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MR Imaging of the Intratemporal Facial Nerve Using Surface Coils

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MR images of the intratemporal portion of the facial nerve were obtained with surface coils using a 0.3-T permanent magnet whole-body imaging system. Various 2DFT spin-echo pulse sequences were used to produce 5-mm thick sections with 0.5-mm pixels on a 512 × 512 acquisition matrix. The MR images from normal volunteers were correlated with cryosection specimens of three fresh human cadavers. The seventh nerve was followed in the internal auditory and fallopian canal and through temporal bone to the stylomastoid foramen. The entire labyrinthine, tympanic, and mastoid portions, as well as the geniculate ganglion, could be shown with appropriate scan planes. MR produces excellent images of the facial nerve with high-contrast resolution. Unlike CT, no beam-hardening artifact from the temporal bone is apparent. MR should be a sensitive study for the evaluation of intratemporal facial nerve disease.

The facial nerve has the longest course within bone of any nerve, and is the most frequently paralyzed nerve in the human body. CT with intravenous contrast, intrathecal air, or metrizamide contrast; plain X-rays; and, in some cases, angiography have been used to image a variety of diseases in the facial nerve with varying degrees of success [1–9].

MR has advantages over many of these older techniques in that it is noninvasive and has excellent soft-tissue contrast resolution in a variety of scanning planes [10–13]. With the use of specialized high-performance RF coils, thin sections and spatial resolution approaching that of CT scanning may be achieved. Unlike CT, no beam-hardening artifact from bone is evident. In addition, variations in pulse sequences may be used to optimize contrast resolution for regions of normal anatomy and pathology. This study evaluates MR of the normal intratemporal facial nerve.

Subjects and Methods

Fifteen examinations of the temporal bone were performed on normal volunteers or patients with no evidence of temporal bone disease with a 0.3-T permanent magnet MR system (Fonar B-3000, Melville, NY). Most of the examinations were conducted to test the RF coils or to study extracranial disease without involvement of the temporal bone. The normal MR images were correlated with cryosection specimens of fresh human cadavers. The seventh nerve was followed through the temporal bone. The entire labyrinthine, tympanic, and mastoid portions, as well as the geniculate ganglion, were shown.

MR images were acquired with a multislice 2DFT spin-echo pulse sequence. Planar surface coils (Fig. 1), used to improve the signal-to-noise performance of the system, permitted the use of steeper magnetic field gradients to decrease the pixel size from 1 × 1 mm to 0.5 × 0.5 mm [14]. Four-mm-thick sections were acquired every 7 mm on a 256 × 256 matrix and interpolated to a 512 × 512 display. A short spin-echo technique was used for most of the scans, with a repetition time (TR) of 500 msec and an echo time (TE) of 28 msec (SE/500/28). This relatively T1-weighted image maximized the visibility of the seventh nerve as it crossed the subarachnoid space surrounding the brainstem and passed through the temporal bone.

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A single-slice scout image obtained in 1 min and 51 sec was often used for localization of the nerve. Subsequent scans through the nerve were positioned with cursors from the scout image. A rapid sagittal view provided a scout for axial images through the internal auditory canal (Fig. 2A). One of the axial images through the descending facial nerve served as a scout for later sagittal images through this structure (Fig. 2B). By using these two scan planes, we could study the entire intratemporal course of the facial nerve.

Occasionally, a second interleaved sequence was obtained by electronically offsetting the next slice series by 2.5 mm to produce overlapping sections. This allowed visualization of planes of tissue missed between slices of the first sequence.

A cryomicrotome freezing sectioning technique described by Rauschning et al. [15] and Holliday et al. [16] was used to better define the normal anatomy of the intratemporal facial nerve. The MR sections from volunteers were compared with matched whole-organ

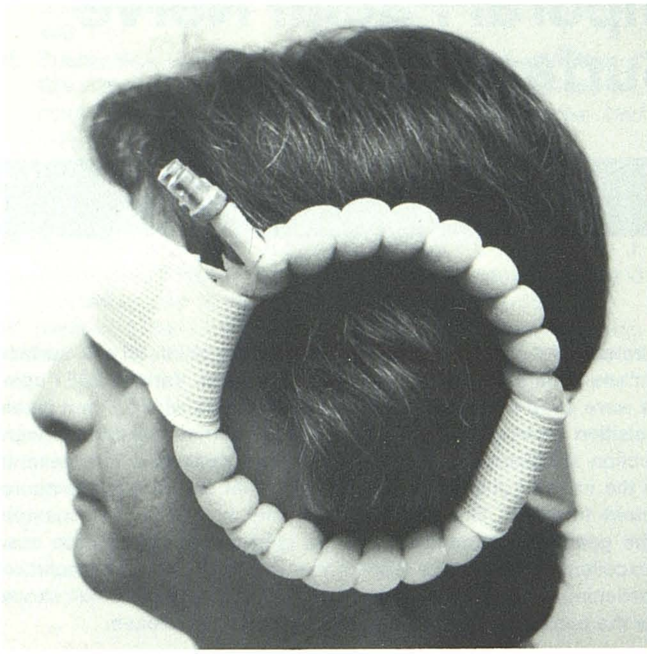
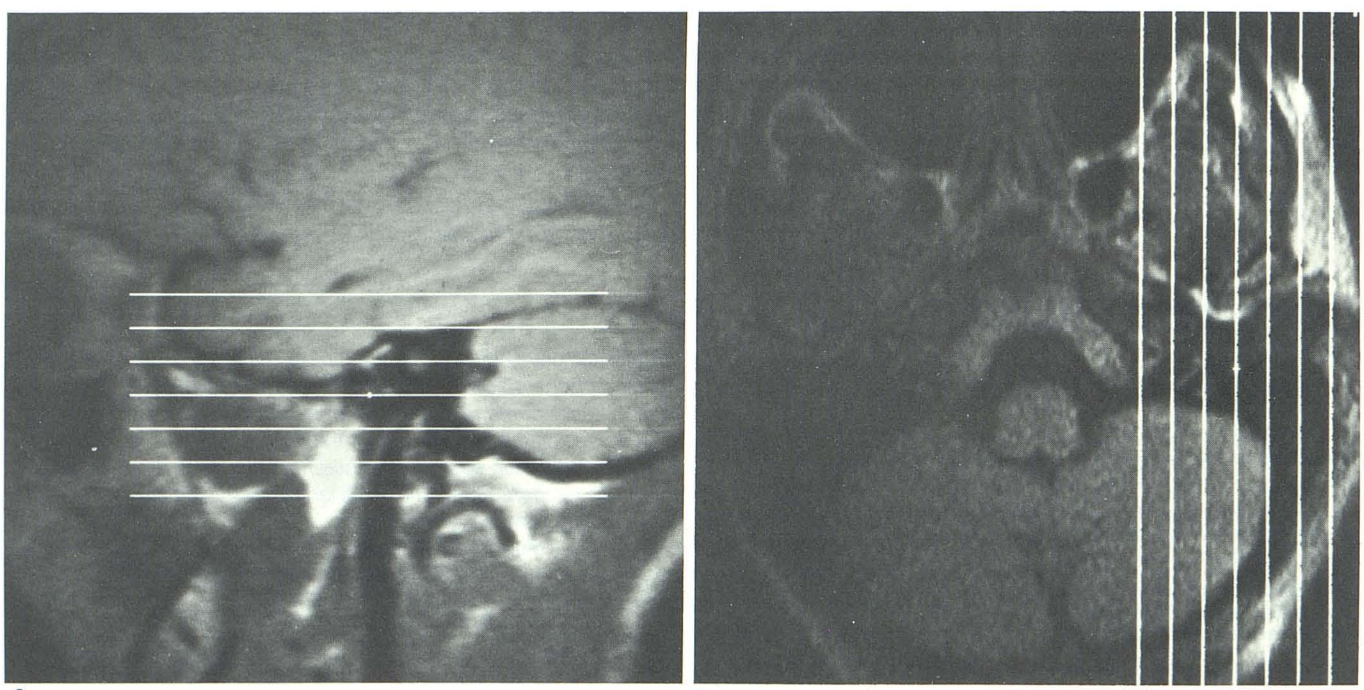


Fig. 1.—14-cm planar surface coil is positioned over temporal bone for facial nerve studies.

Key for Figures 3–5

1. Facial nerve: meatal portion
2. Facial nerve: labyrinthine portion
3. Facial nerve: geniculate ganglion
4. Facial nerve: tympanic (horizontal) portion
5. Facial nerve: mastoid (vertical) portion
6. Facial nerve: intraparotid portion
7. Vestibular nerve(s)
8. Cochlear nerve
9. CN IX–XI
10. Basal turn of cochlea
11. Cochlear aqueduct
12. Vestibule
13. Horizontal semicircular canal
14. Posterior semicircular canal
15. Carotid artery
16. Jugular vein
17. Sigmoid sinus
18. Internal auditory canal
19. External auditory canal
20. Mastoid air cells
21. Stapes



A B

Fig. 2.—Scout views with cursors placed to localize facial nerve.
***A*, Sagittal scout view is used to position subsequent axial sections through level of internal auditory canal.**
***B*, Axial scout view allows accurate positioning of sagittal images through vertical (mastoid) portion of facial nerve.**

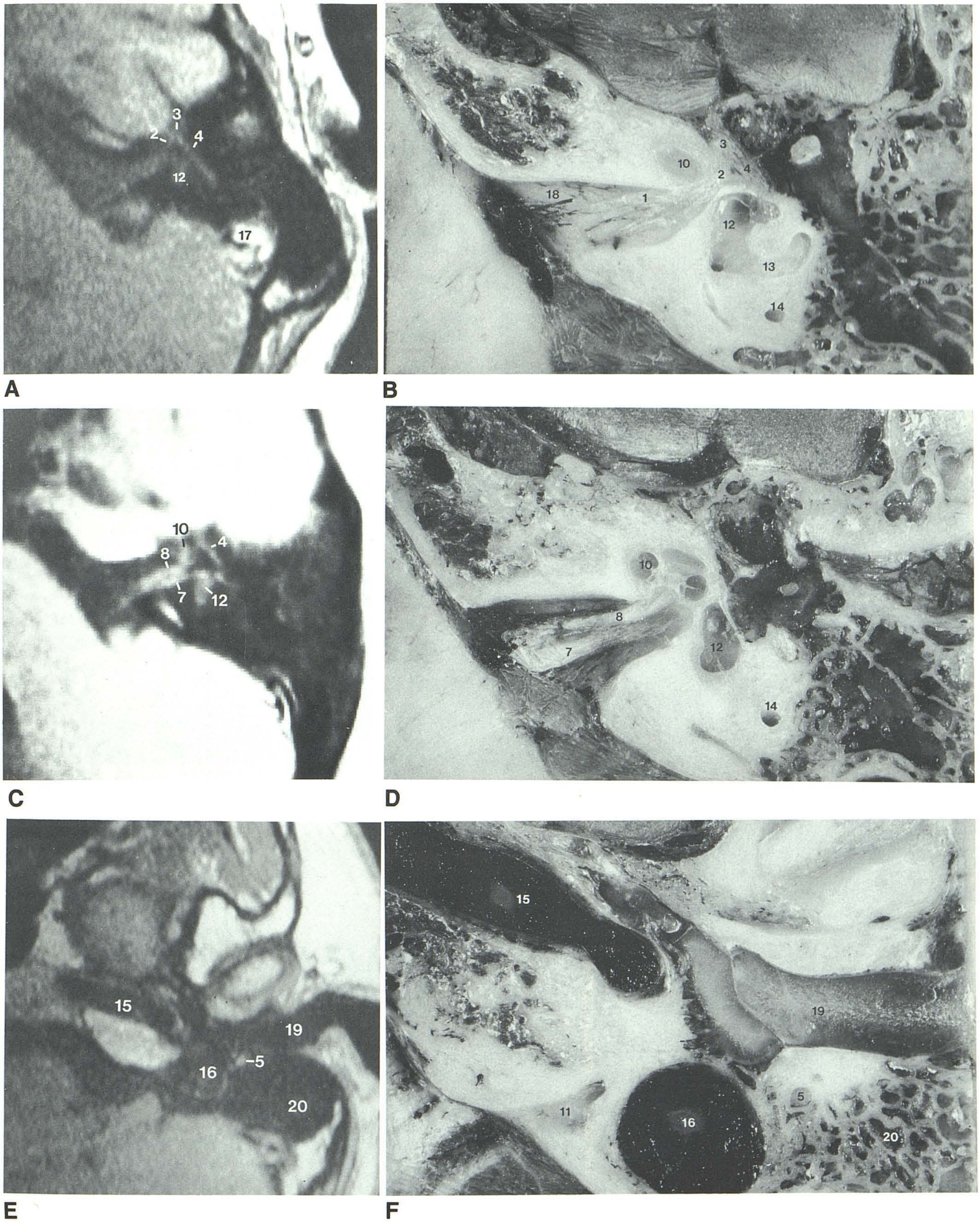


Fig. 3.—Axial MR and cryosections.
A and *B*, Level of superior aspect of internal auditory meatus.
C and *D*, Level of inferior aspect of internal auditory meatus.
E and *F*, Level of external auditory canal.

sections obtained from three cadavers. The specimens were first prepared by arterial injection of a pigmented barium compound to permit identification of arteries and veins. To preserve undistorted topographic anatomy, the soft tissues to be examined were frozen in situ before blood or other fluids from the region of interest were drained.

The frozen specimens were transferred to a horizontal-sectioning, heavy-duty sledge cryomicrotome (LKB 2250, Broma, Sweden). Inside the cabinetlike freezing compartment of the cryomicrotome the specimens were mounted on a bed that weighed approximately 400 pounds, which prevented vibrations and ensured an even shaving slice. The microtome knife sectioned the specimens at predetermined thicknesses varying from 5 to 50 μm.

At intervals, when photography was desired, the surface of the specimen was gently rubbed with a warm cloth soaked in ethylene glycol to produce a frost-free surface. Photographs of representative gross sections were then compared with the respective normal MR sections in the volunteer.

Results

Figures 3 through 5 present anatomic correlations of cadaver cryosections and MR images of the normal intratemporal facial nerve. Axial, sagittal, and coronal scan planes are presented.

Upon leaving the brainstem at the inferior border of the pons, the facial nerve (1) enters the porus of the internal acoustic meatus accompanied by the nervus intermedius, the cochlear (8) and vestibular (7) divisions of the vestibulocochlear nerve, and the internal auditory artery and vein (Fig. 3). The seventh nerve occupies a position anterior to the superior vestibular nerve and cephalad to the cochlear nerve. These structures can be routinely identified on a sagittal view through the internal auditory canal. The sagittal view also serves as a convenient "scout" projection to assure accurate placement of axial scans (Fig. 2A). Although currently not a

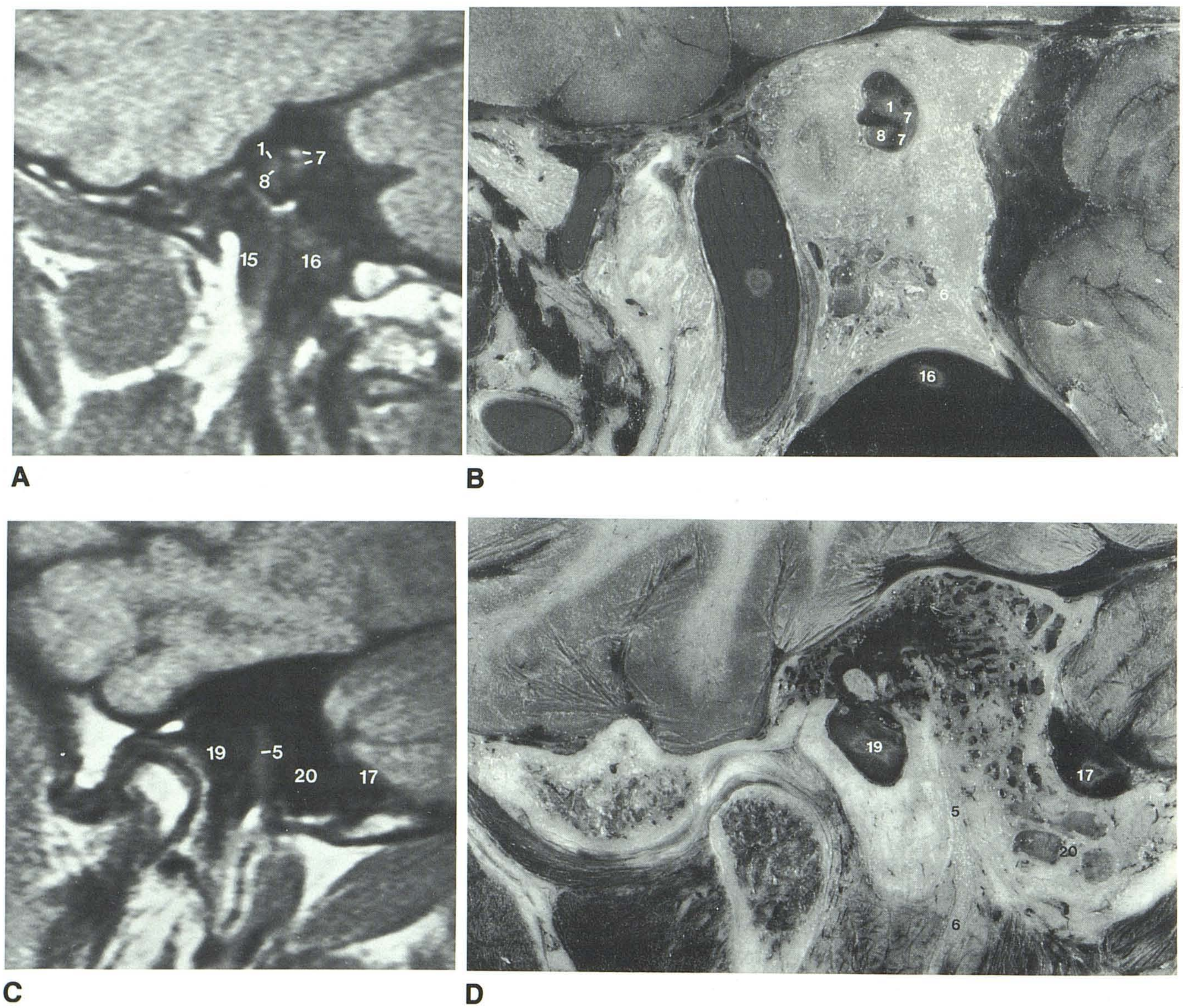


Fig. 4.—Sagittal MR images and cryosections.
***A* and *B*, Level of internal auditory canal. *C* and *D*, Level of vertical portion of facial nerve.**

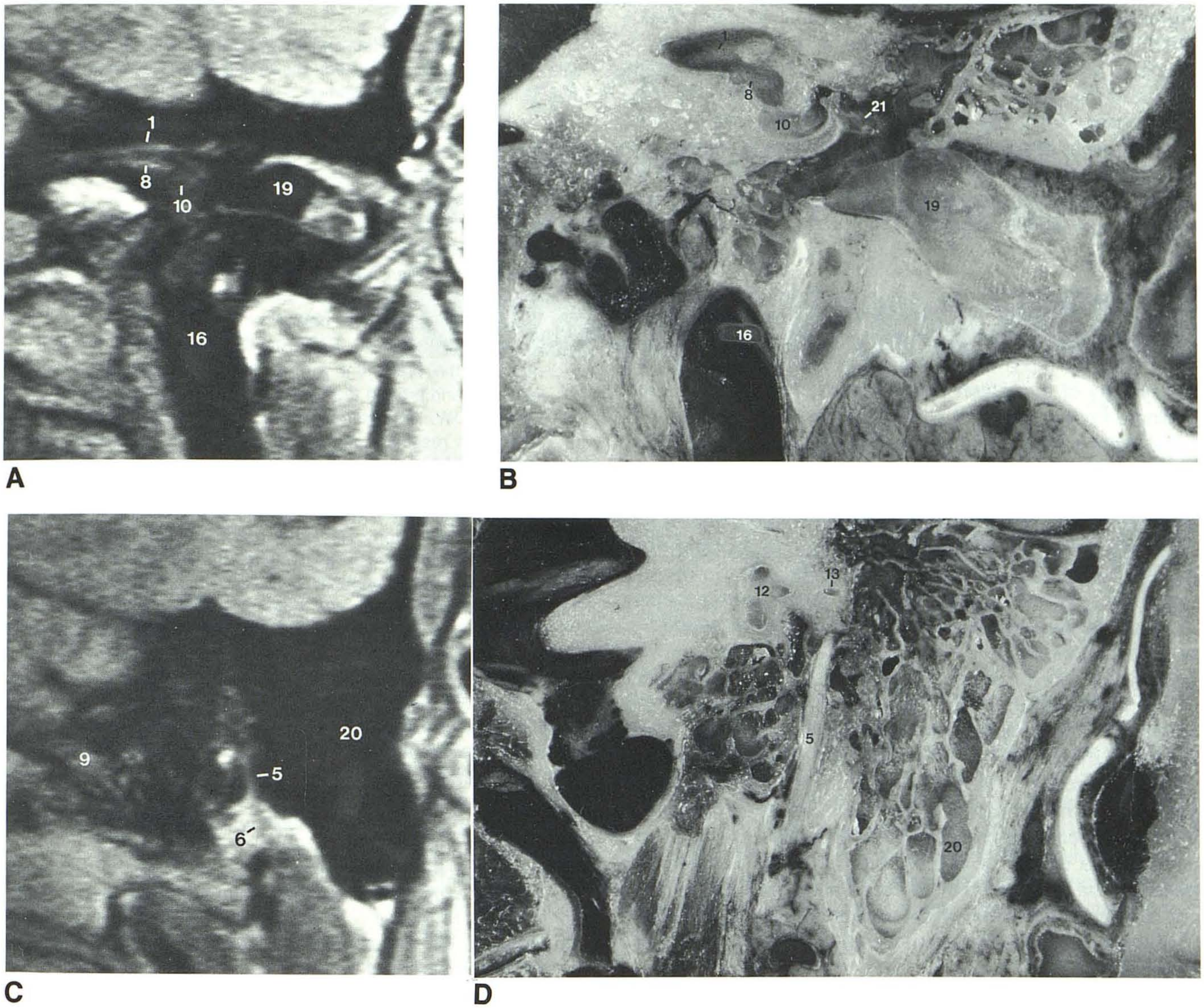


Fig. 5.—Coronal MR images and cryosections.
***A* and *B*, Level of internal auditory canal. *C* and *D*, Level of vertical portion of facial nerve.**

consistent finding on all normal studies, separation of nerves in the internal auditory canal in the axial plane is not unusual (Fig. 3).

The facial nerve exits the internal auditory meatus cephalad to the transverse crest and anterior to a vertical bony landmark, unknown to anatomists but known to surgeons as "Bill's bar." The location of this dense cortical bone is marked by a corresponding region of signal void. At this point, the facial nerve enters the fallopian (or facial nerve) canal, which is roughly 30 mm long and is divided into labyrinthine, tympanic, and mastoid sections. In the labyrinthine portion, the nerve (2) passes anteriorly around the basal turn of the cochlea and expands to form the geniculate ganglion (3). The greater superficial petrosal nerve branches from the main facial nerve at this ganglion, and can occasionally be seen as a high-signal linear structure coursing from the geniculate ganglion to the pterygopalatine fossa.

The tympanic or horizontal portion of the facial nerve (4) begins at the geniculate ganglion where the facial nerve makes an abrupt posterior bend to form its anterior genu. It then courses posteriorly, cephalad to the oval window and caudal to the prominence of the horizontal semicircular canal. Because they travel roughly parallel to the lateral semicircular canal, the labyrinthine and tympanic portions of the facial nerve are best evaluated in the axial projection (Fig. 3).

The facial nerve then curves gently downward to its mastoid or vertical portion (5) (Fig. 5). As it descends toward the stylomastoid foramen, the nerve passes lateral to the sinus tympani and stapedius muscle. The nerve to the stapedius muscle and the chorda tympani are two important branches that both originate in the mastoid portion of the facial nerve. Because of small size and proximity to other high-signal structures, neither branch is routinely identified with present MR techniques. The vertical portion of the facial nerve is identified on axial sections; however, to visualize the entire course of this structure, either sagittal or coronal scans must be obtained. We routinely use the sagittal projection for this purpose because it also provides useful information about the parotid bed. In either case, because of the small size of the nerve, accurate alignment of the MR plane with the nerve using a scout view is essential.

Discussion

The complex course of the facial nerve in the temporal bone may be more fully understood if one considers the embryology of the region. The muscles of facial expression originate from the second branchial arch, and therefore, the facial nerve is known as the nerve of the second arch [17].

Nerves of the branchial arches descend into the arch posterior to the cartilage and then turn anterolaterally to reach the front of the arch. The stapes and styloid processes are both derivatives of second-arch cartilage. This explains why, in the adult, the facial nerve moves posteriorly to descend posterior to both the stapes and styloid processes before turning anterolaterally to reach the facial muscles beyond the stylomastoid foramen.

Each arch also receives a nerve branch from the arch caudal to it. Known as pretrematic, these branches course over and anterior to the adjacent branchial cleft (or trema), which separates the two branchial arches. The pretrematic branch of the first arch, the chorda tympani, leaves the facial nerve to arch over the tympanic cavity to join the lingual division of the mandibular nerve (nerve of the first arch).

The entire course of the facial nerve within the temporal bone may be identified with appropriately positioned surface-coil MR images. MR should be a valuable technique in identifying disease of the facial nerve that results in morphologic alterations.

The superior soft-tissue contrast resolution of MR imaging compared with CT scanning or other imaging techniques has been well documented. This is especially true with the detection of edema and other subtle alterations in nervous tissue without gross morphologic distortion. MR may someday be useful for evaluating patients with facial palsy, including those with idiopathic or Bell's palsy, who show no morphologic alteration in the facial nerve. Current imaging techniques have little to offer this group other than to exclude other causes of the disease.

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