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The Role of NMR Imaging in the Diagnosis and Management of Acoustic Neuroma

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Nuclear magnetic resonance (NMR) scans of 15 patients with acoustic neuroma are compared with the results of computed tomography (CT). The absence of signal from bone has meant that the images are unaffected by artifacts and that small intracranial tumors can be visualized. The multiplanar facility of NMR is emphasized as this allows precise assessment of both tumor volume and its relationship to the ventricular system, brainstem, and tentorial hiatus. The different appearances produced by alternative scan sequences are illustrated and the possibility of predicting the physical constitution from scan appearances is discussed.

Acoustic neuroma is the most common extraaxial tumor in the posterior fossa and is by far the most frequently occurring tumor in the cerebellopontine angle, accounting for 92% in a series reported by Valvassori in 1969 [1]. The most common clinical presentation is progressive unilateral sensorineuronal deafness; if the tumor is large, this may be accompanied by brainstem involvement and increased intracranial pressure.

Materials and Methods

In a combined total of over 500 cranial examinations at the Nottingham and Hammersmith medical centers, 20 patients were clinically suspected to be harboring cerebellopontine angle mass lesions. Of these, 15 proved to have an acoustic neuroma; there was one case each of glioma and epidermoid, and the other three had completely normal examinations at CT, NMR, and meatography. Most acoustic neuromas were larger than 2 cm in at least one dimension; only two were 1 cm or less. In Nottingham the scanning was performed with a Picker resistive system operating at a main field strength of 0.15 tesla and employing a steady-state free precession (SSFP) sequence where the resulting image contrast was given by $\rho \times T_1/T_2$. At Hammersmith Hospital the scanning was performed by a Picker superconducting system with a main field strength of 0.15 tesla and employing a variety of pulse sequences; this report considers inversion recovery images reflecting predominantly T_1 and spin-echo images reflecting predominantly T_2 .

Results

Within the posterior fossa the brainstem, fourth ventricle, and cerebellar hemispheres are easily seen on inversion recovery images, with excellent discrimination of gray and white matter. The proximity of irregular bone and air in the petrous bones and skull base does not give rise to disturbing partial volume artifacts and the margins of the cerebellar hemispheres and brainstem are clearly seen, in contrast to CT. The fact that bone gives no signal means that sclerosis cannot be recognized and bone destruction can only be inferred indirectly, when gross, by soft-tissue encroachment into the area of bone loss. The basal cisterns are well defined on sagittal and coronal sections, which also show clearly the anatomy of the tentorium. The features seen on transverse axial sections mirror those seen at CT [2-5]: a rounded or elliptical mass in the cerebellopontine angle with well defined margins unassociated with any surrounding edema. With larger tumors the fourth ventricle is rotated and displaced posteriorly and to the contralateral side, resulting in a typical deformity which has been likened to a propeller blade or banana (fig. 1A). Since the advent of CT scanning it has become apparent that there are variations in the anatomic disposition of tumors reflecting differences in their direction of growth. Most tumors grow forward, producing indentation and rotational deformity of the brainstem and rendering access to the anterior pole difficult and more likely to be followed by brainstem or facial nerve damage than when the tumor grows predominantly backward and produces indentation of the cerebellum and middle cerebellar peduncle.

Prediction of tumor consistency would be of great value to the surgeon. In an investigation of the reliability of NMR in this regard, using tumor density on SSFP images as a basis, preliminary observations suggest the following correlation: the higher the NMR signal, the softer the consistency of the tumor. Accurate assessment of tumor size is important because where one dimension exceeds 2 cm, craniotomy will be preferred to translabyrinthine removal. The multiplanar facility of NMR is valuable in this respect but several slices are required in each plane to ensure the maximum cross section is included. With 1-cm-thick overlapping slices error will occur due to partial volume averaging. Some tumors with a relatively small cross section have a long vertical dimension on the coronal and parasagittal sections. The coronal sections allow the relation-

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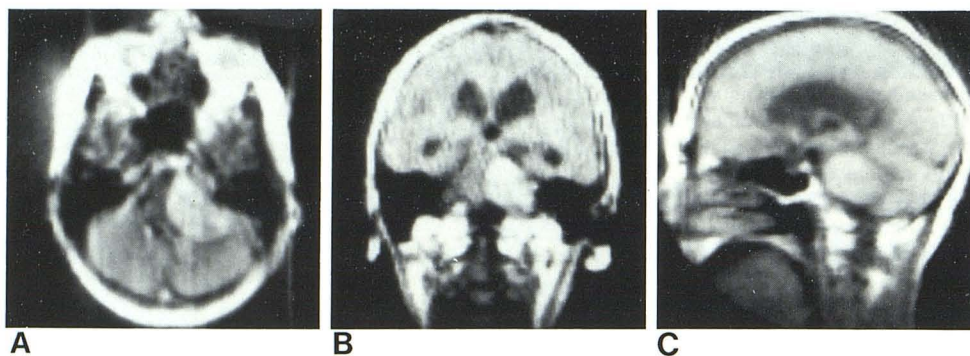


Fig. 1.—Acoustic neuroma. Axial transverse (A), coronal (B), and sagittal (C) NMR scans using SSFP sequence. Size of tumor and its relationship to tentorium are easily seen, as are associated deformity and displacement of brainstem and fourth ventricle.

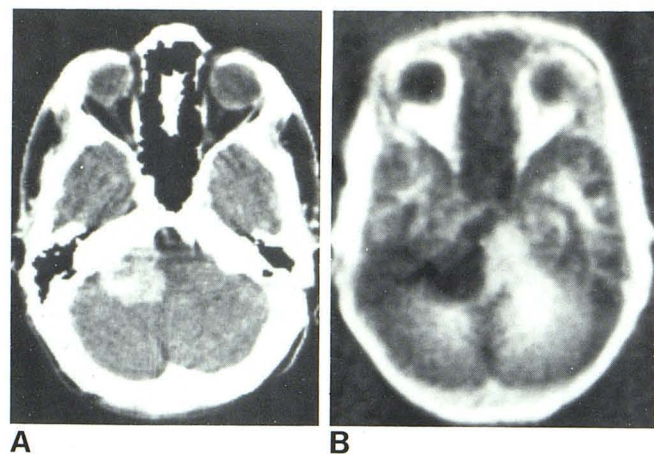


Fig. 2.—Left-sided acoustic neuroma. A, Contrast-enhanced CT scan. B, Inversion recovery scan.

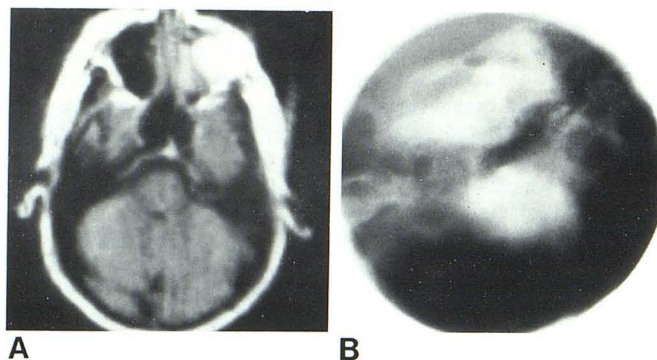


Fig. 3.—Intracanalicular acoustic neuroma encroaching on cerebellopontine angle cistern and indenting pontocerebellar junction. A, Axial transverse NMR scan using SSFP. B, Tomogram shows expanded internal auditory canal.

ship of the tumor to the tentorium to be appreciated as well as any associated deformity and displacement of the brainstem and fourth ventricle. Dilatation of the supratentorial ventricular system can also be recognized (figs. 1B and 1C).

The contrast-enhanced CT scan and inversion recovery scan of a patient with a left-sided acoustic neuroma are shown in figure 2. Because of its long T_1 value the tumor is seen on the inversion recovery image as a dark area indenting the pontocerebellar junction. The anterolateral margin is not always clearly seen on inversion recovery images since it blends with the petrous bone which is also black because of its low proton density. By shortening the interval between the pulses in each scan cycle to 200 msec (which is less

than the average T_1 of the tissues in the slice) the magnetization recovers only slightly after the first 180° pulse and the signal is negative after slice selection. Areas of long T_1 are then shown in white and are clearly distinguished from areas of low proton density. In the spin-echo images acoustic neuromas are clearly seen as white areas reflecting long T_2 value. As with CT it is important to know the smallest tumor that can be detected. We have so far only had experience of two small tumors. Because cortical bone gives a zero signal owing to its low proton density, it was hoped that a small intracanalicular tumor could be visualized by NMR as contrasted against the surrounding bone, and this has been confirmed. The patient whose scan is shown in figure 3 has an 8 mm intracanalicular tumor extending into the right cerebellopontine angle and indenting the pons and cerebellum.

Discussion

The differential diagnosis of angle mass lesions includes a large number of possibilities and our present experience of other pathologies is small. One patient with a 3 year history of trigeminal neuralgia had an extrinsic tumor in the left cerebellopontine angle with a negative Hounsfield number on measurement. The NMR scan showed a corresponding area of high density in concordance with the diagnosis of epidermoid. In another patient referred with a CT diagnosis of suspected acoustic neuroma the clinical findings were atypical. The NMR scan showed conclusively that the tumor was intrinsic, extending into the angle. The corollary is also true. A patient thought to have an intrinsic tumor of the brainstem on the basis of clinical and CT diagnosis was shown conclusively on NMR to have an extrinsic tumor, which proved to be a chondroma at operation. Large aneurysms in the cerebellopontine angle should be identified by the application of flow-dependent sequences. The inability to show bone sclerosis and calcification features of meningioma is a drawback of NMR; nevertheless we believe it will have an important role in the evaluation of mass lesions in the cerebellopontine angle.

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