeso, 2000[55]	Partially	Yes	Yes	Unclear					94		Not stated	Controls not concurrent for anterior surgery group
Loembe, 1991[144]	Yes	No	Yes	No	No	Not stated	Not stated	Yes	100	Not stated	No	Treatment was decided by level and severity of lesion
Lucas, 1977[68]	Partially	Yes	Yes	Unclear	Not stated	Not stated	Not stated	Yes		Not stated	Unclear	Overall *N* and *N* for control group unknown, and control treatment unknown
Lui, 1998[92]	Partially	Yes	Yes	Unclear	Not stated	Not stated	Not stated	Yes	100	Not stated	Unclear	20 out of 28 patients had normal muscle power
Marshall, 1987[83]	Yes	Unclear	No	Unclear	Not stated	Not stated	Not stated	Unclear	100	Not stated	Not stated	Very few useful data reported
Meinecke, 1990[69]	Yes		No	Unclear	Not stated	Not stated	Not stated	Yes		Not stated	Not stated	The results have to be treated with caution as no reliable information is given. Apart from misleading figures and tables there seems to be a large proportion of attrition, resp. varying *N* in the figures, which is not addressed in the text

continued

Study	Groups described?	Groups similar at baseline?	Treatment details reliable?	Comparable on confounding factors?	Adjust for confounding factors?	Dose response?	Outcomes blind?	Follow-up long enough?	Follow up? (%)	Drop-out rates?	Control group?	Comments
Murphy, 1990[40]	Yes	Yes	Yes	No	Not stated	Not stated	Not stated	Unclear	100	Not stated	Yes	Patients were divided into four unmatched groups, and selected for surgical treatment
Odendaal, 1991[49]	Yes	Yes	Yes	Unclear	Not stated	Not stated	Not stated	Yes	99	Not stated	Unclear	Only 7 patients in the comparison group
Osenbach, 1992[95]	Yes	Yes	No	Unclear	Not stated	Not stated	Not stated	Not stated	100	Not stated	Unclear	No useful results reported
Ostl, 1989[50]	Partially	Yes	Yes	Unclear	Not stated	Not stated	Not stated	Partially	Unclear	Not stated	Unclear	Some patients in the control received surgery. Not clear whether the control group was matched to the surgery group
Petitjean, 1995[71]	No	Yes	No	No	Not stated	Not stated	Not stated	Yes	100	Not stated	Unclear	Late surgery and conservative treatment group results were reported together
Place, 1994[85]	Yes	Yes	Partially	Partially	Not stated	Not stated	Not stated	Yes	97	Unclear	Unclear	Two patients appeared to be lost to follow-up but no explanation given
Prasad, 1995[41]	Yes	Yes	Yes	No	Not stated	Not stated	Not stated	Yes	100	Not stated	Unclear	Operative and non-operative groups were not matched
Rockswold, 1990[72]	Yes	Yes	Yes	Unclear	Not stated	Not stated	Not stated	Yes	100	Not stated	Not stated	Very few independent outcome data reported for the SCI subgroup

continued

Study	Groups described?	Groups similar at baseline?	Treatment details reliable?	Comparable on confounding factors?	Adjust for confounding factors?	Dose response?	Outcomes blind?	Follow-up long enough?	Follow up? (%)	Drop-out rates?	Control group?	Comments
Senegas 1976[73]	Yes	Yes	Yes	Unclear	No	Not stated	Not stated	Partially	Unclear	Not stated	Yes	
Sonntag, 1981[75]	Yes	Yes	Yes	Unclear	Not stated	Not stated	Not stated	Yes	87	Not stated	Unclear	Only included 15 patients
Soreff, 1982[59]	Yes	Yes	Partially	No	Not stated	Not stated	Not stated	Unclear	100	Not stated	No	Surgery group included patients without neurological deficit
Sved, 1997[93]												Follow-up rates poor and no details given of who was lost to follow-up. Not much detail on extent of injury to ensure comparability
Takayanagi, 1995[98]	No	Unclear	No	Unclear	Not stated	Not stated	Not stated	Yes	100	Not stated	Unclear	Only 6 patients in each group
Tator, 1987[145]	Yes	Yes	Yes	Yes	Yes	Not stated	Not stated	Yes	86	Unclear	Yes	
Vaccaro, 2001[56]	Partially								100			
Waters, 1996[76]	Yes	Unclear	No	Unclear	Not stated	Not stated	Not stated	Unclear	100	Not stated	Unclear	
Wilberger, 1993[80]	No	Unclear	No	Unclear	Not stated	Not stated	Not stated	Unclear	Not reported	Not stated	Unclear	Abstract – very few details reported
Willen, 1983[77]	Partially								86			
Willen, 1985[81]	Yes	Yes	Partially	Yes	Not stated	Not stated	Not stated	Yes	100	Not stated	No	

continued

Study	Groups described?	Groups similar at baseline?	Treatment details reliable?	Comparable on confounding factors?	Adjust for confounding factors?	Dose response?	Outcomes blind?	Follow-up long enough?	Follow up? (%)	Drop-out rates?	Control group?	Comments
Wilmot, 1986[42]	Partially	Unclear	Yes	Unclear	Not stated	Not stated	Not stated	Unclear	100	Not stated	Not stated	Patients appear to have been selected for surgery based on severity of injury
Wilmot, 1986[51]	Partially	No	No	Partially	Not stated	Not stated	Not stated	Unclear	96	Not stated	No	Surgical patients more severely injured than non-surgical?
Yablon, 1989[94]	No	Yes	Yes	Unclear	Not stated	Not stated	Not stated	Yes	100	Not stated	Unclear	
Yablon, 1991[78]	Yes	Yes	Yes	Yes	Not stated	Not stated	Not stated	Yes	100	Not stated	No	
Young, 1978[52]	Partially	Yes	Yes	Unclear	Not stated	Not stated	Not stated	Yes		Not stated	unclear	

Validity of referral studies

Study	Groups described?	Groups similar at baseline?	Treatment details reliable?	Comparable on confounding factors?	Adjust for confounding factors?	Dose response?	Outcomes blind?	Follow-up long enough?	Follow up? (%)	Drop-out rates?	Control group?	Comments
Aito, 2000[124]	No	Not clear	Yes	Not stated	Not stated	Not stated	No	Not stated	Not stated	Not stated	Not clear	Very poor study with inadequate description and inadequate reporting of data
Aung, 1997[5]	Partially	No	Yes	Not clear	No	Not stated	Not stated	Yes	Not stated	Not stated	Yes	
Bravo-Payno, 1992[125]	Yes	Yes	Yes	Partially	Partially	No	Not stated	Not stated	Not stated	Not stated	Yes	
Carvell, 1989[6]	Not clear	Not clear	Not stated	Not clear	No	Not stated	Not stated	Not stated	Not stated	Not stated	Not clear	Letter describing retrospective review, no sample size given
Dalyan, 1998[126]	Partially	Yes	Not stated	Not clear	Not stated	Not stated	Not stated	Not clear	100	Not stated	Not stated	
DeVivo, 1990[123]	No	Yes	Yes	Yes	Partially	Not stated	Not stated	Not stated	100 (incomplete data excluded)	No	Yes	
Donovan, 1984[127]	Partially	Yes	Yes	Partially	No	Not clear	No	Yes	Not stated	Not stated	Yes	
Gardner, 1986[128]	Partially	Not clear	No	Not stated	Not stated	Not stated	Not stated	Yes	55	Not stated	Not stated	No control group as such. Patients not split into those receiving ventilator before or after entry to the specialist unit

continued

Study	Groups described?	Groups similar at baseline?	Treatment details reliable?	Comparable on confounding factors?	Adjust for confounding factors?	Dose response?	Outcomes blind?	Follow-up long enough?	Follow up? (%)	Drop-out rates?	Control group?	Comments
Heinemann, 1989[129]	Yes	Yes	Yes	Partially	No	No	Not stated	Not stated	Not stated	Not clear	Yes	
Kiwerski, 1981[130]	Partially	No	Not clear	No	No	Not clear	Not stated	Not stated	Not clear	Not clear	Yes	States that includes only patients with complete SCIs but also includes incomplete
Meyer, 1987[137]	Unclear	Yes	Unclear	Unclear	No	Not stated	Not stated	Not stated	Not reported	Not stated	Yes	
Oakes, 1990[131]	Partially	Yes	Yes	Not clear	No	No	No	Yes	Not stated	Not stated	Yes	Problem of group comparability. Late transfers to Centre may well not be comparable as they may be only difficult cases
Ohry, 1983[132]	Partially	No	No	Unclear	No	Not stated	Not stated	Unclear	100	Not stated	Unclear	No details reported for the 110 patients without gibbus formation (i.e. delay to admission)
Richardson, 1981[133]	Partially	Partially	Yes	Yes	Not stated	Not clear	Not clear	Not clear	Not stated	Not clear	Yes	
Selecki, 1986[134]	Partially	Yes	Yes	Not clear	Not stated	Not stated	Not stated	Not stated	100	Not stated	Not clear	
Soopramanien, 1994[138]	Yes	Yes	Yes	Not stated	Not stated	Not stated	Not stated	Not stated	100	Not stated	Not stated	Epidemiology study
Tator, 1995[135]	Partially	Yes	Yes	Yes	Yes	Not stated	No	Yes	100	Not stated	No	

continued

Study	Groups described?	Groups similar at baseline?	Treatment details reliable?	Comparable on confounding factors?	Adjust for confounding factors?	Dose response?	Outcomes blind?	Follow-up long enough?	Follow up? (%)	Drop-out rates?	Control group?	Comments
Wang, 2001[140]	Partially	Yes	Yes	Not clear	Not stated	Not stated	No	Not stated	Not stated	Not stated	Yes	Criteria for transferring patients to NSIU from elsewhere not stated, affecting group comparability
Yarkony, 1985[136]	Not clear	Yes	Yes	Not stated	No	Not stated	No	Yes	Not stated	Not stated	Yes	Uncertainty about group comparability and no attempt to analyse taking confounders into account

Appendix 5

Critical appraisal of systematic reviews of steroids in spinal cord injury

Cochrane review

Bracken MB. Pharmacological interventions for acute spinal cord injury (Cochrane review). In The Cochrane Library, Issue 3, 2002. Oxford: Update Software; 2002.

What was the author's objective?
To collate and review randomised trials of steroids for acute SCI.

Specific interventions included in the review
Steroids [Methylprednisolone sodium succinate (MPSS); naloxone; IM Depo-Medrol] alone or combined with bupivicaine, compared to placebo, no treatment, tirilizad mesylate, nimodipine or bupivicaine alone.

Participants included in the review
Patients admitted to medical centres with a diagnosis of acute SCI. The review includes trials of patients with whip lash injury and those being treated for lumbar disc disease. Included trials imposed their own eligibility restrictions: for example, excluding patients of young age, with gunshot injuries or with severe co-morbidity – particularly severe head trauma. Most acute SCI trials excluded patients with only nerve root damage or cauda equina.

Outcomes assessed in the review
Neurological recovery of motor function at 6 weeks, 6 months and 1 year, mortality and incidence of infections.

Study designs of evaluations included in the review
True or quasi-RCTs were eligible for inclusion. All included trials were true RCTs.

What sources were searched to identify primary studies?
The search strategy developed by the Cochrane Injuries Group was used. Over 40 journals and conference abstracts were hand searched. The files of the National Acute Spinal Cord Injury Study were also searched for trials. This organisation was founded in 1977 and has tracked trials in this area. In addition, MEDLINE was searched using PubMed from 1966 to December 2001 using the terms randomised controlled trial, acute SCI, spinal injury, steroids and corticosteroids, with no limits.

On what criteria was the validity of primary studies assessed?
The quality of trials was assessed using methodology developed by the Cochrane Neonatal Review Group. This considers whether the intervention was blinded, whether people evaluating outcome are blinded, how many subjects were followed up and the quality of the randomisation process. More details can be found in Sinclair and Bracken 1992 (see Other publications of related interest, No. 1).

How were decisions on the relevance of primary studies made?
One reviewer selected the trials.

How were judgements of validity made?
One reviewer assessed the validity of the trials.

How were the data extracted from primary studies?
One reviewer extracted the data. Data were extracted on participants, interventions, outcomes, study design and setting and results.

Number of studies included
Eight RCTs (n = 1698).

How were the studies combined?
The weighted mean difference of neurological improvement scores was computed with 95% confidence intervals. For mortality and morbidity the relative risk and 95% confidence intervals were computed. A fixed effects model was assumed. The author states that the different treatment arms under study, as well as variation in the definition of outcomes, precluded any analysis across different trials except for a comparison of 180-day mortality in the two trials using very high-dose methylprednisolone.

How were differences between studies investigated?

The (chi-squared) heterogeneity test was examined to assist in decisions whether or not to produce typical estimates of effect.

Results of the review

Six out of eight trials were of high-quality and two were of moderate quality. The high quality trials used central randomisation and double-blinding and followed up a large proportion of study participants. The moderate-quality trials randomised to standard treatment (without placebo) or active drug and one experienced significant loss to follow-up.

Moderate- versus low-dose methylprednisone, 10-day regimen (one trial)

This trial found no difference in the neurological outcome scores at 6 weeks, 6 months or 1 year. Because of subsequent interest in the 8-hour therapeutic window for commencing therapy, an *ex post facto* analysis of patients who initiated therapy within this time window is examined in this review. There is a trend for patients treated with the high-dose regimen to recover more than those on the low-dose regimen at all three follow-up periods and on all three neurological parameters. None of these changes reached the nominal $p < 0.05$ level of statistical significance.

All-cause mortality, wound infection, GI haemorrhage and sepsis were examined. Only wound infection was elevated in the high dose regimen (RR = 3.50, 95% CI 1.18 to 10.41).

High-dose methylprednisolone versus placebo or none, 24-hour regimen (three trials)

There is no effect of methylprednisolone on motor function. For the NASCIS 2 trial an *a priori* hypothesis was proposed to examine patients treated early versus late. The 8-hour window was established based on it being close to the median time to treatment. The other two trials restricted patient eligibility to entry within 8-hours of injury. When the analysis is restricted to patients treated within the 8-hour window, high-dose methylprednisolone resulted in greater motor function recovery at 6 weeks, 6 months and the final outcome (which differed among the trials) (WMD = 4.06, 95% CI 0.58 to 7.55).

Pinprick sensation was significantly improved in all patients at 6 months (WMD = 3.37, 95% CI 0.74 to 6.00) but not at 1 year. Among patients treated within 8 hours these differences were enhanced at 6 months but were not different at 1 year. Light touch sensation showed a similar pattern of results as pinprick.

All-cause mortality, wound infection and GI haemorrhage did not differ between the two comparison groups.

High-dose methylprednisolone for 48 versus 24 hours (one trial)

There was a trend for greater motor function improvement in the 48-hour treated patients but at none of the follow-up periods did these differences reach statistical significance. In this trial, an *a priori* hypothesis proposed to examine patients initiating therapy early versus late within the overall 8-hour window of eligibility. The median of 3 hours was selected for a cut-off point. Patients treated within 3 hours after injury did not differ in their recovery from 24- or 48-hour methylprednisolone. Patients treated 3–8 hours improved more motor function if treated with 48-hour methylprednisolone. No meaningful differences were observed for pinprick or touch sensation in the full analysis or in those treated at 3–8 hours at any of the follow-up periods.

Severe pneumonia and severe sepsis tended to be elevated in the 48-hour treated patients but overall mortality at 1 year was not.

High-dose methylprednisolone for 23 hours versus nimodipine for 7 days (one trial)

No meaningful observations could be made from these comparisons because of very high variability in the data.

In the whiplash trial, the identical regimen of methylprednisolone to that administered in NASCIS 2 was found to result in fewer disabling symptoms ($p = 0.047$), fewer sick days ($p = 0.01$) and a healthier sick leave profile ($p = 0.003$) at 6 months post injury.

For patients treated with methylprednisolone at the time of their discectomy for lumbar disc disease (one trial), their hospital stay was significantly shorter than patients not so treated (1.4 versus 4.0 days, $p = 0.0004$).

Was any cost information reported?

No.

Author's conclusions

High-dose methylprednisolone steroid therapy is the only pharmacological therapy shown to have efficacy in a Phase 3 randomised trial when it can be administered within 8 hours of injury. A recent

trial indicates additional benefit by extending the maintenance dose from 24 to 48 hours if start of treatment must be delayed to between 3 and 8-hours after injury.

There is an urgent need for more randomised trials of pharmacological therapy for acute SCI.

CRD commentary

As a Cochrane review, the research question and study inclusion criteria for this review were explicit and seem appropriate. Details of the search strategy are not entirely clear but the search is likely to be comprehensive and it is unlikely that studies will have been missed (our own comprehensive searches found no extra RCTs). Validity assessment seems appropriate for RCTs but could have been more detailed. Details of included studies are presented and the decision not to pool for most outcomes seems sound. The main drawback of this review is that only one reviewer was involved in study selection, validity assessment and data extraction, which increases the likelihood of errors. However, this review has been extensively peer-reviewed and revised in accordance with comments published about the first version (see Other publications of related interest, No. 2).

The author's conclusions follow from the results presented.

What are the implications of the review?

Implications for practice

The author states that methylprednisolone sodium succinate has been shown to enhance sustained neurological recovery in a Phase 3 randomised trial, and to have been replicated in a second trial. Therapy must be started within 8 hours of injury using an initial bolus of 30 mg kg^{-1} by IV for 15 minutes followed 45 minutes later by a continuous infusion of 5.4 mg kg^{-1} h^{-1} for 24 hours. Further improvement in motor function recovery has been shown to occur when the maintenance therapy is extended for 48 hours. This is particularly evident when the initial bolus dose could only be administered 3–8 hours after injury.

Implications for research

The author states that methylprednisolone treatment improves neurological recovery but is unlikely to bring a return to normal function unless there is minimal initial deficit. More research is needed to examine whether different MPSS protocols would achieve even more recovery. It is likely that future trials will be able to examine concurrent pharmacologic therapies (sometimes called drug cocktails) or sequential therapies which operate on different aspects of the secondary injury processes ranging from early neurone protection to nerve regeneration in the chronic patient. In this respect, GM-1 has been administered after initial management by methylprednisolone as the two drugs do not appear to compete with each other and have different pharmacological properties. GM-1 does not appear to lead to permanently improved neurological recovery but further research with extended drug administration is warranted.

Other publications of related interest

1. Sinclair JC, Bracken MB, editors. Effective care of the newborn infant. Oxford: Oxford University Press; 1992. p. 9.
2. Bracken MB. Pharmacological interventions for acute spinal cord injury (Cochrane review). In The Cochrane Library, Issue 3, 2001. Oxford: Update Software; 2001.

Other review

Short DJ, Masry WSE, Jones PW. High dose methylprednisolone in the management of acute spinal cord injury – a systematic review from a clinical perspective.

What was the author's objective?

To evaluate the evidence for an effect of high-dose methylprednisolone (MPSS) on neurological improvement following acute traumatic spinal cord injury (ASCI).

Specific interventions included in the review

High-dose (short-duration) methylprednisolone, or equivalent dexamethasone, given within hours (maximum 12) following SCI. All the included studies employed high-dose methylprednisolone given as a 30 mg kg^{-1} bolus, then 5.4 mg kg^{-1} h^{-1} for 23 hours. In the RCTs, the comparison was a placebo, no treatment or nimodipine.

Participants included in the review

People with acute traumatic ASCI. Only one study stated that participants were aged between 15 and 65 years.

Outcomes assessed in the review

Outcome measures had to be reported separately for steroid and non-steroid treated groups. The

primary outcome was standardised neurological examination or neurological function (i.e. admission or pretreatment neurological impairment and post treatment assessment). Secondary outcomes were acute mortality and early morbidity. Outcomes were assessed at varying intervals with the final follow-up being 1 year.

Study designs of evaluations included in the review

RCTs, non-RCTs, prospective cohort studies, retrospective cohort studies and case series were included. Inclusion criteria for study designs were not specified *a priori*.

What sources were searched to identify primary studies?

MEDLINE was searched from 1966 to December 1999 using the search terms 'spinal cord injury', and 'methylprednisolone' or 'spinal cord injury' and 'dexamethasone' with no other restrictions. The Cochrane review as published in 1998 was searched for references (see Other publications of related interest, No. 1). Reference lists from recent publications, cross-checking with previous reviews and personal reference files were also used.

On what criteria was the validity of primary studies assessed?

Validity of RCTs was assessed using the guides of Guyatt *et al*. (see Other publications of related interest, No. 2); criteria were details of randomisation, loss to follow-up, intention to treat analysis, blinding, group comparability at baseline, equal treatment of groups. Validity of cohort studies was assessed using the method of Loblaw and Laperriere (see Other publications of related interest, No. 3); criteria were description of inception cohort, selection of cohort, sources of bias, similarity of cohorts, similarity of treatment of cohorts. The authors state that studies of questionable validity were excluded.

How were decisions on the relevance of primary studies made?

The electronic data set generated by the MEDLINE search was searched manually by title and abstract on-screen and references selected. These printed citations were re-reviewed and the full articles obtained where necessary for clarification. The authors do not state how many of the reviewers performed the selection.

How were judgements of validity made?

The authors do not state how judgements of validity were made or how many reviewers performed the validity assessment.

How were the data extracted from primary studies?

The authors do not state how data were extracted from studies or how many of the reviewers performed the data extraction. Data were not presented in tables but were described in a narrative for each included study. Data were extracted on participants, interventions and dosage, study design, follow-up, outcomes and results.

Number of studies included

Two RCTs (n = 593), one RCT/controlled trial (n = 158), two concurrent cohort studies (n = 434), four historical cohort studies (n = 882). Two of the historical cohort studies were about penetrating/gunshot spinal cord injuries (n = 506). A further 12 studies of animals were included in the discussion but these were not addressed in this abstract.

How were the studies combined?

The studies were combined narratively using levels of evidence to group by study design for primary outcomes. Secondary outcomes were presented in a table. No pooling was undertaken.

How were differences between studies investigated?

Interventions and participants were similar and outcomes were presented according to study design. Results for studies involving gunshot wounds were presented separately. No formal test was used for assessing heterogeneity.

Results of the review

Study quality

None of the included studies measured up fully to current standards for study design, conduct of trial, analysis and presentation. Many did not include a justification for sample size, were unclear about their method of randomisation and did not include a discussion of clinical versus statistical significance.

Neurological outcomes

In both RCTs, no differential effect between groups was seen on motor scores at any time point. In one RCT, sensory scores were significantly better in the MPSS group at 6 months but not at 6 weeks or 1 year. The controlled study, the two concurrent cohort studies and the two historical cohort studies of gunshot wounds also found no significant differences in neurological recovery between treatment groups. One historical cohort study did not measure neurological outcomes and one reported a significantly better

level of mobility in the non-steroid group than in the steroid group on discharge from hospital ($p < 0.05$).

Acute mortality
Five studies report this outcome; there do not appear to be any significant differences between steroid and non-steroid groups.

Morbidity
Five studies report this outcome. One historical cohort study found that incidence of pneumonia was significantly higher in the steroid than the non-steroid group. One RCT found the incidence of hyperglycaemia was significantly higher in the steroid than the non-steroid group.

Duration of ventilation
One RCT and one historical cohort study report this outcome. The historical cohort study found that duration of ventilation was significantly more in the steroid than the non-steroid group. The RCT found no difference between groups.

Intensive care length of stay
One RCT and one historical cohort study report this outcome. The historical cohort study found that length of stay in intensive care was significantly more in the steroid than the non-steroid group. The RCT found no difference between groups.

Was any cost information reported?
No.

Authors' conclusions
The evidence produced by this systematic review does not support the use of high-dose methylprednisolone in ASCI to improve neurological recovery. A deleterious effect on early mortality and morbidity cannot be excluded by this evidence. The use of MPSS as a positive control is not justified by the evidence available. The lack of a placebo control group potentially compromises research methodology and progress in the management of ASCI.

CRD commentary
The review question was focused on high-dose methylprednisolone administration within 12 hours of injury (more focused than the Cochrane review). However, the inclusion of all study designs probably weakens the validity of the review; even though evidence from different study designs was presented separately for the neurological outcomes, the results for mortality and morbidity are not so reliable. Another major weakness is the literature search, which was not comprehensive and was supplemented by an old version of the Cochrane review. There are seven RCTs in the Cochrane review which would seem to meet inclusion criteria for this review but only three are included here. Validity assessment was done well and results presented. Study details are also well presented in the text. The method of pooling seems appropriate, given the differences in study designs. No details are given of how many reviewers were involved in the review process. The authors' conclusions do follow from the results as presented in this review, but do not necessarily follow from the evidence, some of which is known to be missing from this review.

What are the implications of the review?
Practice
The authors state that on the basis of this review, it would be recommended that the administration of high-dose MPSS within 8 or 12 hours of injury should be excluded from consideration as an intervention for ASCI.

Research
The authors do not state any implications for further research.

Other publications of related interest
1. Bracken MB. Pharmacology for spinal cord injury. Pharmacologic treatment of acute spinal cord injury. In: The Cochrane Library, Issue 4, 1998. Oxford: Update Software; 1998.
2. Guyatt GH, Sackett DL, Cook DJ. Users' guides to the medical literature. *JAMA* 1993; **270**:2598–601.
3. Loblaw DA, Laperriere NJ. Emergency treatment of malignant extradural spinal cord. Compression: an evidence-based guideline. *J Clin Oncol* 1998;**16**:1613–24.

Appendix 6

Excluded studies

Study	Acute SCI?	Fixation?	Referral?	Steroids?	Economics?	Reason for exclusion
Aarabi, 1996[147]	Yes	No	No	No	No	About exploratory surgery, not fixation
Abraham, 1998[148]	No	No	No	No	No	Non-systematic review of cervical spinal fusions
Abramovitz, 1986[149]	No	No	No	No	No	Does not include trauma SCI patients
Abumi, 1994[150]	Yes	Yes	No	No	No	Case series (n = 13)
Abumi, 1999[151]	Yes	Yes	No	No	No	Case series, only 6 with SCI from trauma
Abumi, 2000[152]	Yes	Yes	No	No	No	Case series (n = 16)
Achouri, 1997[153]	No	Yes	No	No	No	Pott's disease, not acute SCI
Acikgoz, 1991[154]	No	No	No	No	No	About patients with Pott's paraplegia
Acosta, 1998[155]	No	No	No	No	No	Mixed trauma patients. Study not relevant
Adelstein, 1983[156]	No	No	No	No	No	Non-systematic review about cervical spine injuries
Aebi, 1983[157]	Yes	Yes	No	No	No	Case series (n = 76). In German
Aebi, 1986[117]	Yes	Yes	No	No	No	Case series (all had surgery)
Aebi, 1991[158]	Yes	Yes	No	No	No	Case series (n = 86)
Agrillo, 1994[159]	No	Yes	No	No	No	No SCI? case series (n = 4)
Aguiar, 1999[160]	Yes	No	No	No	No	Non-systematic review/overview of cervical spine fractures
Aho, 1988[161]	Yes	Yes	No	No	No	Case series (n = 30), all had SCI
Akahn, 1994[162]	Yes	Yes	No	No	No	Case series (n = 44)
Al Arabi, 1992[163]	Yes	Yes	Yes	No	No	Outcomes are not reported seperately for surgery and conservative groups. No useful data on referral or discharge
Albert, 1993[164]	Yes	No	No	No	No	Reports features of patients with noncontigious thoracolumbar and sacral features
Alderson, 1999[165]	No	No	No	No	No	Multiple letters referring to systematic review of corticosteroids for acute traumatic brain injury
Aldrich, 1991[166]	Yes	Yes	No	No	No	Case series (n = 21), not all had SCI
Aldrich, 1993[167]	No	Yes	No	No	No	Do not report SCI
Amar, 1999[168]	Yes	Yes	No	No	No	Background, non-systematic review
Amar, 1999[169]	Yes	No	No	No	No	Non-systematic review of of pathogenic process and drugs. Useful background?

continued

Study	Acute SCI?	Fixation?	Referral?	Steroids?	Economics?	Reason for exclusion
Amundson, 1997[170]	Yes	Yes	No	No	No	Non-systematic review
An, 1992[171]	Yes	Yes	No	No	No	All patients with SCI had surgical fixation
Anderson, 1980[172]	Yes	No	No	No	No	Review of cases of spinal injury in children. No relevant information
Anderson, 1980[172]	Yes	No	No	No	No	Review of treatment of children with spinal injury, some SCI and some not. Not sure results are useable
Anderson, 1991[173]	Yes	Yes	No	No	No	Prospective case series (n = 30)
Anderson, 1992[174]	Yes	Yes	No	No	No	Case series
Anon, 1990[175]	Yes	No	No	No	No	Editorial regrading NASCIS I and II
Anon, 1993[176]	No	Yes	No	Yes	No	Short report on drugs for SCI
Anon, 1995[177]	Yes	No	No	No	No	Case reports of how SIUs have reduced length of stay
Anon, 1997[178]	Yes	No	No	No	No	Short report/communication on how one hospital cut length of stay. Case management
Anon, 2001[179]	Yes	No	No	No	No	About transfer (not delay)
Arnold, 1985[180]	Yes	Yes	No	No	No	Case series (n = 12)
Arnold, 1993[181]	No	No	No	No	No	Not trauma patients
Arnold, 1997[182]	No	Yes	No	No	No	Treatment of osteomyelitis
Baba, 1994[183]	No	Yes	No	No	No	Not acute SCI
Baba, 1996[184]	No	No	No	No	No	Non-SCI patients
Babichenko, 1972[185]	No	No	No	No	No	Not fixation, no control group. In Russian
Bailey, 1972[186]	No	Yes	No	No	No	Operative treatment for tuberculosis of the spine, case series
Balmaseda, 1985[187]	Yes	Yes	No	No	No	Case report
Banovac, 2001[188]	Yes	No	No	No	No	RCT of indomethacin for prevention of heterotopic ossification after SCI
Barbeau, 1999[146]	Yes	No	No	No	No	Systematic review of walking function. Not acute SCI
Barr, 2000[15]	No	Yes	No	No	No	osteoporosis and neoplasms
Barros, 1993[189]	Yes	Yes	No	No	No	Case series (n = 62)
Bartolozzi, 1984[190]	No	No	No	No	No	Description of stabilisation technique – no data. In Italian
Beck, 1980[191]	No	No	No	No	No	Non-systematic review of conservative treatment. In German

continued

Study	Acute SCI?	Fixation?	Referral?	Steroids?	Economics?	Reason for exclusion
Beck, 1999[192]	Yes	No	No	No	No	Irrelevant
Bedbrook, 1975[193]	Yes	No	No	No	No	Non-systematic review of treatment (thoracolumbar dislocation/fracture)
Bedbrook, 1985[194]	Yes	No	No	No	No	Opinion-based article
Been, 1999[103]	Yes	Yes	No	No	No	Compress two types of surgery, no control group
Belanger, 2000[195]	Yes	No	No	No	No	General non-systematic review of SCI management
Benacker, 1993[196]	No	Yes	No	No	No	Not acute SCI
Benazet, 1994–5[197]	No	Yes	No	No	No	Mixed case series (n = 170) over 9 years reporting the neurological complications of spinal surgery
Benazet, 1996[198]	No	Yes	No	No	No	Mixed case series (n = 4 trauma) of patients with thoracic disc hernia
Benini, 1995[199]	No	Yes	No	No	No	Correspondence. Refers to study in non-SCI patients
Bennett, 1992[200]	Yes	Yes	No	No	No	Non-systematic review of techniques
Benson, 1992[201]	Yes	Yes	No	No	No	Case series (n = 25)
Benzel, 1986[122]	Yes	Yes	No	No	No	Compares two surgical techniques, no control group
Benzel, 1986[202]	Yes	Yes	No	No	No	Case series (n = 105)
Benzel, 1987[203]	No	Yes	No	No	No	Case series (n = 99)
Benzel, 1987[204]	No	No	No	No	No	Gunshot wounds to the spinal cord
Berlanda, 1991[205]	No	Yes	No	No	No	Case series (n = 135) over 12 years
Bernard, 1983[206]	Yes	Yes	No	No	No	Case series (n = 11)
Bernhang, 1985[207]	Yes	Yes	No	No	No	Case report
Bhojraj, 1993[208]	Yes	No	No	No	No	Case report, non-traumatic SCI
Binh, 1995[209]	Yes	Yes	No	No	No	Case series (n = 73)
Blauth, 1987[210]	Yes	Yes	No	No	No	Includes different treatment approaches but no real comparison
Böhler, 1983[211]	No	Yes	No	No	No	Non-systematic, opinion-based review. No patient data
Böhler, 1984[212]	Yes	No	No	No	No	Non-systematic review of operative treatment
Bohlman, 1979[84]	Yes	No	No	No	No	Series of cervical spine injuries, some treated operatively and some not. Analysis does not compare operated with non-operated groups
Bohlman, 1992[213]	Yes	Yes	No	No	No	Case series

continued

Study	Acute SCI?	Fixation?	Referral?	Steroids?	Economics?	Reason for exclusion
Bollati, 1983[214]	No	No	No	No	No	Case series (n = 57). All operated on with Cloward's technique
Boltze, 1994[215]	Yes	Yes	No	No	No	Case series (n = 21)
Boni, 1980[216]	Yes	Yes	No	No	No	Case series (n = 22)
Boni, 1984[217]	No	No	No	No	No	Description of surgical technique and case series (no patient characteristics reported)
Borne, 1988[218]	Yes	Yes	No	No	No	Case series (n = 102)
Bosch, 1971[219]	Yes	No	No	No	No	Correlates different types/severity of quadriplegia with outcome
Bostman, 1987[220]	Yes	Yes	No	No	No	Fixation, case series
Botel, 1997[221]	Yes	Yes	No	No	No	No real comparison with non-operated group
Botterell, 1975[222]	Yes	No	Yes	No	No	Epidemiology and outcomes at non-specialist centres (Canada). No specialist comparison
Bouchet, 1982[223]	Yes	No	No	No	No	Case series (n = 58) about surgical risks. In French, English abstract
Bracken, 1980[224]	Yes	No	No	No	No	Irrelevant study – examines relationship between neurological and functional recovery
Bracken, 1984[225]	Yes	No	No	Yes	No	Already included in the Cochrane review
Bracken, 1985[226]	Yes	No	No	Yes	No	Already included in the Cochrane review
Bracken, 1990[227]	Yes	No	No	No	No	Reply to letter
Bracken, 1990[9]	Yes	No	No	Yes	No	Already included in the Cochrane review
Bracken, 1991[228]	Yes	No	No	Yes	No	Summary of study already included in Cochrane review
Bracken, 1992[229]	Yes	No	No	No	No	Brief review of NASCIS studies and future prospects
Bracken, 1992[230]	Yes	No	No	Yes	No	Already included in the Cochrane review
Bracken, 1993[231]	Yes	No	No	Yes	No	Paper already included in the Cochrane review
Bracken, 1993[232]	Yes	No	No	Yes	No	Already included in the Cochrane review
Bracken, 1997[13]	Yes	No	No	Yes	No	Already included in the Cochrane review
Bracken, 1998[233]	Yes	No	No	Yes	No	Already included in the Cochrane review
Bracken, 2001[234]	Yes	No	No	Yes	No	Short abstract of Cochrane review reported in Swiss journal

continued

Study	Acute SCI?	Fixation?	Referral?	Steroids?	Economics?	Reason for exclusion
Brasil, 1998[235]	Yes	No	Yes	No	No	Compares a group of people with SCI admitted to a general hopsital in a developing country with a group admitted to SIU Stoke Mandeville. Not a relevant comparison for the UK
Bremer, 1983[236]	No	Yes	No	No	No	Some SCI patients? Case series (n = 6). All patients had internal metal plate fixation
Brocklehurst, 1973[237]	Yes	No	No	No	No	Transcript of 'Grand Rounds'
Brooks, 1992[238]	Yes	Yes	No	No	No	Non-systematic review
Brown, 1988[239]	No	No	No	No	No	Case series (only 3 trauma patients)
Bryant, 1983[240]	Yes	Yes	No	No	No	Case series (n = 15). All treated with Harrington distraction rods
Buchanan, 1982[241]	Yes	No	No	No	No	Description of patient preparation and the process of transfer
Buhren, 1999[242]	Yes	Yes	No	No	No	Case series, surgery only
Burke, 1975[243]	Yes	No	No	No	No	Case series, conservative treatment only
Burke, 1985[244]	Yes	No	No	No	No	Epidemiological data about treatment, stability, mortality, etc.
Burney, 1989[245]	Yes	No	No	No	No	Reports data on methods of stabilisation for early transfer. Not relevant
Cahill, 1983[246]	Yes	No	No	No	No	Case series (n = 25). All patients received spinal fusion
Campagnolo, 1997[247]	Yes	Yes	No	No	No	Early versus late fixation (no non-operated group)
Canakci, 1997[248]	No	No	No	Yes	No	Experimental study in rats
Capen, 1985[101]	Yes	Yes	No	No	No	No useful outcomes reported
Capen, 1994[249]	Yes	No	No	No	No	Non-surgical management – no surgical comparision group
Caroli, 1989[250]	Yes	Yes	No	No	No	Case series (n = 21). In Italian
Caspar, 1989[251]	Yes	Yes	No	No	No	Case series (n = 66)
Catz, 1997[252]	Yes	No	No	No	No	Validation of a disability scale
Celani, 2001[253]	Yes	No	No	No	No	About rehabilitation centre – not acute care
Chandler, 1992[254]	No	No	No	No	No	Experimental trial in 'normal' men
Chapman, 1996[255]	Yes	Yes	No	No	No	Case series (n = 23)
Chiang, 2001[256]	Yes	Yes	No	No	No	Non-systematic review of surgical stabilisation for thoracolumbar burst fractures

continued

Study	Acute SCI?	Fixation?	Referral?	Steroids?	Economics?	Reason for exclusion
Chiles, 1996[257]	Yes	No	No	No	No	Non-systematic review: current concepts in acute spinal injury
Cigliano, 1997[258]	Yes	No	No	No	No	Case series (n = 24)
Cigliano, 1998[259]	Yes	Yes	No	No	No	Case series
Citterio, 2000[260]	No	No	No	No	No	Non-traumatic SCI patients
Clar, 1994[261]	No	Yes	No	No	No	Overview (non-systematic) of techniques for spine surgery. In German
Clark, 1981[262]	Yes	Yes	No	No	No	Non-systematic review
Clark, 1995[263]	Yes	No	No	No	No	Non-systematic review of lazaroids (21-aminosteroids)
Clifton, 1996[264]	Yes	No	No	No	No	Not acute SCI, not fixation
Coleman, 2000[265]	Yes	No	No	No	No	Critical appraisal of NASCIS II and III
Collins, 1995[266]	Yes	No	No	No	No	Non-systematic review of surgery in acute treatment of SCI
Connolly, 1996[267]	No	No	No	No	No	Not SCI patients
Convery, 1978[268]	Yes	Yes	No	No	No	Case series (n = 24). All received Harrington instrumentation
Copes, 1996[269]	No	No	No	No	No	Mixed trauma group. No data on referral
Coric, 1996[270]	Yes	Yes	No	No	No	Case report
Cotler, 1985[271]	Yes	No	No	No	No	Case series (n = 37). All patients treated with corpectomy and vertebral body replacement
Craig, 1997[272]	Yes	No	No	No	No	Compares SCI patients who received CBT with those who did not
Craig, 1998[273]	Yes	No	No	No	No	Compares SCI patients who received CBT with those who did not
Crawford, 1994[105]	Yes	Yes	No	No	No	Compares two types of surgery, no control group
Crisan, 1978[274]	Yes	No	No	No	No	Case series (n = 59). In Romanian
Cristuib Grizzi, 1984[384]	Yes	No	No	No	No	Description of technique: no results
Crockard, 1994[275]	No	Yes	No	No	No	Case series (n = 72). Mixed pathology, results not presented separately for trauma patients
Crotti, 1984[276]	Yes	No	No	No	No	Compares laminectomy with conservative treatment
Crutcher, 1991[277]	Yes	Yes	No	No	No	Case series (n = 44). Not sure if outcomes are useful
Cybulski, 1989[278]	No	No	No	No	No	Gunshot injuries of spinal cord
Dai, 2000[279]	Yes	Yes	No	No	No	Case series

continued

Study	Acute SCI?	Fixation?	Referral?	Steroids?	Economics?	Reason for exclusion
Dai, 2000[280]	Yes	Yes	No	No	No	Case series (n = 24)
Dall, 1972[281]	Yes	No	No	No	No	Non-surgical reduction
Danielisova, 1998[282]	No	No	No	No	No	Experimental study in rabbits
Danisa, 1995[112]	Yes	Yes	No	No	No	Compares two types of surgery, no control group
Davey, 1985[283]	Yes	Yes	No	No	No	Case series
Davies, 1980[284]	No	No	No	No	No	Compares patients treated conservatively with series by Dickson *et al*. (ordered)
De Vivo, 1989[285]	Yes	No	Yes	No	No	Time to admission to rehabilitation unit related to source of support. Not acute
De Vivo, 1991[286]	Yes	No	No	No	No	Not acute care
DeJong, 1998[287]	Yes	No	No	No	No	Non-systematic review of managed care in SCI
Delattre, 1995[288]	No	No	No	No	No	About ocular complications of spinal surgery
DeMaria, 1985[289]	No	No	No	Yes	No	Retrospective chart review of patients with CNS injury
Denis, 1984[111]	Yes	Yes	No	No	No	Compares two types of surgery, no control group
Denis, 1984[290]	No	Yes	No	No	No	Patients did not have a neurological deficit (i.e. no SCI)
Denis, 1992[291]	Yes	No	No	No	No	No useful surgical outcomes reported
DeVivo, 1999[292]	Yes	No	No	No	No	About factors influencing discharge from SIU (does not cover delay in referral). No useful economics
Dickman, 1994[109]	Yes	Yes	No	No	No	Compares types of surgery, no control group
Dickson, 1978[293]	Yes	Yes	No	No	No	Case series (n = 95). Harrington instrumentation and fusion
Dietz, 1986[294]	Yes	No	No	No	No	General study of complications of SCI
Dijkers, 1997[295]	Yes	No	No	No	No	Effects of disablement components on quality of life
Dillingham, 1988[296]	Yes	No	No	No	No	General article on acute SCI care
Ditunno, 1995[298]	Yes	No	No	No	No	Background paper on functional outcomes
Ditunno, 1997[299]	Yes	No	No	No	No	Background paper on neurological assessment
Doerr, 1991[119]	Yes	Yes	No	No	No	Compares two types of surgery, no control group
Dollfus, 1987[300]	Yes	No	No	No	No	Non-systematic overview of initial hospital care in SCI patients

continued

Study	Acute SCI?	Fixation?	Referral?	Steroids?	Economics?	Reason for exclusion
Donovan, 1982[301]	Yes	No	Yes	No	No	Describes the development of a system of care
Donovan, 1984[302]	Yes	No	Yes	No	No	Update (non-systematic) on early management of traumatic paraplegia
Donovan, 1994[303]	Yes	Yes	No	No	No	Non-systematic review
Ducker, 1983[304]	Yes	Yes	No	No	No	Non-systematic review of recovery from SCI
Ducker, 1990[305]	Yes	No	No	No	No	Comment on NASCIS I
Ducker, 1990[306]	Yes	No	No	Yes	No	Commentary on SCI and glucocortical steroid therapy
Ducker, 1994[307]	Yes	No	No	No	No	Critical review of NASCIS I and II
Ducker, 1996[308]	Yes	No	No	Yes	No	Editorial on medical treatment for SCI
Ducker, 1996[309]	Yes	No	No	No	No	Summary of Martins[833] plus commentary
Dudeney, 2000[310]	No	Yes	No	No	No	Osteoporosis, not traumatic SCI
Dunn, 1984[311]	Yes	Yes	No	No	No	Case series (n = 48)
Duriau, 1973[312]	Yes	Yes	No	No	No	No real results. Opinion-based review, illustrated by case series. In French
Durward, 1981[313]	Yes	Yes	No	No	No	Very small n (8 surgical, 3 non-surgical), no usable results
Dvorak, 2001[314]	Yes	Yes	No	No	No	Non-systematic review
Dyson-Hudson, 1999[315]	Yes	No	No	No	No	Non-systematic review
Eastwood, 1999[316]	Yes	No	No	No	No	No data on referral
Ebraheim, 1995[317]	No	Yes	No	No	No	Mixed aetiologies. No useful outcomes reported. All had fixation
Egges, 1980[318]	No	No	No	No	No	Mixed trauma patients
Eismont, 1984[319]	No	No	No	No	No	Case report of post-traumatic spinal cord cyst
El Masry, 1996[320]	No	No	No	No	No	Validation of ASIA Motor score
Eleraky, 2000[321]	Yes	Yes	No	No	No	Patients received different types of surgery and no surgery; however no usable results are reported
Elzayat, 1988[322]	Yes	No	No	Yes	No	Non-randomised trial
Evans, 1994[323]	Yes	No	No	No	No	Assessing quality of life in SCI patients
Exner, 1993[324]	Yes	No	No	No	No	Overview of rehabilitation processes and utilisation in Germany
Eysel, 1991[325]	Yes	Yes	No	No	No	Case series (n = 135)

continued

Study	Acute SCI?	Fixation?	Referral?	Steroids?	Economics?	Reason for exclusion
Faciszewski, 1995[326]	Yes	No	No	No	No	Retrospective case series (n = 1223) to document complications of fusion surgery
Fadeev, 1984[327]	No	No	No	No	No	Not fixation, no control group. In Russian
Falci, 1999[328]	Yes	No	No	No	No	Surgery for progressive myelopathy (not acute care)
Farcy, 1988[342]	Yes	Yes	No	No	No	Case series (n = 27)
Farley, 1992[329]	Yes	No	No	No	No	No useful data
Fehlings, 1993[330]	No	Yes	No	No	No	Case series (n = 3 trauma patients). No useful data reported
Fehlings, 1999[331]	Yes	Yes	No	No	No	Evidence-based review, but search would not pass DARE criteria
Fehlings, 2001[332]	Yes	No	No	Yes	No	Short review of Matsumoto study[834]
Feingold, 1991[333]	No	No	No	No	No	Non-systematic review of complications in lumbar spine surgery
Feldmann, 1979[334]	No	Yes	No	No	No	Opinion-based review – does not appear to report any patient data
Fielding, 1967[335]	No	Yes	No	No	No	Case series (n = 3)
Finch, 1998[336]	Yes	No	No	No	No	Review of hospital admissions data in children and adolescents with major cervical spine injuries
Flabouris, 2001[337]	Yes	No	No	No	No	Reports on patterns of referral (not delay) and transport
Fletcher, 2000[338]	No	No	No	No	No	Non-systematic review of improving outcomes for the injured brain and spinal cord
Floman, 1985[339]	Yes	Yes	No	No	No	Description of technique
Floman, 1986[340]	Yes	Yes	No	No	No	Case series. No useful outcomes reported
Forsyth, 1959[341]	Yes	Yes	No	No	No	Opinion-based study illustrated by case series (n = 84)
Frankel, 1969[343]	Yes	No	No	No	No	Case series. Non-operative treatment
Frankel, 1987[344]	Yes	No	No	No	No	Described characteristics of SCI units
Fratianne, 1990[345]	Yes	No	No	No	No	Non-systematic review of concerns of receiving facilities
Gaebler, 1997[346]	Yes	Yes	No	No	No	Case series (n = 88)
Gaebler, 1999[347]	Yes	Yes	No	No	No	Case series, but some info on timing of surgery related to results
Galandiuk, 1993[348]	Yes	No	No	Yes	No	Cohort study with historical controls
Garcia Reneses, 1991[349]	Yes	No	No	No	No	Epidemiological study

continued

Study	Acute SCI?	Fixation?	Referral?	Steroids?	Economics?	Reason for exclusion
Garfin, 1985[350]	Yes	No	No	No	No	Case series (n = 9). All patients underwent decompression
Garg, 1992[351]	Yes	No	No	No	No	Case series (n = 53). M-c flap surgery for pressure ulcers
Gassman, 1983[352]	No	No	No	No	No	Mixed clinical groups. Case series (n = 13)
Gaufin, 1975[353]	Yes	No	No	No	No	Not fixation, 3 case reports
Geisler, 1988[354]	Yes	No	No	No	No	Non-systematic review of acute management of SCI
Geisler, 1989[355]	No	Yes	No	No	No	Case series (n = 9). No outcomes of interest
Geisler, 1991[356]	Yes	No	No	Yes	No	Already included in the Cochrane review
Geisler, 1992[357]	Yes	No	No	Yes	No	Already included in Cochrane review
Geisler, 1992[358]	Yes	No	No	Yes	No	Already included in Cochrane review
Geisler, 1993[359]	Yes	No	No	Yes	No	Non-systematic review of study already inlcuded in the Cochrane review and design of future study
Geisler, 1998[360]	Yes	No	No	Yes	No	Overview of GMYes ganglioside studies (already inlcuded in the Cochrane review)
George, 1995[361]	Yes	No	No	Yes	No	Comparison of SCI patients before and after routine use of methylprednisolone
Gerhart, 1991[362]	Yes	No	No	No	No	No data on referral
Gertzbein, 1988[363]	Yes	Yes	No	No	No	Results not useable, fixation and non-fixation groups combined
Glaser, 1998[364]	No	Yes	No	No	No	Case series (n = 15). Majority intact to neurological testing
Glidden, 1999[365]	Yes	No	No	No	No	Description and hypothetical (?) comparison of 'case management' versus 'no case mangement'
Goffin, 1989[366]	No	Yes	No	No	No	Case series (n = 41)
Goldsmith, 1999[367]	Yes	Yes	No	No	No	Editorial
Gomez, 1996[368]	No	No	No	No	No	Experimental study
Gradischnig, 1967[369]	No	No	No	No	No	Non-systematic literature review and 3 case reports
Graftieaux, 1994[370]	Yes	No	No	No	No	French report of NASCIS II
Graham, 1989[371]	No	Yes	No	No	No	Survey (5 years) of complications of cervical spine surgery
Grande, 1988[372]	Yes	No	No	No	No	Letter to the editor – techniques for airways management

continued

Study	Acute SCI?	Fixation?	Referral?	Steroids?	Economics?	Reason for exclusion
Graneto, 1993[373]	No	No	No	No	No	Non-systematic review of stabilisation and transport of paediatric trauma patients
Green, 1987[374]	Yes	No	No	No	No	Opinion based review of pre-hospital management of SCI. No patient data
Green, 1987[375]	Yes	No	No	No	No	Describes systems approach to SCI. No patient data
Greene, 1994[376]	Yes	No	No	Yes	No	Non-systematic review of pharmacological strategies for SCI
Greene, 1996[377]	Yes	No	No	No	No	Review of scientific and regulatory processes
Greenwald, 1991[378]	No	Yes	No	No	No	No useful outcomes reported. Compares surgery by type of burst fracture
Greenwald, 1994[379]	Yes	Yes	No	No	No	Case series (n = 6)
Gregg, 1967[380]	Yes	No	No	No	No	Description of Irish SIU
Griffiths, 1988[381]	Yes	No	Yes	No	No	Non-systematic review
Grilli, 1980[382]	No	No	No	No	No	2 case reports. In Italian
Grimes, 1995[383]	No	No	No	No	No	Non-systematic review of treatment of complications of thoracolumber spine trauma
Grootboom, 1990[385]	Yes	Yes	No	No	No	Case series (n = 30) (21 with SCI)
Grootboom, 1993[386]	Yes	Yes	No	No	No	Case series (n = 50). Not all had SCI. Only 4 had surgery. Results may not be usable
Grote, 1978[387]	Yes	Yes	No	No	No	Data only given for surgical group. In German
Grundy, 1986[388]	Yes	No	No	No	No	Not about fixation
Guha, 1987[389]	No	No	No	No	No	Experimental SCI in rats
Gunby, 1982[390]	No	No	No	No	No	News report of preliminary results of NASCIS I
Gunnewicht, 1997[391]	Yes	No	No	No	No	Recommendations of ways to prevent pressure sores on non-specialist units
Hachen, 1977[392]	Yes	No	No	No	No	Opinion based review
Hadley, 1992[393]	Yes	Yes	No	No	No	Case series (n = 68)
Haid, 2001[394]	No	No	No	No	No	Various aetiologies – not reported
Haid, 2001[395]	Yes	Yes	No	No	No	Case series, and not all had traumatic injury
Hall, 1987[396]	Yes	No	No	Yes	No	Non-systematic review of methylprednisolone therapy
Hall, 1988[397]	Yes	No	No	Yes	No	Non-systematic review about new pharmacological treatment for acute spinal cord trauma

continued

Study	Acute SCI?	Fixation?	Referral?	Steroids?	Economics?	Reason for exclusion
Hamer, 1993[398]	No	Yes	No	No	No	Whiplash injury, not acute SCI
Hamilton, 1976[399]	Yes	No	No	No	No	Describes an evaluation framework for SCI care systems
Hamilton, 1979[400]	Yes	No	No	No	No	Letter to the editor. Costs of rehabilitation
Hammell, 1995[401]	Yes	No	No	No	No	Non-systematic review of occupational therapy
Hammond, 1994[402]	Yes	No	No	No	No	Incidence of pressure ulcers
Hanci, 1995[403]	Yes	No	No	No	No	Three case reports. Oesophageal perforation
Hannon, 1976[404]	Yes	Yes	No	No	No	Case series (n = 23)
Hansebout, 1993[405]	Yes	No	No	No	No	Not a steroid, chronic not acute SCI
Hardaker, 1992[406]	Yes	Yes	No	No	No	Case series (n = 58). All patients received bilateral transpedicular decompression and fusion
Harkonen, 1979[407]	Yes	Yes	No	No	No	Some treated by fixation and some managed conservatively; however, no usable results
Harkonen, 1979[408]	Yes	Yes	No	No	No	Only 2 with SCI had fixation (out of 98 in the study)
Harland, 1998[409]	No	No	No	No	No	About current use of surgical techniques for decompression
Harms, 1992[410]	Yes	Yes	No	No	No	Descriptive review of methods and a few case reports
Harris, 1967[411]	Yes	No	No	No	No	Non-systematic review of the diagnosis and early treatment of patients with SCI
Harrison, 1997[412]	No	No	No	No	No	Letter
Hasegawa, 1994[413]	Yes	No	No	No	No	Not about acute care
Hatsuta, 1980[414]	Yes	No	No	No	No	About discharge from hospital but not about the issue of transfer or referral to SIU. In Japanese
Hauswald, 1998[415]	Yes	No	No	No	No	Not about steroids, fixation or referral
Havel, 1993[416]	Yes	No	No	No	No	Overview of implications for discharge in patients with gunshot SCI
Hayes, 1993[417]	Yes	No	No	Yes	No	Preclinical trial (no control) (n = 6)
Hearty, 1998[418]	Yes	No	No	No	No	Description of a Regional Spinal Cord Centre in Belfast
Hegde, 1988[419]	Yes	No	No	No	No	Case reports
Heinemann, 1995[420]	Yes	No	Yes	No	No	Time to admission to rehabilitation unit (not acute)

continued

Study	Acute SCI?	Fixation?	Referral?	Steroids?	Economics?	Reason for exclusion
Hein-Sorensen, 1979[421]	No	No	No	No	No	Case series. Evaluation of program of tilting
Helle, 1981[422]	Yes	No	No	No	No	Case report
Herrlin, 1983[423]	Yes	Yes	No	No	No	Case series (n = 27)
Herrmann, 1976[424]	Yes	Yes	No	No	No	Case series and description of techniques. In German
Hill, 1993[425]	Yes	No	No	Yes	No	Commentary on Wells, 1993[772]
Hilton, 1991[426]	Yes	No	No	Yes	No	Non-systematic review of high-dose methylprednisolone
Himmelseher, 1999[427]	Yes	No	No	Yes	No	Non-systematic review of management of acute SCI
Hoenig, 2001[428]	Yes	No	No	No	No	Assesses validity of the SRFM measure
Hofmann, 1966[429]	Yes	Yes	No	No	No	Comapres two conservative techniques
Honnart, 1982[430]	Yes	Yes	No	No	No	Case series (n = 61)
Horgan, 1999[431]	No	Yes	No	No	No	Mixed pathology. No useful data reported
Horn, 1998[432]	Yes	No	No	No	No	No data on referral
Horsey, 1977[433]	Yes	Yes	No	No	No	No real control group
Houdart, 1973[434]	No	No	No	No	No	Overview of emergency surgery for spinal injuries. In French
Hu, 1993[100]	Yes	Yes	No	No	No	All had fixaton
Hu, 1993[435]	No	Yes	No	No	No	Not SCI, case series (n = 31)
Huang, 1995[104]	Yes	Yes	No	No	No	Compares two types of surgery, no control group
Huang, 1999[436]	No	No	No	No	No	Case series (n = 90). Complications in spinal surgery. Mixed pathology
Hurlbert, 2000[437]	Yes	No	No	No	No	Critique of NASCIS II and III
Igun, 1999[438]	Yes	No	No	No	No	Surgical and conservative group but neurological function is not clearly reported for each group
Inman, 1999[439]	Yes	No	No	No	No	Not acute SCI services (rehab.)
Isiklar, 1998[440]	Yes	No	No	No	No	Non-systematic review of techniques, not results
Iumashev, 1989[441]	No	No	No	No	No	Not about fixation, steroids or referral. In Russian
Jackson, 1975[442]	No	No	No	No	No	Non-systematic overview of surgical stabilisation of the spine
Jackson, 1994[443]	Yes	No	No	No	No	Reports incidence of respiratory complications
Jacobs, 1980[444]	Yes	Yes	No	No	No	No real results reported. In German

continued

Study	Acute SCI?	Fixation?	Referral?	Steroids?	Economics?	Reason for exclusion
Jacobs, 1984[445]	No	No	No	No	No	Non-systematic review of surgical management of spinal injuries
Jankowski, 1998[446]	Yes	Yes	No	No	No	No control group. In Polish
Jenzer, 1968[447]	No	No	No	No	No	Case series (n = 29)? In Spanish
Johnson, 1983[448]	No	No	No	No	No	Case series (n = 11 patients with fracture). All patients received anterior decompression
Johnston, 1993[449]	Yes	No	No	No	No	Non-systematic review of management of acute spinal cord compression
Jones, 1978[450]	Yes	No	No	No	No	Clinical assessment of hyperbaric oxygen
Jonsson, 1991[99]	Yes	Yes	No	No	No	All had fixation (posterior plating vs no posterior plating)
Judet, 1971[451]	Yes	Yes	No	No	No	Case series of 20, early vs late fixation
Kabut, 1981[452]	No	No	No	No	No	Not about steroids, fixation or referral. In Polish
Kalff, 1993[453]	No	Yes	No	No	No	Case series (n = 124). Not sure if fits into acute care
Kalsbeek, 1980[454]	Yes	No	Yes	No	No	Data are for all hospitals, not SIUs, and no outcomes are reported
Kandabarow, 1997[455]	No	No	No	No	No	Overview of injuries of the thoracolumbar spine
Kaneda, 1984[456]	No	No	No	No	No	Case series (n = 27). All patients received anterior decompression
Karimi-Nejad, 1978[457]	Yes	Yes	No	No	No	Unclear reporting of results – not usable. In German
Karimi-Nejad, 1980[458]	Yes	Yes	No	No	No	Case series (n = 66). In German
Kawaguchi, 1999[459]	No	No	No	No	No	Non-SCI patients
Keene, 1992[460]	Yes	No	No	No	No	Compares two types of graft. No useful outcome reported
Keim, 1971[461]	No	No	No	No	No	Describes use of non-surgical stabilisation following trauma
Keith, 1986[462]	Yes	No	No	No	No	Abstract with very few results reported
Kempf, 1973[463]	Yes	Yes	No	No	No	Case series (n = 8). In French
Kempf, 1980[464]	Yes	Yes	No	No	No	Case series (n = 50)
Khvisiuk, 1986[465]	Yes	No	No	No	No	Not fixation. In Russian
Kinnard, 1986[466]	Yes	Yes	No	No	No	Case series (n = 21). All patients treated with Roy–Camille plates
Kinoshita, 1989[467]	Yes	Yes	No	No	No	Case series (n = 30)
Kinzl, 1986[468]	No	No	No	No	No	Describes stabilisation operation for traumatic spinal column injuries. No patient data. In German

continued

Study	Acute SCI?	Fixation?	Referral?	Steroids?	Economics?	Reason for exclusion
Kirkpatrick, 1995[469]	Yes	Yes	No	No	No	Case series of 20, only 4 with SCI
Kiwerski, 1979[470]	Yes	No	No	No	No	Not fixation, no control group. In Polish
Kiwerski, 1982[121]	Yes	Yes	No	No	No	Compares two fixation techniques, no control group
Kiwerski, 1992[471]	Yes	Yes	No	No	No	No useable results
Kiwerski, 1992[472]	No	No	No	Yes	No	Cohort study (Polish)
Kiwerski, 1993[473]	No	Yes	No	Yes	No	Cohort study of dexamethasone
Klapp, 1977[474]	No	Yes	No	No	No	Includes patients without serious neurological injury. In German
Klauber, 1990[475]	Yes	Yes	No	No	No	Case series (n = 18). In Hungarian
Knight, 1993[476]	No	Yes	No	No	No	Excluded patients with neurological compromise
Knop, 1997[477]	Yes	Yes	No	No	No	Case series (n = 76)
Knop, 2000[478]	Yes	Yes	No	No	No	Does not appear to report any useful outcomes. In German
Knop, 2000[479]	No	Yes	No	No	No	Not a clinical study – biomechanical test series of a vertebral body replacement
Knop, 2001[480]	Yes	Yes	No	No	No	Case series (n = 56)
Knoringer, 1985[481]	Yes	Yes	No	No	No	Case series. In German
Korovessis, 1994[114]	Yes	Yes	No	No	No	Case series (n = 30)
Kortmann, 1986[482]	Yes	Yes	No	No	No	Case series. In German
Kossmann, 2000[483]	Yes	Yes	No	No	No	Non-systematic review of operative SCI treatment, illustrated by cases
Kostuik, 1983[484]	Yes	Yes	No	No	No	All had fixation
Kostuik, 1984[485]	No	Yes	No	No	No	Case series (n = 49)
Kostuik, 1988[486]	Yes	Yes	No	No	No	Case series, not all with traumatic injury
Kostuik, 1993[487]	No	Yes	No	No	No	Case series (n = 42). Mixed indications and all received anterior cervical plate fixation
Koyanagi, 1989[488]	Yes	No	No	No	No	Not fixation, case series (n = 7)
Koyanagi, 1989[489]	Yes	No	No	No	No	Case reports (n = 4), myelotomy
Kozlowski, 1979[490]	Yes	No	No	No	No	Not fixation, no control group. In Polish

continued

Study	Acute SCI?	Fixation?	Referral?	Steroids?	Economics?	Reason for exclusion
Kramer, 1995[491]	No	No	No	No	No	Mixed trauma patients
Kramer, 1997[492]	Yes	No	No	No	No	Not acute SCI
Krause, 1996[493]	Yes	No	No	No	No	Not about fixation, steriods or referral
Krause, 1999[494]	Yes	No	No	No	No	Not about fixation, referral or steroids
Krbec, 2001[495]	Yes	Yes	No	No	No	Case series (n = 120), not all had SCI. In Czech
Krengel, 1993[496]	Yes	Yes	No	No	No	Case series. Historical controls are used but these are from other published case series and results are not reported as for treated group
Krengel, 1996[497]	Yes	No	No	No	No	Early versus delayed surgery. No treatment comparison
Kuo, 1982[498]	Yes	Yes	No	No	No	Case series (n = 17 acute patients)
Lalonde, 2001[499]	Yes	Yes	No	No	No	Only 3 had SCI
Lang, 1989[500]	No	Yes	No	No	No	Case series. In German
Lapeyre, 1971[501]	No	No	No	No	No	Description of surgical technique and 6 case reports
Larson, 1976[502]	Yes	Yes	No	No	No	Case series (n = 62)
Laus, 1993[503]	No	Yes	No	No	No	Case series (n = 20)
Laus, 1997[504]	Yes	Yes	No	No	No	Case series (n = 37)
Lausberg, 1974[505]	Yes	Yes	No	No	No	Looks like a case series (n = 15 SCI patients). In German
Lazorthes, 1974[506]	No	No	No	No	No	4 case reports used to illustrate attitudes to surgery? In French
Le, 2001[507]	No	No	No	No	No	Side effects of a substance used in lumbar discectomy
Lee, 1997[508]	Yes	Yes	No	No	No	3 case reports
Lemons, 1992[509]	Yes	Yes	No	No	No	Case series (n = 22). All stablised by posterior instrumentation and fusion
Lesoin, 1984[510]	Yes	Yes	No	No	No	Case series (n = 165)
Lesoin, 1984[511]	Yes	No	No	No	No	Case series (n = 160). All received surgery
Lesoin, 1984[512]	Yes	Yes	No	No	No	Case series (n = 290)
Lesoin, 1986[513]	Yes	Yes	No	Yes	No	Case series (n = 165)
Levi, 1991[514]	Yes	Yes	No	No	No	Early vs delayed surgery. All had fixation
Levi, 1998[515]	Yes	No	No	No	No	Protocols for record keeping at SIUs, not a study

continued

Study	Acute SCI?	Fixation?	Referral?	Steroids?	Economics?	Reason for exclusion
Levy, 1982[516]	No	No	No	No	No	Five case reports. Not SCI patients
Levy, 1998[517]	Yes	No	No	No	No	Problems with SCI, specifically related to Zimbabwe
Lewis, 1992[518]	No	No	No	No	No	Executive summary of management of acute traumatic injury
Linares, 1987[519]	Yes	No	No	No	No	Study not relevant. Aetiology of pressure sores, does not report delayed referral or fixation
Lincoln, 1993[520]	No	No	No	No	No	SCI as a complication of spinal surgery
Lindsey, 1991[521]	Yes	Yes	No	No	No	Case series
Liu, 1997[522]	No	Yes	No	No	No	Case series (n = 12). Not acute care
Loty, 1984[523]	No	No	No	No	No	Non-SCI patients
Louis, 1992[524]	No	Yes	No	No	No	Case series (n = 43 fractures) of anterior surgery of the upper cervical spine
Louis, 1998[525]	Yes	Yes	No	No	No	Case series (n = 56). Louis plates
Louw, 1987[526]	No	Yes	No	No	No	Case series (n = 30)
Lu, 1998[527]	Yes	Yes	No	No	No	Case series (n = 6)
Ludwig, 1997[528]	No	No	No	No	No	Case report
Luque, 1982[529]	Yes	Yes	No	No	No	Case series (n = 14). All patients received segmental spinal instrumentation
Luther, 1974[530]	No	Yes	No	No	No	Looks like overview (non-systematic) of ventral fusion. No patient data. In German
Lyons, 1990[531]	Yes	No	No	No	No	Letter regarding NASCIS II
Mackenzie, 1999[532]	Yes	No	No	No	No	Non-systematic review of management of cervical spine injury
Magerl, 1980[533]	Yes	Yes	No	No	No	Description of methods. No data given. In German
Maglio, 1967[534]	Yes	No	No	No	No	Description of spinal unit. No patient data
Maiman, 1986[535]	Yes	Yes	No	No	No	Case series (n = 28)
Maiman, 1992[536]	Yes	No	No	No	No	Treatment of spasticity
Malcolm, 1994[537]	No	Yes	No	No	No	Not trauma
Mann, 1990[538]	Yes	Yes	No	No	No	Case series (n = 16)
Mann, 1993[539]	Yes	No	No	No	No	Retrospective review of cases of spinal injuries in young patients
Marciano, 1995[540]	Yes	No	No	Yes	No	Non-systematic literature review of pharmacological management of SCI

continued

Study	Acute SCI?	Fixation?	Referral?	Steroids?	Economics?	Reason for exclusion
Marczynski, 1999[541]	No	Yes	No	No	No	Case series (n = 56)
Markel, 1995[118]	Yes	Yes	No	No	No	Compares two types of surgery, no control group
Masferrer, 1998[542]	No	Yes	No	No	No	Case series (n = 95). Pedicle screw fixation
Maurice-Williams, 1988[543]	No	No	No	No	No	Does not include patients with SCI resulting from trauma
Mayer, 1992[544]	Yes	Yes	No	No	No	Case series (n = 51). In German
Mayer, 2001[545]	Yes	No	No	No	No	Interview with a surgeon about artificial discs – in German
Maynard, 1979[546]	Yes	No	No	No	No	No data reported on delayed referral and surgery data are not well described
McAfee, 1985[547]	Yes	Yes	No	No	No	Case series (n = 31) of complications
McAfee, 1989[548]	Yes	Yes	No	No	No	Case series
McCullen, 1998[549]	No	Yes	No	No	No	Non-systematic review of fusion techniques
McDonald, 2002[550]	Yes	No	No	No	No	Review, useful background
McIlvoy, 2000[551]	Yes	No	No	No	No	Compares treatment of SCI before and after implementation of a clinical pathway
McNamara, 1991[552]	No	Yes	No	No	No	Case series (n = 6)
Meinecke, 1982[553]	Yes	No	Yes	No	No	Delayed referral mentioned but no consequences stated
Meinecke, 1992[554]	Yes	No	No	No	No	Describes facilities in German SCI centres
Meinecke, 1997[555]	Yes	No	No	No	No	Does not include any patient data
Merianos, 1994[556]	Yes	Yes	No	No	No	Only 4 had SCI
Mestdagh, 1988[557]	No	Yes	No	No	No	Case series (n = 58), not clear how many had SCI
Mimatsu, 1993[558]	Yes	Yes	No	No	No	Case series (n = 14)
Mirza, 1999[559]	Yes	Yes	No	No	No	Early versus late fixation (no non-operated group)
Moon, 1981[560]	Yes	Yes	No	No	No	Case series (n = 25)
Moraes, 1995[561]	Yes	Yes	No	No	No	Unclear whether all had SCI. Case series (n = 10)
Morgan, 1971[562]	Yes	No	No	No	No	Laminectomy – not fixation
Mosdal, 1989[563]	Yes	Yes	No	No	No	Case series (n = 25). In Danish
Motomochi, 1981[564]	No	No	No	No	No	Case report. In Japanese

continued

Study	Acute SCI?	Fixation?	Referral?	Steroids?	Economics?	Reason for exclusion
Munro, 1961[565]	Yes	Yes	No	No	No	Non-systematic review
Munro, 1965[566]	Yes	Yes	No	No	No	Non-systematic review illustrated by selected case reports and case series
Mutoh, 1993[567]	No	Yes	No	No	No	Not acute SCI
Mylotte, 2001[568]	Yes	No	No	No	No	Not acute hospital care
Nechwatal, 1975[569]	No	No	No	No	No	About transportation of people with cervical spine injury. In German
Nesathurai, 2001[570]	Yes	No	No	No	No	Reply to Bracken[232]
Neugebauer, 1990[141]	Yes	No	No	Yes	No	Only identified one study in patients with acute SCI
Niedeggen, 1997[571]	Yes	No	Yes	No	No	Non-systematic review?
Noreau, 2000[572]	Yes	No	No	No	No	Not acute care – patients with long-standing SCI
Norrell, 1970[573]	Yes	Yes	No	No	No	Case series (n = 57). Not all have SCI
Norrell, 1973[574]	Yes	Yes	No	No	No	Retrospective cohort (controlled) study (n = 273), but surgical and non-surgical groups are not compared
Olerud, 1988[575]	Yes	Yes	No	No	No	Case series (n = 20)
Ordonez, 2000[576]	Yes	Yes	No	No	No	Case series (n = 6 SCI). All underwent ventral reduction and stabilisation
Ostermann, 1990[577]	Yes	Yes	No	No	No	Case series (n = 35)
Paeslack, 1967[578]	Yes	No	No	No	No	Describes spinal injuries unit. No patient data
Pagliacci, 2000[579]	Yes	No	No	No	No	Re-hospitalisation – not acute care
Pagni, 1984[580]	No	No	No	No	No	Some SCI patients. No data for comparison between treatments
Palomo, 1976[581]	No	Yes	No	No	No	Case series (n = 16)? Not fixation. In Spanish
Pan, 1999[582]	No	No	No	No	No	Case series (n = 20). Mixed diagnoses
Papavero, 1999[583]	No	No	No	No	No	Describes techniques for less invasive anterior fusion
Patzug, 1989[584]	Yes	No	No	No	No	Case series. Not linked to outcomes. In German
Paul, 1975[585]	Yes	No	No	No	No	Not fixation, 3 case reports
Peerless, 1992[586]	Yes	No	No	No	No	Summary of study already included in the Cochrane review
Pepin, 1985[587]	No	No	No	No	No	Case series of patients with odontoid fracture (n = 262). Outcomes not useful
Peris, 1998[588]	Yes	No	No	No	No	Non-systematic review of complications of cervical spine surgery

continued

Study	Acute SCI?	Fixation?	Referral?	Steroids?	Economics?	Reason for exclusion
Perrouin-Verbe, 1998[589]	Yes	No	No	No	No	Occurrence of syringomyelia
Petitjean, 1995[590]	Yes	No	No	Yes	No	Abstract of study which has since been reported in full
Petitjean, 1998[591]	Yes	No	No	Yes	No	Already included in the Cochrane review
Pia, 1968[592]	No	No	No	No	No	Non-systematic review of surgical measures for SCI. In German
Pia, 1969[593]	No	Yes	No	No	No	Overview (non-systematic) of techniques for spine surgery. In German
Pia, 1973[594]	No	No	No	No	No	Overview of surgery, no patient data. In German
Pick, 1994[595]	Yes	No	No	No	No	Describes incidence of MRSA in spinal injuries centre
Platz, 2001[596]	Yes	No	No	No	No	Retrospective study of gunshot injuries to the spine
Podolsky, 1983[597]	No	No	No	No	No	Study of immobilisation methods in healthy volunteers
Pointillart, 2000[598]	Yes	No	No	Yes	No	Already included in the Cochrane review
Powers, 1997[599]	Yes	No	No	No	No	Reducing pressure ulcers related to wearing cervical collars
Protsenko, 1989[600]	Yes	Yes	No	No	No	Case series (n = 420). In Russian
Randle, 1991[603]	Yes	No	No	No	No	Case series (n = 54). All patients underwent Caspar technique and instrumentation
Rao, 1987[604]	No	Yes	No	No	No	Case series (n = 49). In Chinese
Rao, 1991[605]	No	No	No	No	No	Case series (n = 88). Not all trauma patients and all received the IVBF dual-blade plate
Rao, 1991[606]	No	Yes	No	No	No	Case series (n = 18). Unsure if SCI patients
Raynor, 1968[607]	Yes	Yes	No	No	No	Case series of 14 plus 4 detailed case reports
Razack, 2000[608]	Yes	Yes	No	No	No	Case series (n = 22)
Rehabilitation R&D Progress Reports, 1996[609]	Yes	No	No	No	No	Does not include any relevant studies
Rekate, 1999[610]	Yes	No	No	No	No	Not about fixation, steroids, referral or discharge (non-systematic review)
Richaud, 1988[611]	Yes	Yes	No	No	No	Case series (n = 15). In French
Richaud, 1990[612]	No	Yes	No	No	No	Case series (n = 31). In French
Richman, 1997[613]	No	No	No	No	No	Overview of flexion–distraction injuries of the cervical spine
Rimoldi, 1992[614]	Yes	Yes	No	No	No	Case series (n = 147)
Riska, 1981[615]	Yes	Yes	No	No	No	Case series (n = 56). Antero-lateral decompression

continued

Study	Acute SCI?	Fixation?	Referral?	Steroids?	Economics?	Reason for exclusion
Risko, 1977[616]	Yes	No	No	No	No	Not a study. In Hungarian
Rodgers, 1999[617]	No	No	No	No	No	Non-SCI patients
Rohl, 1997[618]	Yes	No	No	No	No	Treatment of long bone fractures. In German
Roos, 1991[619]	Yes	No	No	No	No	Swiss report of NACSIS II
Roosen, 1982[620]	Yes	No	No	No	No	Includes some SCI patients. Outcomes are not relevant
Rose, 1993[621]	Yes	No	No	No	No	Non-systematic review
Rosenfeld, 1998[622]	Yes	Yes	No	No	No	Non-systematic review of early decompression in cervical SCI
Rosner, 1991[623]	Yes	No	No	No	No	Correspondence regarding NASCIS II
Rossier, 1967[624]	Yes	No	No	No	No	Describes paraplegic centre. No patient data
Rossier, 1977[625]	Yes	Yes	No	No	No	Case series ($n = 6$)
Rossier, 1977[626]	Yes	No	No	No	No	Case series ($n = 6$). Interbody fusion
Rossier, 1984[627]	Yes	Yes	No	No	No	2 case reports
Rossier, 1985[628]	Yes	No	No	No	No	About syringomyelia – not acute care
Roth, 1992[629]	Yes	No	No	No	No	Epidemiological study about SCI in older persons
Royal College of Surgeons, 1984[630]	Yes	No	No	No	No	Not a research study. Useful background
Roy-Camille, 1972[631]	Yes	Yes	No	No	No	Case series ($n = 54$ 'fresh')? In French
Roy-Camille, 1972[632]	No	No	No	No	No	Describes surgical techniques. In French
Roy-Camille, 1976[633]	Yes	Yes	No	No	No	Case series ($n = 26$)
Roy-Camille, 1989[634]	No	No	No	No	No	Not acute SCI
Ruan, 1998[635]	Yes	Yes	No	No	No	Case series ($n = 96$). Shen instrumentation
Ryan, 1982[636]	Yes	Yes	No	No	No	Case series ($n = 28$)
Saboe, 1997[637]	Yes	No	No	No	No	Not about fixation, delay in referral, discharge or steroids
Salmon, 1970[638]	No	No	No	No	No	Overview of fractures to the odontoid process
Sandford, 1999[639]	Yes	No	No	No	No	Reports different factors related to time to return to school. No relevant factors reported
Sandor, 1975[640]	Yes	No	No	No	No	Case series, about decompression not fixation. In Hungarian

continued

Study	Acute SCI?	Fixation?	Referral?	Steroids?	Economics?	Reason for exclusion
Sandor, 1988[641]	Yes	Yes	No	Yes	No	Case series
Sandor, 1990[642]	Yes	Yes	No	No	No	Case reports. In German
Sapkas, 1995[643]	Yes	Yes	No	No	No	Case series (n = 11)
Saruhashi, 1998[644]	Yes	Yes	No	No	No	Delayed surgical intervention. No comparison to acute care
Sasso, 1993[110]	Yes	Yes	No	No	No	Compares two types of surgery, no control group
Sauerland, 2000[645]	No	No	No	Yes	No	Includes surgical SCI patients. Literature search would not pass DARE criteria
Savic, 2000[646]	Yes	No	No	No	No	Not acute care – includes patients injured more than 20 years ago
Savitsky, 1996[647]	Yes	No	No	No	No	Brief article on glucocorticosteroids
Savitsky, 1997[648]	Yes	No	No	No	No	Non-systematic overview of acute spine injury management
Scapinelli, 1995[649]	No	No	No	No	No	Case report
Schaller, 1999[650]	Yes	No	No	No	No	Evaluation of surgical treatment for posttraumatic syringomyelia
Scheffel, 1999[651]	Yes	No	No	No	No	Description of case management
Schevtsov, 1999[652]	Yes	Yes	No	No	No	Case series (n = 54)
Schlegel, 1996[653]	Yes	Yes	No	No	No	Case series (n = 138). All patients underwent surgery
Schmeisser, 1970[654]	Yes	No	No	No	No	Non-systematic review of orthopaedic aspects of SCI
Schmidek, 1980[655]	No	Yes	No	No	No	Case series (n = 26). All patients received one-stage anterolateral decompression and fusion
Schmitt, 1985[656]	Yes	Yes	No	No	No	Surgery and conservative treatment given, but not linked to outcomes
Schnee, 1997[106]	Yes	Yes	No	No	No	Compares types of surgery, no control group
Schurmann, 1970[657]	Yes	Yes	No	No	No	About techniques, not results
Schurmann, 1972[658]	No	No	No	No	No	Opinion-based review. No patient data reported
Schurmann, 1978[102]	No	No	No	No	No	Case series (n = 201). In German
Schwab, 1998[659]	Yes	No	No	No	No	Reports number of transfers pre- and post-affiliation. No outcomes
Schwarz, 1993[660]	No	No	No	No	No	Case series (n = 22)
Schweighofer, 1997[661]	Yes	Yes	No	No	No	Case series (n = 9)
Scott, 1968[662]	No	No	No	No	No	Non-systematic review of surgery of the spinal column/cord
Scott, 1970[663]	Yes	No	No	No	No	Non-systematic review about surgery of the spinal column/cord

continued

Study	Acute SCI?	Fixation?	Referral?	Steroids?	Economics?	Reason for exclusion
Scrimgeour, 1981[664]	No	No	No	No	No	Non-traumatic paraplegia
Selecki, 1986[665]	No	No	Yes	No	No	Data for subgroup of patients with spinal injuries has been reported in Selecki 1970.[667] No additional data reported
Selecki, 1970[667]	Yes	Yes	No	No	No	Case series (n = 211 trauma patients). No useful outcomes reported
Seybold, 1999[668]	No	Yes	No	No	No	Mix of neurologically intact and neurologic loss. Unable to analyse results separately
Seye, 1987[669]	Yes	No	No	No	No	Reviews cases of trauma (n = 120). No useful data reported
Sgouros, 1996[670]	Yes	No	No	No	No	About omental grafting, case series
Shacked, 1993[671]	Yes	Yes	No	No	No	Case series (n = 19) in children
Shah, 1994[672]	Yes	Yes	No	No	No	Case series (n = 7) (<48 h)
Shapiro, 1993[673]	Yes	Yes	No	No	No	Case series (n = 22 acute injury)
Shapiro, 1999[674]	Yes	Yes	No	No	No	Unclear whether those with SCI (n = 6) had fixation or not. No clear comparison between surgical and non-surgical groups
Shapovalov, 1998[675]	No	No	No	No	No	Not fixation, no control group. In Russian
Sharafuddin, 1990[676]	No	No	No	No	No	Three case reports
Shaw, 1990[677]	Yes	No	No	No	No	About first aid for SCI patients
Shepard, 1994[678]	Yes	No	No	Yes	No	Irrelevant outcomes (liver enzymes) of study already included in the Cochrane review
Shevelev, 1997[679]	Yes	Yes	No	No	No	Case series (n = 6). In Russian
Shih, 1997[680]	No	Yes	No	No	No	Case series (n = 10). Seat belt type injury
Shufflebarger, 1991[681]	No	Yes	No	No	No	Not acute stage fixation. Not SCI
Sicard, 1974[682]	Yes	No	No	No	No	Non-systematic review of treatment methods
Signoret, 1999[683]	Yes	Yes	No	No	No	Case series (n = 8)
Silberstein, 1992[684]	Yes	No	No	No	No	About surgical decompression
Silvestro, 1992[685]	Yes	Yes	No	No	No	Case series (n = 25)
Simpson, 1984[686]	Yes	No	Yes	No	No	153 patients but only 13 with SCI; results not presented separately so cannot use
Simpson, 1986[666]	No	No	No	No	No	Considers patients with head injury

continued

Study	Acute SCI?	Fixation?	Referral?	Steroids?	Economics?	Reason for exclusion
Simpson, 1989[687]	Yes	No	No	No	No	Not about fixation, referral, discharge or steroids
Singh, 1998[688]	Yes	No	No	No	No	Case report
Six, 1979[689]	Yes	Yes	No	No	No	Cohort study (controlled) of gunshot wounds (n = 59) but only 3 had fusion. No usable results
Smith, 1991[690]	No	Yes	No	No	No	Mixed aetiologies – not clear if result of trauma
Sniezek, 1996[691]	No	No	No	No	No	Letter to editor (comment on study about trauma morbidity patterns)
Snowdy Jr, 1987[692]	Yes	No	No	No	No	Non-systematic review of stabilisation procedures in SCI patients
Sobel, 1985[693]	No	No	No	No	No	Case series (n = 5). Charcot's arthropathy of the spine
Solenyi, 1981[694]	Yes	Yes	No	No	No	Description of techniques, not results. In Russian
Sonntag, 1999[74]	No	No	No	No	No	General non-systematic review on neurological surgery
Spielholz, 1979[695]	Yes	No	No	No	No	Looks at somatosensory evoked potentials. Outcome not relevant
Spinal Injuries Association, 1997[8]	Yes	No	No	No	No	Background – SIA recommendations
Spissak, 1985[696]	No	Yes	No	No	No	Observational study, unclear whether SCI was due to trauma. In Czech
Splavski, 1996[697]	Yes	No	No	No	No	Only 1 had fixation
Stambough, 1996[116]	Yes	Yes	No	No	No	Case series (n = 17)
Stancic, 2001[120]	Yes	Yes	No	No	No	Compares two surgical techniques, no control group
Standaert, 1997[698]	Yes	No	No	No	No	Late complications of SCI
Stauffer, 1974[699]	Yes	No	No	No	No	Non-systematic review of orthotics for SCI
Stauffer, 1982[700]	No	No	No	No	No	Non-systematic review of cervical spine injuries in children
Stauffer, 1984[701]	No	Yes	No	No	No	Non-systematic review of techniques, not results
Stauffer, 1986[702]	No	No	No	No	No	Non-systematic review of management of spine fractures to C3 to C7
Stavrev, 1994[703]	Yes	Yes	No	No	No	Case series (n = 13) with SCI
Stavrev, 1994[704]	Yes	Yes	No	No	No	Cohort study (controlled), but surgical and non-surgical groups are not compared, no usable results
Stejskal, 1971[705]	Yes	Yes	No	No	No	Opinion-based review. In Czech
Stevenson, 1996[706]	Yes	No	No	No	No	Patients with spinal cord pathology
Stover, 1994[707]	Yes	No	No	No	No	Transcript of lecture

continued

Study	Acute SCI?	Fixation?	Referral?	Steroids?	Economics?	Reason for exclusion
Street, 1967[708]	Yes	No	No	No	No	Three case reports
Stromsoe, 1997[709]	Yes	Yes	No	No	No	Case series (n = 78)
Stromsoe, 2000[710]	Yes	Yes	No	No	No	3 case reports
Sugarman, 1982[711]	Yes	No	No	No	No	Mixed acute and long-term care
Sugarman, 1984[712]	Yes	No	No	No	No	About osteomyelitis
Sumida, 2001[713]	Yes	No	No	No	No	Early rehabilitation, not acute care
Sun, 1997[714]	Yes	No	No	Yes	No	Not a RCT, not about fixation or referral. In Chinese
Sunami, 1977[715]	Yes	Yes	No	No	No	Controlled study (n = 25); of these 10 had spinal fusion (related to severity of injury) but surgical and non-surgical groups not compared
Sussman, 1978[716]	Yes	Yes	No	No	No	No useful data
Svendgaard, 1982[717]	Yes	Yes	No	No	No	Case series (n = 24)
Swain, 1996[718]	Yes	No	No	No	No	About first aid for SCI patients
Sypert, 1984[719]	Yes	No	No	No	No	Non-systematic review of acute SCI management
Taborelli, 1984[720]	Yes	Yes	No	No	No	Case series, about technique rather than results
Tachibana, 1984[721]	Yes	No	No	No	No	Case series (n = 6). Myelotomy. In Japanese (English abstract)
Talmi, 2000[722]	Yes	Yes	No	No	No	Case series (n = 6) of post-surgical complications
Tasdemiroglu, 1995[723]	Yes	Yes	No	No	No	Case series (n = 60)
Tator, 1984[724]	Yes	No	Yes	No	No	No comparative data about delayed referral vs non-delayed referral
Tator, 1993[725]	Yes	No	No	No	No	Possible economics
Tator, 1999[726]	Yes	Yes	No	No	No	Assesses incidence of surgery, not effectiveness
Teanby, 1993[727]	No	No	No	No	No	Mixed trauma patients – no separate discussion of SCI
Tell, 1991[728]	Yes	No	No	No	No	Case series (n = 76) reporting on complications after anterior cervical spine surgery
Tertsch, 1986[729]	No	Yes	No	No	No	Overview (non-systematic) of techniques for spine surgery. In German
Thalgott, 1997[730]	Yes	Yes	No	No	No	Case series, only 3 with SCI
Thomas, 1987[731]	No	No	No	No	No	Mixed patients (no trauma)
Tippets, 1988[732]	Yes	Yes	No	No	No	Case series (n = 19, trauma patients)

continued

Study	Acute SCI?	Fixation?	Referral?	Steroids?	Economics?	Reason for exclusion
Tominaga, 1994[733]	No	No	No	No	No	Case series (n = 12). All patients received anterior cervical fixation
Turker, 1995[736]	No	No	No	No	No	Two case reports
Tzivian, 1979[734]	Yes	No	No	No	No	Laminectomy, not fixation. In Russian
Tzivian, 1976[735]	Yes	No	No	No	No	Decompression rather than fixation. In Russian
Tzivian, 1980[737]	Yes	Yes	No	No	No	Case series (n = 15). In Russian
Ulrich, 2001[115]	Yes	Yes	No	No	No	Case series (n = 119)
Usbeck, 1981[738]	Yes	Yes	No	No	No	No comparison between groups
Vaccaro, 1997[739]	Yes	Yes	No	No	No	Early versus late fixation
Vaccaro, 1997[740]	Yes	No	No	No	No	Describes the management of acute spinal trauma
Vaccaro, 1999[741]	No	Yes	No	No	No	Description of fixation techniques, not a study
Vaccaro, 1999[742]	Yes	No	No	No	No	Non-systematic review of pharmacological treatment and surgical timing for SCI
Vaiss, 1977[743]	Yes	Yes	No	No	No	No control group. In Russian
Vale, 1997[744]	Yes	No	No	Yes	No	Case series study of 'aggressive medical treatment'; all received steroids
Van de Kelft, 1994[745]	No	Yes	No	No	No	Case series (n = 10)
Verbiest, 1969[746]	Yes	Yes	No	No	No	Case series (n = 47)
Verbiest, 1970[747]	Yes	Yes	No	No	No	A few case series to illustrate different methods of surgery – no non-operated controls
Virozub, 1982[748]	Yes	No	No	No	No	Not about delayed referral, fixation or steroids. In Russian
Vishnevsky, 1998[749]	Yes	No	No	No	No	Not about fixation, referral, discharge or steroids
Vishteh, 1998[750]	No	Yes	No	No	No	Case series (n = 17). Mixed pathology
Vitaz, 2001[751]	No	No	No	No	No	Compares groups before and after implementation of clinical pathway
Wagner, 1981[752]	Yes	No	Yes	No	No	Not a study, a report of general experiences in an SIU. No data
Wagner, 1982[753]	Yes	No	No	No	No	Decompression, not fixation
Walker, 1978[754]	Yes	No	No	No	No	Short article on surgical treatment in paraplegia
Walker, 1979[755]	Yes	Yes	No	No	No	No results? Report of technique. In German
Wang, 1979[756]	No	No	No	No	No	Case series (n = 9)

continued

Study	Acute SCI?	Fixation?	Referral?	Steroids?	Economics?	Reason for exclusion
Wang, 1984[757]	No	Yes	No	No	No	Case series (n = 27). In Japanese (English abstract)
Ward, 2000[758]	Yes	Yes	No	No	No	No control group
Wawro, 1994[759]	No	Yes	No	No	No	Case series (n = 12 acute injuries). In German
Weber, 1966[760]	No	Yes	No	No	No	Case report. In German
Weber, 1978[761]	Yes	Yes	No	No	No	Techniques, not results. In German
Weber, 1985[108]	Yes	Yes	No	No	No	No useful outcomes reported
Weigert, 1971[762]	No	Yes	No	No	No	No data. In German
Weigert, 1974[763]	Yes	Yes	No	No	No	Overview (non-systematic) of indications and techniques for spine surgery, illustrated by case reports. In German
Weil, 1974[764]	No	Yes	No	No	No	Describes spine fracture treatment/management in USA. In German
Weinshel, 1990[765]	Yes	Yes	No	No	No	Compares surgical and non-surgical groups but no useable comparative results presented
Weinstein, 1992[766]	No	No	No	No	No	Describes technical aspects of pedicle screws
Weiss, 1973[767]	Yes	No	No	No	No	Case report
Weiss, 1975[768]	Yes	Yes	No	No	No	Overview of technique of dynamic spine alloplasty, and case series (n = 92)
Weiss, 1991[769]	Yes	Yes	No	No	No	Case series (n = 92)
Weiss, 1980[770]	Yes	Yes	No	No	No	Case series. In German
Welch, 1986[771]	Yes	No	No	No	No	Not about fixation, steroids or referral
Wells, 1993[772]	Yes	No	No	No	No	Compares care before and after implementation of multidisciplinary team
Wells, 1995[773]	Yes	No	No	No	No	Background paper on scoring SCI severity
Wendsche, 1988[774]	No	Yes	No	No	No	No comparison of outcomes
Weyns, 1994[775]	Yes	Yes	No	No	No	All had fixation – no control group
Wharton, 1978[776]	No	No	No	No	No	Non-systematic review of stabilisation of spinal injuries for early mobilisation
White, 1976[777]	Yes	No	No	No	No	Not about fixation
White, 1984[778]	No	No	No	No	No	Non-systematic review. Guidelines for deciding which operation to do for a particular patient
Whitehill, 1983[779]	No	No	No	No	No	Case report

continued

Study	Acute SCI?	Fixation?	Referral?	Steroids?	Economics?	Reason for exclusion
Whitehill, 1983[780]	Yes	Yes	No	No	No	Case series
Whitehill, 1988[781]	Yes	Yes	No	No	No	Case series (n = 12 with SCI)
Whiteneck, 1992[782]	No	No	No	No	No	About new measures of handicap
Wiberg, 1988[783]	Yes	Yes	No	No	No	Case series (n = 30)
Wiberg, 1993[784]	Yes	Yes	No	No	No	Case series (n = 54). In Norwegian
Wildburger, 1994[113]	Yes	Yes	No	No	No	Compares two types of surgery, no control group
Williams, 1995[785]	Yes	Yes	No	No	No	Case report
Wilson, 1999[786]	No	Yes	No	No	No	Case report
Wineman, 1999[787]	Yes	No	No	No	No	Not acute care
Wing, 1998[788]	Yes	No	No	Yes	No	Prospective cohort study (methylprednisolone)
Winter, 1991[789]	No	No	No	No	No	Case report
Woertgen, 1997[790]	No	No	No	No	No	Non-SCI patients (herniated disc)
Wolf, 1991[791]	Yes	Yes	No	No	No	Case series (n = 52)
Wolter, 1985[792]	Yes	Yes	No	No	No	Overview (non-systematic) of indications and techniques for spine surgery, illustrated by case reports. In German
Wolter, 1992[793]	No	Yes	No	No	No	Case series? In German. No data given
Yahiro, 1994[794]	No	No	No	No	No	Literature review – no named databases. Mixed diagnoses
Yamada, 1967[795]	No	No	No	No	No	Description of (non-surgical) plaster jacket? In Japanese
Yanase, 1995[796]	No	Yes	No	No	No	Not trauma SCI
Yarkony, 1987[797]	Yes	No	No	No	No	On comprehensive rehabilitation services
Yarkony, 1988[798]	Yes	No	No	No	No	Rehabilitation, not acute services
Yarkony, 1990[799]	Yes	No	Yes	No	No	Statistics on transfer times to a rehabilitation unit (not acute)
Yarkony, 1990[800]	Yes	No	No	Yes	No	Letter commenting on NASCIS
Ye, 1992[601]	No	Yes	No	No	No	Mixed case series (n = 7 acute trauma) of the application of Dick instrumentation
Ye, 1993[602]	No	No	No	No	No	Duplicate of Ye[601]. In Chinese
Yeo, 1998[801]	Yes	No	No	No	No	Reports long-term mortality (deaths within 18 months excluded)

continued

Study	Acute SCI?	Fixation?	Referral?	Steroids?	Economics?	Reason for exclusion
Yosipovitch, 1977[802]	Yes	Yes	No	No	No	Case series (n = 16)
Young, 1981[803]	Yes	Yes	No	No	No	Case series (n = 11)
Young, 1988[804]	No	No	No	No	No	Experimental study in cats
Young, 1992[805]	Yes	No	No	Yes	No	Paper on implications of NASCIS 2
Young, 1992[806]	Yes	No	No	No	No	Editorial – medical treatments of acute SCI
Young, 1994[807]	Yes	No	No	Yes	No	Non-systematic review of glucocorticoid therapy. Useful background?
Young, 1998[808]	Yes	No	No	No	No	Non-systematic review. Useful background?
Yu, 1989[809]	Yes	Yes	No	No	No	Only 6 with surgery only 5 with SCI, cannot tell who had what
Yuan, 1986[810]	Yes	Yes	No	No	No	Case series (n = 32). In Chinese (English abstract)
Yumashev, 1982[811]	Yes	No	No	No	No	Case series of patients (n = 19) examining local hypothermia during surgery. In Russian
Zach 1976[812]	Yes	No	Yes	No	No	Results not presented by treatment or referral differences
Zakrevskii, 1978[813]	Yes	Yes	No	No	No	Not sure how many had SCI, no control group. In Russian
Zampolini, 2000[814]	Yes	No	No	No	No	Management of SCI in Italy. No useful information
Zangger, 1993[107]	No	Yes	No	No	No	Excluded patients with severe or complete paraplegia
Zaripov, 1989[815]	No	No	No	No	No	Not fixation, no control group. In Russian
Zdeblick, 1993[816]	Yes	Yes	No	No	No	Non-systematic review of techniques, not results
Zeidman, 1996[817]	Yes	No	No	Yes	No	Non-systematic review of the evidence. Useful background?
Zeidman, 1997[818]	No	No	No	No	No	Incidence of complications in cervical spine surgery. Mixed diagnoses
Zhao, 1984[297]	Yes	Yes	No	No	No	Case series (n = 86)
Zhao, 1986[819]	Yes	Yes	No	No	No	Case series (n = 20). In Chinese (English abstract)
Zheng, 1992[820]	Yes	Yes	No	No	No	Case series (n = 16)
Zhia, 1980[821]	No	No	No	No	No	Case report. In Chinese
Zielke, 1975[822]	Yes	Yes	No	No	No	Case series. In German
Zigler, 2001[823]	Yes	Yes	No	No	No	Description of techniques
Zilch, 1984[824]	Yes	No	No	No	No	Description of indications for stabilisation of the spine
Zoch, 1972[825]	Yes	Yes	No	No	No	Case series (n = 31)

Appendix 7

Excluded 'economic' studies identified from search

Study	Reason for exclusion
Webb, 1978[835]	Not a full economic evaluation. Retrospective costing study with no comparison of patient outcomes
DeVivo, 1997[836]	Not a full economic evaluation. Prospective costing with no control group and no assessment of patient outcomes
Fiedler, 1999[837]	Not a full economic evaluation. Cost function analysis attempting to explain, using regression techniques, the impact of economic variables on the cost of treating spinal cord injury (SCI)
Cardenas, 2001[838]	Not a full economic evaluation. Review of previous studies. Concentrates on rehabilitation studies
Ditunno, 1997[839]	Not a full economic evaluation. Discussion document
Webb, 1979[840]	Not a full economic evaluation. Retrospective costing without control group and without comparison of patient outcomes. Based in rehabilitation centre
Rubin, 1989[841]	Not a full economic evaluation. Hypothetical costing study based on benefits of avoiding SCI
Richmond, 1995[842]	Not a full economic evaluation. Prospective costing of requirement for nursing care in SCI patients
Harvey, 1992[843]	Not a full economic evaluation. Comprehensive prospective costing of SCI patients. No control group or comparison of patient outcomes
Tator, 1993[725]	Not a full economic evaluation. Cost function analysis to assess predictors of cost (including length of stay and cost of complications)
Young, 1978[844]	Not a full economic evaluation. Retrospective costing of initial hospitalisation without control group or measures of patient outcome
Price, 1994[845]	Not a full economic evaluation. Retrospective costing of initial hospitalisation
Charles, 1978[846]	Not a full economic evaluation. Costing study comparing those patients with delayed entry into system with those whose entry was not delayed finding that those who entered quicker were less expensive. However, no comparison of outcomes and no randomisation
Burnett, 2001[847]	Not a full economic evaluation. Cost function analysis using retrospective data to assess impact of socio-economic and clinical variables on cost
Forrest 1995[848]	Not a full economic evaluation. Retrospective costing of delayed discharge from rehabilitation units
Girard, 1983[849]	Not a full economic evaluation. Analysis of cost and length of stay and factors impacting on these

continued

Study	Reason for exclusion
Johnson, 1996[850]	Not a full economic evaluation. Prospective costing of SCI patients. No comparison of patient outcomes
Botel, 1997[851]	Not a full economic evaluation. Comparison of costs of managing SCI patients in hospital and at home. Patient outcomes not measured
DeVivo, 1999[292]	Not a full economic evaluation, nor a cost analysis. Paper considers factors influencing the discharge destination of SCI patients
Charles, 1974[852]	Not a full economic evaluation. Cost comparison of 'system' versus 'non-system' approach to managing SCI. Patient outcomes are not measured; the study assumes that patient outcomes are comparable under each system

Appendix 8

Asia and Frankel scales

ASIA impairment scale I[826]

Grade	Description
A	Complete; no sensory or motor function preserved in the sacral segments S4–S5
B	Incomplete; sensory but not motor function preserved below the numerological level and extending through the sacral segment S4–S5
C	Incomplete; motor function preserved below the neurological level; most (more than half) key muscles have a grade <3. Sensory function is present below the neurological level and includes sacral segments S4–S5
D	Incomplete; motor function preserved below the neurological level; most (at least half) key muscles have a grade 3 or more. Sensory function is present below the neurological level and includes sacral segments S4–S5
E	Normal motor and sensory function

Frankel's classification[827]

Grade	Description
A	Complete sensorimotor loss
B	Sensory only (complete motor loss)
C	Motor useless
D	Motor useful
E	Recovery

Health Technology Assessment Programme

Prioritisation Strategy Group

Members

Chair,
Professor Kent Woods,
Director, NHS HTA Programme & Professor of Therapeutics, University of Leicester

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We look forward to hearing from you.

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