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# Three-Dimensional Fast Spin-Echo T2-Weighted Magnetic Resonance Images of the Cerebellopontine Angle

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**Abstract:** In patients experiencing dizziness and hearing disorders, it is essential to rule out the possibility of an intracranial affection, typically a cerebellopontine angle (CPA) process. Clinically, this often is accomplished using audiology and otoneurology and by interpreting the time course of the symptoms. However, in many cases, we must resort to imaging of the skull base and the CPA.

The use of thin-section, fast spin-echo, heavily T2-weighted images can eliminate the need for gadolinium contrast administration, offering a cheaper and quicker investigation as compared with the customary T1-weighted images using gadolinium. With three-dimensional volume sampling, slice thickness can be reduced to 0.7 mm. Data reconstruction in every desired direction is possible. Ninety-two patients with hearing and balance disorders were examined using this method.

In subjects free of tumor in the CPA, the seventh and eighth nerves could be followed accurately from the internal auditory meatus to the brainstem. The tumors could be outlined with reasonable accuracy even without gadolinium contrast.

Three-dimensional, fast spin-echo, T2-weighted images are useful in evaluating the CPA in cases of suspected tumor. Most often the use of gadolinium can be avoided. This seems to be a cheap alternative for magnetic resonance screening of patients experiencing dizziness and hearing disorders.

Recently, the number of patients with unilateral hearing loss, tinnitus, or dizziness (or a combination of these) who are referred for magnetic resonance imaging (MRI) examination to exclude acoustic neuroma or another treatable cause of the symptoms has increased significantly. Contrast-enhanced, spin-echo MRI is the gold standard for investigating the cerebellopontine angle (CPA) and internal auditory meatus (IAM). The technique is sensitive, but gadolinium

contrast is expensive. Thus, there is a demand for a short and less costly MRI screening examination of the CPA and IAM.

The thin-section, gradient echo sequences that were used to create high-resolution images of the inner ear and IAM without contrast [1] are prone to magnetic susceptibility artifacts. Fast spin-echo (FSE) images are less affected by these artifacts, and so high-resolution, heavily T2-weighted (T2) images of the ear, IAM, and CPA can be obtained [2–4]. A refinement of the technique is the combination of FSE T2 data acquisition and three-dimensional (3D) volume sampling. The tiny structures of the inner ear can be reliably visualized on the 3D FSE T2 images [5]. Cost-effective screening for acoustic neuroma by FSE T2-weighted images or by constructive interference in the steady state (CISS) 3D technique were suggested by Allen et al [2] and Stuckey et al [6].

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To the best of our knowledge, this is the first time that 3D FSE T2 images were used routinely in a large patient population for screening for acoustic neuroma.

## MATERIAL AND METHODS

Between September 1996 and February 1997, a total of 92 patients (59 men, 33 women; mean age,  $57 \pm 14$  years) were referred to the University Hospital in Linköping for MRI for unilateral sensorineural hearing loss and abnormal findings of hearing or balance (or both). Seven of these patients were referred for size control of a known acoustic neuroma.

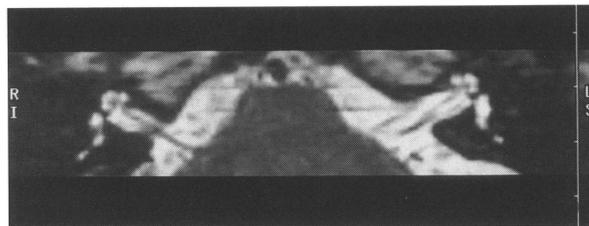
The MRI examinations were performed on super-conductive 1.5 T (Signa, GE) equipment. Sagittal and axial 5- and 7-mm-thick T2-weighted FSE images of the whole brain and T2-weighted 3D FSE images of the CPA (TR/TE: 3,500–4,000 msec/143–243 msec; matrix:  $256 \times 256$ ,  $256 \times 192$ ,  $256 \times 512$ ; field of view [FOV]:  $15 \times 15$ ,  $22 \times 16$ ; slice thickness: 0.7 mm) were obtained for every patient. Reconstructions in the axial and coronal planes were obtained in every case and, occasionally, sagittal images were obtained also.

The study was completed with 3-mm-thick T1-weighted axial and coronal images (with and without gadolinium) of the CPA in every patient with a known neuroma (each of whom served as his or her own control). The investigations were completed with gadolinium images when the findings on the 3D FSE pictures were doubtful. Five-millimeter-thick T1-weighted images of the whole brain before and after contrast administration were obtained in a few cases. Altogether 25 patients (27%; all postoperative cases and size controls, 11 cases of suspected neuroma, 1 case of epidermoid, and 1 case of a supposed vessel loop) were administered gadolinium contrast. They served as their own controls. Gadolinium administration did not alter the diagnosis in any case.

## RESULTS

On the 3D FSE images, the full length of the seventh and eighth nerves could be properly followed in all negative cases (Figure 1). Good contrast among fluids, nerves, bone, and tumor was detected in all cases (Figures 1, 2). The tumors were hypointense relative to cerebrospinal fluid on the 3D FSE images and could be identified also on the customary T1-weighted series with gadolinium contrast. The lateral extent of the acoustic neuroma into the IAM could be correctly described with the new sequence (Figure 2).

Seventy-two of the examined patients (78%) were referred for suspected acoustic neuromas. In only two (3%) of them, the presumed diagnosis was confirmed.



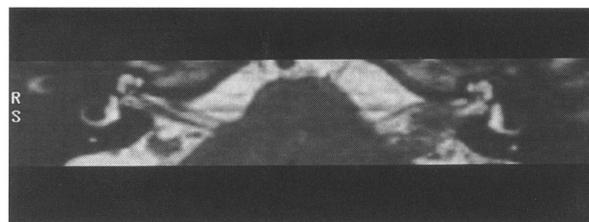
**Figure 1.** Axial image of the seventh and eighth nerves, which can be followed well over their entire length in the cerebellopontine angle.

Of these 72 patients, 24 (33%) had some pathology in the brain, most often of ischemic origin. Hearing loss due to cochlear pathology (e.g., posttraumatic) (Figure 3) was found in two cases; Ramsay-Hunt syndrome and CPA epidermoid were found in one patient each. Two of three presumed vascular loops were confirmed. None of the known neuromas that were examined for size control grew (follow-up time was approximately 1 year). One meningioma recurred postoperatively. These findings are summarized in Table 1.

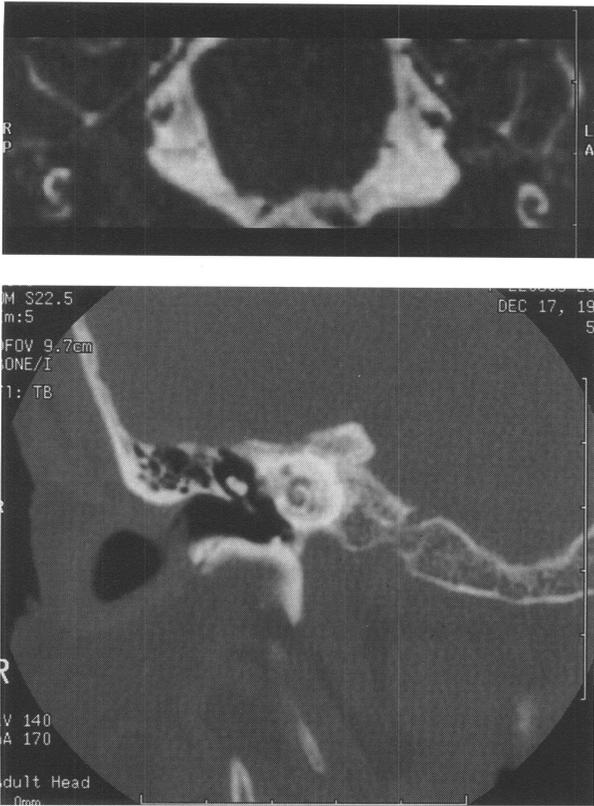
The size of the extracanalicular portions of the examined neuromas was between 10 and 18 mm. Two tumors were intracanalicular and measured  $3 \times 6$  and  $6 \times 9$  mm, respectively.

## DISCUSSION

In the 1980s, MRI became an excellent tool for identifying pathological processes in the CPA and IAM. The intravenous administration of gadolinium (Gd-DTPA) further enhanced the sensitivity of MRI for detecting pathology in this region [7]. MRI was used to demonstrate alterations in the inner ear as early as the end of the 1980s [8]. The detailed anatomy of the membranous labyrinth was studied by MRI in the beginning of the 1990s [9]. The combination of thin MRI slices and gadolinium drew attention to pathologies that cause enhancement within the inner ear [10,11]. Gradient-echo



**Figure 2.** Axial image of a small extracanalicular neuroma in the left internal auditory meatus (IAM). There is a space filled with cerebrospinal fluid between the tumor's lateral part and the fundus of the IAM.



**Figure 3.** Narrowing of the right cochlea due to cochlear otosclerosis. MRI (above) CT (below).

technique [9,12] as well as steady-state free precession images [13] allowed the use of sequences that provided thinner slices and better contrast among fluids, nerves, and bone. However, the advantages of the thin-section gradient-echo techniques were overshadowed by magnetic susceptibility signal loss seen in the temporal bone and attributable to various tissue interfaces inherent to this area [1,2] or by the bright signal from cerebrospinal fluid [13].

FSE images have been demonstrated to be less affected by these artifacts, allowing the acquisition of high-resolution, T2-weighted images of the inner ear, CPA, and IAM. FSE is a new, rapid scanning method that provides conventional spin-echo contrast in shorter times by using an altered k-space filling. Heavily T2-weighted images, which provide good contrast among bone, nerves, and liquor in the CPA region, can be obtained in a reasonable time. FSE images were shown to be useful as the preliminary radiological investigation for most otoneurological disorders [2–4,14]. Further refinement of the method is accomplished by using 3D volume imaging, which allows 0.7- to 1-mm slices as compared to the 3-mm thickness of the 2D images. The 3D FSE T2 sequences can provide detailed visualization of the labyrinth [5].

**Table 1.** Presumed Diagnosis Versus Actual Diagnoses

Presumed Diagnosis	Actual Diagnosis
Acoustic neuroma, 72 (78%)	Acoustic neuroma, 2 (3%) Epidermoid in CPA, 1 (1.5%) Central pathology, 24 (33%) Cochlear pathology, 2 (3%) Ramsay-Hunt syndrome, 1 (1.5%) Normal, 42 (58%)
Central hearing loss, 2 (2%)	Central, 1 Normal, 1
Cochlear disease, 3 (3%)	Cochlear disease, 2 Normal, 1
Vessel loop, 3 (3%)	Vessel loop, 2 Normal, 1
Size control, 7 (8%)	No growth, 7
Postoperative control, 5 (5%)	Recurrence, 1 No recurrence, 4

In studies by Allen et al. [2] and Stuckey et al. [6], the 3-mm-thick 2D FSE T2 and CISS images could differentiate reliably between normal subjects and tumor patients in most cases. However, the thickness of these images made difficult definitive evaluation of the images in which the IAM was narrow. The amount of cerebrospinal fluid surrounding the seventh and eighth nerves is decreased in slim IAMs, making difficult the interpretation of these images. This problem could be overcome by 3D volume imaging. There is less partial volume averaging in the thinner slices, and the technique allows reconstruction in every direction. Pictures in the sagittal direction were useful for excluding tumors in patients with a narrow IAM. On oblique reconstructions, the nerves were reliably followed over their entire length; alternatively, these reconstructions could provide an extra view of the cochlea.

The size of the known neuromas in patients referred for follow-up can be explained by patient selection. The examined subjects were selected on the basis of election not to undergo an operation (except the one with an 18-mm tumor), so obviously the tumors in these patients could not be large.

A criticism of screening for neuroma with unenhanced MRI is that the pathological processes detectable only on enhanced images (e.g., labyrinthitis, sarcoidosis, cochlear enhancement in acute hearing loss, or neuritis) will be overlooked [15]. These lesions are rare and, in general, are not surgically treatable, or present with severe obvious clinical symptoms that allow other means of diagnosis. Moreover, if the referring clinician is especially interested in these diseases, he or she can request for a contrast-enhanced MRI of the IAM. The problem of missing a tiny neuroma and falsely reassuring a patient is beyond the scope of this study. In the event that a tumor measuring a few milli-

meters is found, the wait-and-see policy is followed at our institution; we presume this is true elsewhere as well.

Examination of the entire brain in every patient with suspected CPA tumor is mandatory to cover the full length of the hearing pathways. The large number of cases with some type of central pathology in the studied sample (34% of all patients examined for acoustic tumor) confirms the usefulness of imaging the whole brain, though no direct relation between the brain alterations and hearing loss could be detected.

The 3D FSE T2 images could reliably exclude CPA pathology or demonstrate the presence of a tumor in the CPA. In all doubtful cases, the study must be completed with a gadolinium-enhanced T1 series.

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