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Non-Contrast High Resolution Fast Spin Echo Magnetic Resonance Imaging of Acoustic Schwannoma

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ABSTRACT

Aim of Study: **The current gold-standard of examination for the exclusion of acoustic schwannomas is contrast-enhanced magnetic resonance (MR) imaging. Many patients however, still cannot afford to pay for the cost of this examination. As a result, many clinicians still resort to contrast-enhanced computed tomography (CT) scan; an examination which could miss small intracanalicular acoustic schwannomas. The aim of this study was to report on our experience on the usage of the more affordable high-resolution fast spin-echo (FSE) MR imaging for the diagnosis of acoustic schwannoma.**

Methodology: **A study involving 123 patients with symptoms of sensorineural hearing loss, vertigo and tinnitus was carried out between August 1996 and March 1997. All cases were scanned with a 1.5 T MR unit using a quadrate head coil. The section thickness was 1.5 mm, with TR/TE of 4000/96. Any mass arising from the vestibulocochlear nerve was considered to be an acoustic schwannoma, and most of these positive cases underwent further contrast-enhanced MR imaging to confirm the diagnosis.**

Results: **A total of 7 acoustic schwannomas were detected on high resolution FSE MR imaging and for 5 of these cases, the diagnosis was confirmed with contrast-enhanced MR imaging. Three of the 7 positive patients had contrast-enhanced CT scan done just prior to the MR study and the tumours were not detected on CT scan. The smallest acoustic schwannoma detected on high-resolution FSE MR imaging had a dimension of 0.5 x 0.4 x 0.5 cm.**

Conclusion: **High resolution FSE MR imaging is more sensitive than contrast-enhanced CT scan in the diagnosis of acoustic schwannoma. Although the sensitivity is less than that of contrast-enhanced MR imaging, high resolution FSE MR is more affordable and therefore can play a role in the screening for acoustic schwannomas in selected groups of patients.**

Keywords: **intra-canalicular tumour, sensorineural hearing loss, cost, internal auditory canal, vestibulocochlear nerve**

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INTRODUCTION

Contrast-enhanced spin-echo magnetic resonance (MR) imaging has high sensitivity and specificity for the diagnosis of acoustic schwannoma and is now the investigative modality of choice for this condition[1]. However, despite the ready availability of MR imaging in Singapore, a fair number of patients in most restructured hospitals are still subjected to contrast-enhanced computed tomography (CT) of the internal auditory canals (IAC). This method is known to miss small intra-canalicular acoustic schwannomas[2], although combination with air cisternography could increase the sensitivity[3]. The procedure of injecting air into the cerebrospinal fluid (CSF) space has its complications[3] and should not be done presently with the availability of MR scanner. The main reason why contrast-enhanced CT scan of the IAC is still being carried out today is that most of these patients cannot afford the cost of contrast-enhanced MR imaging; even at a subsidised rate. The purpose of this paper is to report on our experience on the usage of high-resolution fast spin-echo (FSE) MR for the diagnosis of acoustic schwannoma. This technique does not require the use of intravenous gadolinium and the total scanning time is about half that of contrast-enhanced MR. All these translates to cheaper cost of examination, thereby making it more affordable. In our series, high-resolution FSE MR could detect acoustic schwannomas with a diameter of 4 mm or more. Three of these patients with acoustic schwannoma had contrast-enhanced CT scans of the IAC done prior to the MR imaging and the lesions were missed on CT. Therefore, high-resolution FSE MR imaging should replace contrast-enhanced CT scan in those patients who cannot afford the cost of contrast-enhanced MR. It can also be used as a screening test for those whose presenting symptoms suggest that their chances of having acoustic schwannomas are low.

MATERIALS AND METHODS

Between August 1996 and March 1997, 123 patients underwent high-resolution FSE MR of the IAC in Tan Tock Seng Hospital. Their presenting symptoms included sensorineural hearing loss, vertigo and tinnitus. The purpose of the examinations was for the exclusion of acoustic schwannomas. All cases were

scanned in a 1.5-T MR unit (Signa, GE Medical Systems). A quadrature head coil was used. The imaging parameters were: FSE sequence without fat saturation, 1.5 mm section thickness, TR/TE of 4000/96, 17 cm field of view, matrix size of 512 x 512 and 4 excitations. Sections of the IAC were acquired in the axial and coronal planes. The total scan time taken including the scout view was 16 minutes and 30 seconds. All the scans were analysed by a head and neck radiologist. The main aim was to look for any mass lesion arising from the nerves in the IAC and cerebellopontine angle. The anatomy of the membranous labyrinth was also reviewed to exclude any congenital abnormality.

There were 64 males and 57 females. The age ranged from 11 to 78 years with a mean of 45.56 years.

RESULTS

The vestibulocochlear and facial nerves were consistently visualised within the IAC as linear structures against the background of high signal CSF (Fig 1a); although they were better visualised when the canals were wide than when they were narrow. The nerves could also be visualised as they exited from the medullo pontine junction in the cerebellopontine angles except in 8 patients where CSF flow artefacts obscured the nerves in this region (Fig 4). The nerves were also equally well seen on the axial and the coronal planes.

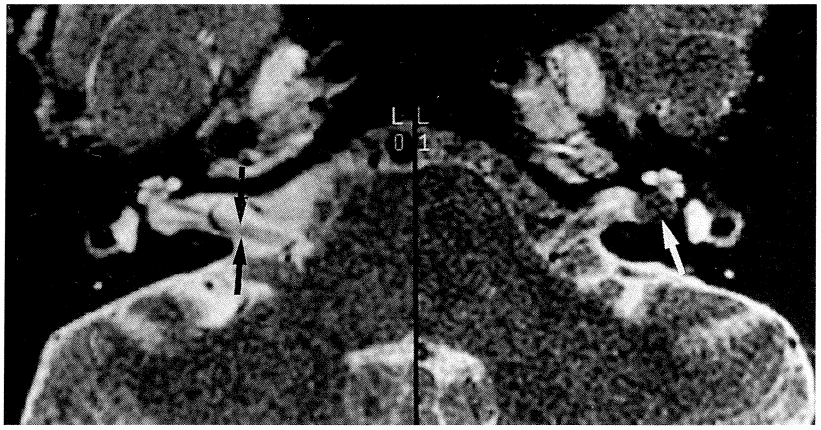

Fig Ia – Intra-canalicular acoustic schwannoma demonstrated on high-resolution FSE MR in the axial plane (white arrow). The normal nerves traversing the IAC on the right side are also demonstrated (black arrows).

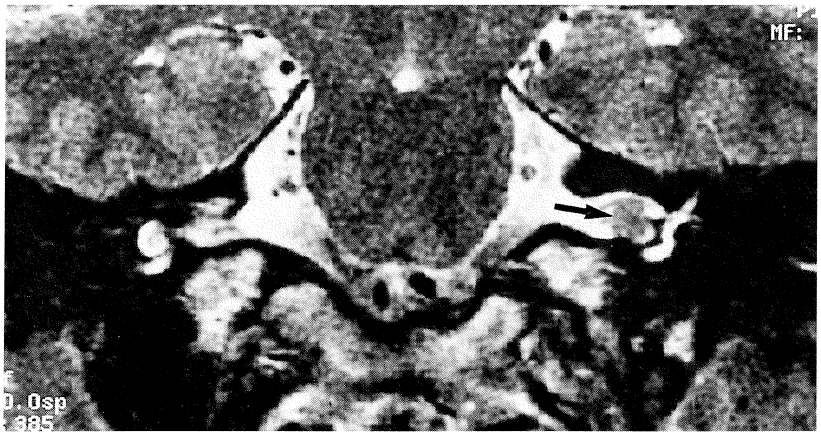

Fig Ib – The same tumour demonstrated on the coronal plane (black arrow). Contrast enhanced CT scan done previously on this patient did not demonstrate the tumour.

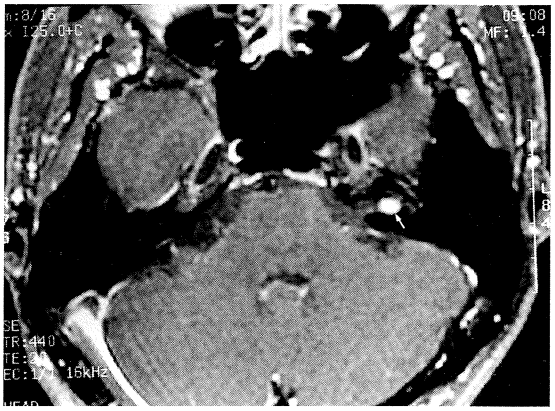

Fig Ic – Contrast-enhanced Tl-weighted spin-echo image of the same patient confirming the presence of an intra-canalicular acoustic schwannoma (white arrow).

A mass lesion was detected in 7 patients. In 5 of these patients, the mass lesion was confined within the IAC (Figs 1a, 1b). The remaining 2 masses had both a cerebellopontine angle component and an IAC component (Fig 2a). The first 5 of the 7 cases had intravenous contrast-enhanced T1 weighted spin-echo images of the IAC performed immediately following detection of the mass in the high-resolution FSE images. These masses showed up as enhancing lesions consistent with acoustic schwannomas (Figs 1c, 2b). In the last 2 patients, diagnosis of acoustic schwannoma was made based on the high-resolution FSE images and subsequently, these 2 patients were offered Gamma-knife treatment.

Three of the 7 patients (including one patient with an acoustic schwannoma that had both cerebellopontine angle and IAC components) had contrast-enhanced CT scan of the IAC done just a few weeks prior to the MR scan in another institution and the scans were reported as 'normal'. Retrospective review of these scans showed that the 2 cases of intra-canalicular schwannomas had truly normal CT scan appearance whereas in the case with both cerebellopontine angle and IAC components, the tumour could barely be seen on hindsight as a filling-in by some soft tissue of the cerebellopontine cistern (Fig 2c) and slight widening of the IAC on the affected side.

The largest acoustic schwannoma in this series had a length of 3.5 cm long, width of 1.3 cm in diameter (cerebellopontine angle component) and a height of 1.2 cm. The smallest tumour had a dimension of 0.5 x 0.4 x 0.5 cm (Fig 1a).

There were 2 false positive cases. In the first case, there was slight irregularity noted in the right vestibulocochlear nerve seen both on the axial and coronal scans. Since the hearing loss was on the same side, contrast-enhanced T1 weighted spin-echo scan was done to rule out a small schwannoma. The post-contrast scan showed no evidence of any enhancing mass lesion. CSF flow artefacts had resulted in a 'nodular mass' in the right cerebellopontine angle in the second case (Fig 3). As the patient had rightsided hearing loss, contrast-enhanced T1 weighted spin-echo scan was also performed to rule out a true mass lesion. The post-contrast scan showed no evidence of

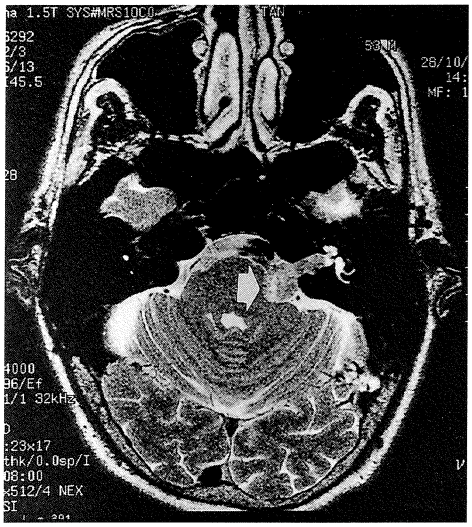

Fig 2a – Left acoustic schwannoma with cerebellopontine angle and IAC components (white broad arrow) demonstrated on high resolution FSE MR.

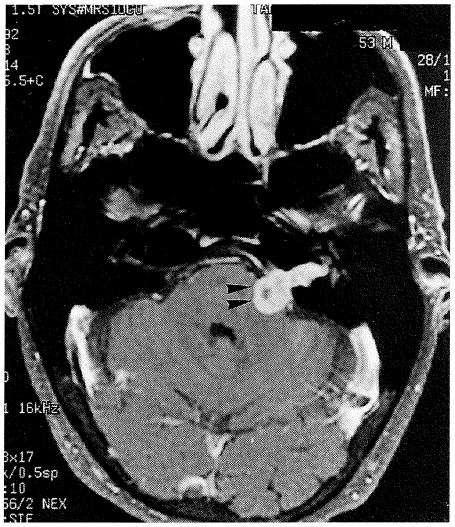

Fig 2b – Contrast-enhanced Tl-weighted spin-echo image of the same patient confirming the diagnosis of left acoustic schwannoma (arrowheads).

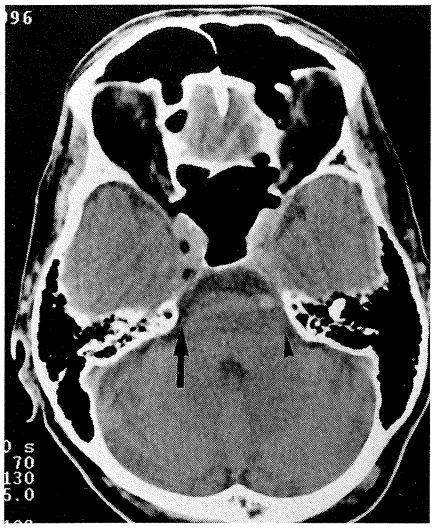

Fig 2c – Contrast-enhanced CT scan of the same patient. The acoustic schwannoma could barely be seen as a soft tissue lesion within the left cerebellopontine angle (arrowhead). Compare this with the low attenuation CSF in the right cerebellopontine angle (arrow).

any enhancing mass and the 'nodular mass' was part of the CSF flow artefacts.

One case of congenital abnormality of the membranous labyrinth was also detected. The left vestibule and lateral semi-circular canal formed a common cavity in this patient (Fig 4).

DISCUSSION

The most common mass lesion of the cerebellopontine angle found to be responsible for unilateral sensorineural hearing loss is acoustic schwannoma[1]. The current gold-standard of examination for the assessment of this condition is contrast-enhanced conventional spin-echo MR imaging[4], which provides high sensitivity and specificity for the diagnosis of acoustic schwannoma[1]. One major drawback of this examination is the high cost. In Tan Tock Seng Hospital (TTSH), it costs SGD 950 for a full-paying patient and half that amount for a subsidised patient. Even at a cost of SGD 475, many patients still cannot afford the treatment. It is for this reason that contrast-enhanced CT scans of the IAC are still being requested frequently in many of the restructured hospitals. It is customary to have at least one such request per day at TTSH. It costs only SGD 88 for a subsidised patient, and SGD 430 for a full-paying patient for this examination.

Contrast-enhanced CT scan, however, is not as sensitive as contrast-enhanced MR in the detection of acoustic schwannoma[2]. This is especially so for small (less than 1 cm in diameter) intra-canalicular tumours. The 3 cases of acoustic schwannomas in this series that were missed initially on contrast-enhanced CT scans could bear witness to this fact. The consequence of missing small acoustic schwannomas can be grave especially for younger patients as they can present years later with large cerebellopontine angle tumours. Besides this,

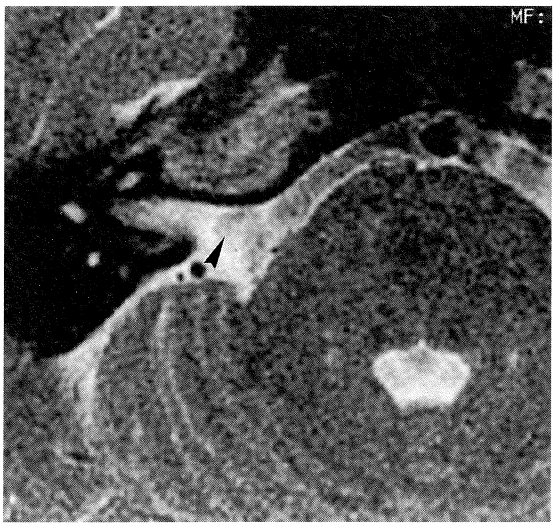

Fig 3 – False-positive case. The CSF flow artefact mimicked a nodular mass in the right cerebellopontine angle (arrowhead). No enhancing lesion was seen in the post-contrast scan, confirming that it was part of the CSF flow artefact.

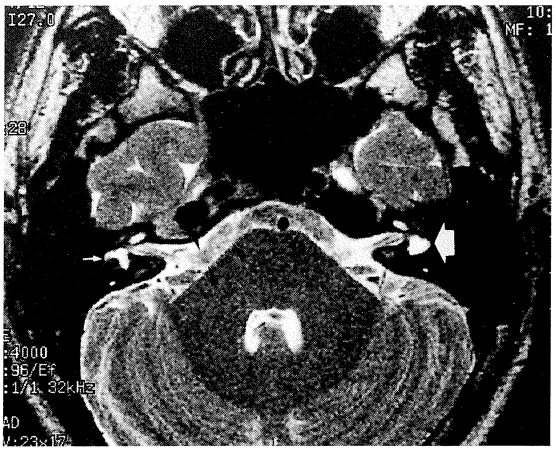

Fig 4 – High-resolution FSE MR showing the left semi-circular and the vestibule forming a common cavity in this patient (white arrow), comparing this with the normal canal and vestibule on the right side (white arrow). This is a congenital abnormality of the labyrinth. The arrowheads point to the low signal band-like CSF flow artefact which, in this case, obscures the medial ends of the right 7th and 8th nerves.

missing small tumours would mean that the opportunity to remove them with functional preservation (eg, facial expression and hearing) may be lost forever[5]. Contrast-enhanced CT scan of the IAC is therefore not an ideal alternative examination for patients who cannot afford to pay for contrast-enhance MR. Before the era of MR, CT air cisternography was used to improve the sensitivity of diagnosing acoustic schwannoma[3]. This examination, however, was not fool-proof as false positive results were not that infrequent and it also had its fair share of complications eg. persistent headache that required blood patch[3]. The availability of MR imaging has confined CT air cisternography to the history book.

The yield of contrast-enhanced MR for acoustic schwannomas varies with different series. This was partly dependent on the selection criterias of patients subjected to the examination. In Armington's series[6], where only patients with unilateral or asymmetrical sensorineural hearing loss were subjected to the examination, 17 acoustic schwannomas were detected out of a total of 176 cases (9.7%). A recent review was done on 314 cases of contrast-enhanced MR performed in TTSH[7]. A total of 13 acoustic schwannomas (4%) were detected. We were less stringent on our selection criterias and this could explain the lower yield. Besides those with unilateral or asymmetrical progressive sensorineural hearing loss, we scanned a number of patients who were at a lower risk of having acoustic schwannomas on clinical grounds, eg. those with sudden onset of sensorineural hearing loss, those with bilateral symmetrical sensorineural hearing loss, and those with vertigo and/or tinnitus without any hearing loss. It was noted however that all the 13 acoustic schwannoma patients had sensorineural hearing loss[7]. The yield therefore of scanning a patient presenting with vertigo and/or tinnitus without sensorineural hearing loss with contrast-enhanced MR was exceptionally low. Hence it would not be cost-effective to subject such patients to a contrast-enhanced MR. This is not to say that these patients should not be investigated as there were uncommon instances where acoustic schwannomas presented with vestibular symptoms and tinnitus without any hearing loss[8]. Therefore, there is a need for a more cost-effective but fairly sensitive screening test for this group of patients and obviously, contrast-enhanced CT scan is not the answer.

Some authors have recently published papers on the use of non-enhanced FSE MR sequence for the detection of acoustic schwannomas and other cerebellopontine angle mass lesion[1,9]. In the FSE sequence, the CSF in the IAC and in the cisterns around the pons appears hyperintense with the facial and vestibulocochlear nerves appearing as linear structures transversing through the cerebellopontine angle and the IAC[1]. In the usual T2-weighted images with TR of 2000 and TE of between 20 – 90, acoustic schwannomas appear as hyperintense mass lesions which would make them less conspicuous against the high signal CSF. However, if the TR is increased to greater than 3000 and the TE greater than 90, the schwannomas would appear as hypointense masses whereas the CSF would remain hyperintense[9]. Using these parameters would make acoustic schwannomas more conspicuous.

The above technique also has the added advantage of clearly delineating the anatomy of the membranous labyrinth, demonstrating them as high signal structures in the inner ear. This technique had been used in the assessment of children with congenital sensorineural hearing loss, who were suspected to be suffering from the large endolymphatic sac and duct syndrome[10].

We started to use high resolution FSE MR technique since August 1996 for patients who otherwise would have undergone contrast-enhanced CT scan of the IAC because they could not afford the cost of contrast-enhanced MR. Up to March 1997, a total of 123 patients were examined. A total of 7 acoustic schwannomas were detected by this technique. Five of these cases had contrast-enhanced MR performed to confirm their diagnosis whereas for the last 2 cases, we were confident enough to make the diagnosis based on the high resolution FSE images alone. One case of congenital abnormality of the membranous labyrinth was also detected. The smallest tumour had a dimension of 5 x 5 x 4 mm. Using dual 3-inch phased-array receiver multicoils, Allen[1] was able to detect tumours as small as 1 x 1 x 2 mm. We used a standard head receiver coil which was not able to give as good a resolution as that given by a dual 3-inch phased-array receiver multicoils but with our setup, we were able to pick up tumours of at least 3 mm and above.

In terms of cost of examination, a full-paying patient was charged SGD 400 and a subsidised patient, SGD 200; certainly more affordable than a contrast-enhanced MR. The entire scanning time for high-resolution FSE sequence was 16 minutes and 30 seconds compared to 28 minutes and 33 seconds needed for a contrast-enhanced MR scan. The tumours were equally well seen on both the axial and coronal views and we needed only to scan in the axial plane. This further cut down the time and cost of the examination.

CSF flow artefacts can be a problem when using this technique. Firstly, they can obscure the medial ends of the nerves as in 8 of our patients, and secondly they can mimic as a mass lesion. In the latter case, a post-contrast T1-weighted spin echo scan can be performed and a true mass lesion excluded. By preventing the visualisation of the medial ends of the nerves, however, may result in the failure to detect small tumours adjacent to the cerebellopontine angle. Nevertheless, the chances of an acoustic schwannoma originating from the medial end of the vestibulocochlear nerve is small as most of the time, the tumour originates near the Scarpa's ganglion[9] which is usually located within the IAC near the fundus where there are hardly any CSF flow artefacts.

One limitation in our series was that we did not know the true false-negative rate as contrast-enhanced MR scans were not carried out for most of the patients undergoing the examination. Allen[1] had a false-negative rate of 4% whereas Fukui[9] missed 3 out of 50 tumours (6%) when they used similar technique in their series. All the tumours missed were 4 mm or less in diameter. Therefore, it would be reasonable to assume that if we were to scan all patients suspected of having acoustic schwannomas using the high-resolution FSE technique, we could be missing some of the smaller acoustic schwannomas, perhaps of about 6% to 8%[5] of them. Despite this limitation, high resolution FSE MR of the IAC, was still more sensitive in detecting acoustic schwannomas than contrast-enhanced CT scan of the IAC, something which we had also demonstrated in this series.

We do not therefore recommend that high-resolution FSE MR be replaced with contrast-enhanced MR of the IAC as the investigation of choice for the assessment of acoustic schwannomas, as the latter technique is still more sensitive. However, we feel that high resolution FSE MR of the IAC could still play a role in the following groups of patients:

1) Those who cannot afford the cost of contrast-enhanced MR of the IAC and who would otherwise have opted for contrast-enhanced CT scan instead.
2) Those whose presenting symptoms suggest that they are at low risk of having acoustic schwannomas, eg. those with vertigo and/or tinnitus without sensorineural hearing loss.
3) Elderly patients and those medically infirmed patients with short life expectency where no real harm would be done to the patients even if tiny tumours were missed.
4) Those with a long history of sensorineural hearing loss; so that if it was due to an acoustic schwannoma, the tumour would be of the size to be easily detected by high-resolution FSE MR.
5) Those with congenital sensorineural hearing loss where the abnormality is suspected to be in the membranous labyrinth or the endolymphatic system.

CONCLUSION

Contrast-enhanced MR of the IAC is still the modality of choice for the exclusion of acoustic schwannomas because of its high sensitivity. High-resolution FSE MR of the IAC on the other hand, is more affordable and although may not be as sensitive as contrast-enhanced MR in the detection of small tumours, can play an important role in the screening for acoustic schwannomas in selected groups of patients. Patients suspected of having acoustic schwannomas should no longer be subjected to a contrast-enhanced CT scan of the IAC unless they have contraindications to MR imaging.

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