The role of magnetic resonance imaging in the identification of suspected acoustic neuroma: a systematic review of clinical and cost-effectiveness and natural history

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Executive summary

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Executive summary

Background

Advances in technology within health care should lead us to continually question the most effective methods for investigation, diagnosis, intervention and rehabilitation. Recent advances in imaging techniques raise questions of clinical effectiveness and cost-effectiveness in many areas of health care. This report aims to address some of these questions in the identification of acoustic neuroma.

Objectives

This report aimed to answer the following three questions:

1. What is the role of magnetic resonance (MR) imaging in investigating patients with unilateral hearing loss and/or tinnitus for suspected acoustic neuroma?
2. What is the cost-effectiveness of MR imaging compared with other diagnostic strategies in these patients?
3. What is known about the natural history of acoustic neuroma?

The objectives of the study were to:

- evaluate the clinical effectiveness and cost-effectiveness of a range of diagnostic strategies for investigating patients with unilateral hearing loss and/or tinnitus with a view to confirming or eliminating a diagnosis of acoustic neuroma
- describe the natural history of acoustic neuroma
- synthesise the findings from these two elements of the study to formulate guidelines for clinical practice and proposals for future primary research priorities.

Methods

Systematic reviews of the literature from January 1980 to October 2006 were conducted in each of three themes:

- the clinical effectiveness of diagnostic strategies to identify acoustic neuroma in patients presenting with relevant symptoms (to include only papers that compared a diagnostic strategy with the gold standard of MR imaging)
- the costs and cost-effectiveness of diagnostic strategies
- the natural history of acoustic neuroma including incidence, prevalence, symptomatology and growth.

Before the final submission a further simplified search covering all three themes was conducted for the period October 2006 to August 2008.

Clinical and methodological experts selected papers for review based on comprehensive inclusion criteria.

Results

The evidence from the review of diagnostic strategies is that:

- The sensitivity and specificity of studies comparing auditory brainstem response (ABR) with MR imaging were highly heterogeneous.
- ABR measurement has high sensitivity compared with MR imaging for acoustic neuromas greater than 1 cm in size but not for smaller neuromas.
- The sensitivities of studies of T2-weighted (T2W) and T2-star-weighted (T2*W) imaging strategies (high-resolution, non-contrast-enhanced) compared with gadolinium-enhanced T1-weighted (GdT1W) MR imaging (gold standard, contrast-enhanced) were high and relatively homogeneous. The pooled test sensitivity for T2W imaging as the reference test was 98% [95% confidence intervals (CI) 94–99%] and for T2*W imaging as the reference test was 96% (95% CI 86–99%). The specificity of T2W studies ranged from 90% to 100% and for T2*W studies from 86% to 99%.
- Non-contrast, high-resolution, three-dimensional T2W or T2*W sequences enable

accurate evaluation of the VIIIth and VIIth cranial nerves within the cerebellopontine angle (CPA) and internal auditory canal (IAC) as well as evaluation of the cochlea and labyrinth. When these structures are clearly and confidently identified, inclusion of GdT1W sequences is unlikely to contribute information that would alter patient management in the screening population.

The evidence from the review of costs and cost-effectiveness is that:

- Compared with 'traditional' protocols that deploy what have become essentially redundant tests such as computerised tomography (CT) and electronystagmography (ENG), strategies that deploy GdT1W MR imaging immediately or in conjunction with ABR appear to be more cost-effective.
- Comparisons of ABR/GdT1W MR imaging protocols with a direct to GdT1W MR imaging protocol after audiometry concluded that interposing an intervening screen was more cost-effective than going directly to GdT1W MR imaging.
- Comparisons of non-contrast-enhanced MR imaging with GdT1W MR imaging found non-contrast-enhanced MR imaging to be a more cost-effective test for acoustic neuroma than GdT1W MR imaging.
- The evidence reviewed indicates the relative cost-effectiveness of a non-contrast-enhanced MR screen before contrast MR imaging relative to a direct to contrast MR imaging for all patients in the investigation of acoustic neuroma.

The evidence from the review of incidence and prevalence is that:

- There has been a significant increase in the incidence of acoustic neuroma over the past 30 years, from five tumours per million per year in 1976 to just under 20 per million per year in 2001.
- Much of this increase in incidence is due to the advent of better non-invasive diagnostic techniques, especially MR scanning.
- The incidence of giant tumours has dropped, whereas that of small and medium-sized tumours has increased.
- The median age at diagnosis has not changed (around 55 years).

The evidence from the review of symptomatology is that:

- The literature does not clearly distinguish between the prevalence of symptoms determined after further investigation, examination and questioning, and the number of patients who report that symptom as their principal complaint.
- The majority of patients diagnosed with acoustic neuroma present with insidious symptoms of unilateral hearing impairment, tinnitus and/or vertigo.

The evidence from the review of growth is that:

- Studies of the natural history and growth of acoustic neuroma have one or more serious weaknesses in their methodological design.
- The pattern and rate of growth are highly variable and currently unpredictable. At least 50% of acoustic neuromas do not grow for at least some years after diagnosis.
- No reliable predictors of growth have been identified. Some studies have found large initial size to be a determinant of later growth, although the opposite has also been reported.
- The mean growth rate for all tumours varies between 1 and 2 mm/year, whereas considering only those that grow the rate varies between 2 and 4 mm/year; however, there are cases with significant regression or exceptional growth (which may exceed 18 mm/year).
- Regression is a small but real possibility (around 5%).
- There are various patterns of growth, and a tumour that shows growth may stop doing so and vice versa.
- The first year after diagnosis may be crucial for determining the pattern of tumour growth; however, this is not always the case and the tumour may be stable for many years before showing continuous growth.

Conclusions

The majority of the evidence reviewed in all three themes was poorly reported and there is therefore an inherent risk of bias.

Given the recent improvement in resolution and reduction in the cost of MR imaging, ABR can no longer be considered appropriate as

the primary test used to screen for an acoustic neuroma. Although it is relatively inexpensive and offers acceptable sensitivity for medium to larger tumours, its ability to reliably indicate tumours under 1 cm is poor.

In current clinical practice MR imaging is the first-line investigation for the identification of suspected acoustic neuroma in appropriately selected patients. The GdT1W sequence remains the gold standard sequence for evaluating cases in which the screening sequence is indeterminate and for characterising any suspected pathology.

The quality of the imaging chain and the experience of the reporting radiologist are key factors determining the efficacy of a non-contrast screening strategy.

The applicability of previous studies reporting cost and cost-effectiveness data is limited given their age and the fact that many were undertaken outside the UK. Based on a cost-effectiveness model developed to reflect UK practice, a diagnostic algorithm that deploys non-contrast MR imaging as an initial imaging screen in the investigation of acoustic neuroma is less costly than, and likely to be as effective as, available contrast MR imaging.

There are no regional or national tumour registries in the UK for acoustic neuromas. Trends in incidence are difficult to capture, and research is heavily reliant on data from tertiary centres, which are often unrepresentative of what is happening in the general population.

The typical presentation of acoustic neuroma is with symptoms of progressive unilateral hearing impairment and associated tinnitus and imbalance. These should be clear 'red flags' for investigation and this would usefully be enshrined in clinical protocols. It should also be borne in mind that atypical presentation with facial pain, otalgia or facial numbness occurs, and the clinician's acumen should bear this possibility in mind.

Although the biology of the tumours is well understood, the pathophysiological mechanisms by which patients become symptomatic are not, and much of the relevant literature is inferential rather than based on experimental evidence.

The pattern and rate of growth and the predictors of growth are highly variable and there is little useful information in the reviewed literature.

Recommendations for research

- The evidence highlights the need for primary longitudinal studies to address unanswered questions. The studies reviewed were generally of poor quality in terms of the detail of the reporting of methodology as well as the consistency of reporting, and it is recommended that studies be undertaken to provide evidence of the true incidence and natural history of acoustic neuroma. To ensure that the findings are timely, apply to current practice and have a sufficient number of subjects to draw robust conclusions, such studies should be collaborative and multicentre.
- A national audit should explore the true prevalence of unilateral auditory symptoms and their relation to acoustic neuromas.
- This review did not address issues of treatment strategies nor outcomes, and useful knowledge would be gathered and disseminated by a systematic review of the evidence around these issues.
- Research is required to provide evidence to further understand the pathophysiological mechanisms by which patients become symptomatic.
- It is recommended that studies of current practice be undertaken. Developments in technology have reduced the costs of imaging and increased the resolution achievable.

Publication

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NIHR Health Technology Assessment Programme

The Health Technology Assessment (HTA) Programme, part of the National Institute for Health Research (NIHR), was set up in 1993. It produces high-quality research information on the effectiveness, costs and broader impact of health technologies for those who use, manage and provide care in the NHS. 'Health technologies' are broadly defined as all interventions used to promote health, prevent and treat disease, and improve rehabilitation and long-term care.

The research findings from the HTA Programme directly influence decision-making bodies such as the National Institute for Health and Clinical Excellence (NICE) and the National Screening Committee (NSC). HTA findings also help to improve the quality of clinical practice in the NHS indirectly in that they form a key component of the 'National Knowledge Service'.

The HTA Programme is needs led in that it fills gaps in the evidence needed by the NHS. There are three routes to the start of projects.

First is the commissioned route. Suggestions for research are actively sought from people working in the NHS, from the public and consumer groups and from professional bodies such as royal colleges and NHS trusts. These suggestions are carefully prioritised by panels of independent experts (including NHS service users). The HTA Programme then commissions the research by competitive tender.

Second, the HTA Programme provides grants for clinical trials for researchers who identify research questions. These are assessed for importance to patients and the NHS, and scientific rigour.

Third, through its Technology Assessment Report (TAR) call-off contract, the HTA Programme commissions bespoke reports, principally for NICE, but also for other policy-makers. TARs bring together evidence on the value of specific technologies.

Some HTA research projects, including TARs, may take only months, others need several years. They can cost from as little as £40,000 to over £1 million, and may involve synthesising existing evidence, undertaking a trial, or other research collecting new data to answer a research problem.

The final reports from HTA projects are peer reviewed by a number of independent expert referees before publication in the widely read journal series *Health Technology Assessment*.

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Reports are published in the HTA journal series if (1) they have resulted from work for the HTA Programme, and (2) they are of a sufficiently high scientific quality as assessed by the referees and editors.

Reviews in *Health Technology Assessment* are termed 'systematic' when the account of the search, appraisal and synthesis methods (to minimise biases and random errors) would, in theory, permit the replication of the review by others.

The research reported in this issue of the journal was commissioned by the HTA Programme as project number 05/08/01. The contractual start date was in May 2007. The draft report began editorial review in December 2007 and was accepted for publication in October 2008. As the funder, by devising a commissioning brief, the HTA Programme specified the research question and study design. The authors have been wholly responsible for all data collection, analysis and interpretation, and for writing up their work. The HTA editors and publisher have tried to ensure the accuracy of the authors' report and would like to thank the referees for their constructive comments on the draft document. However, they do not accept liability for damages or losses arising from material published in this report.

The views expressed in this publication are those of the authors and not necessarily those of the HTA Programme or the Department of Health.

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