The Architecture of the Arcuate Eminence—A Microanatomical Study and Its Application to the Transpetrosal Approach

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ABSTRACT

This study was performed to determine if the arcuate eminence can be drilled down without opening the semicircular canal to obtain a flatter operative field during an anterior or posterior transpetrosal approach. The depth of the superior semicircular canal from the top of the arcuate eminence was measured in 43 dry temporal bones. We found that the arcuate eminence was situated approximately 20 mm from the petrosigmoid intersection, and the superior semicircular canal was located 2.0 mm deep from the top of the arcuate eminence (range, 0.2 mm to 4.2 mm). The arcuate eminence consists of either (1) the otic capsule and additional overlying bone, (2) the naked otic capsule of normal thickness, or (3) the thinned otic capsule. In cases strictly selected by preoperative computed tomography, it may be possible to drill down the arcuate eminence with meticulous manipulation. The relationship between opening the semicircular canal and hearing preservation is also discussed.

KEYWORDS: Arcuate eminence, superior semicircular canal, transpetrosal approach

The anterior¹ and posterior²⁻⁶ (i.e., retrolabyrinthine, translabyrinthine, and transcochlear) transpetrosal approaches are established methods for accessing pathologies situated in Meckel's cave or the petroclival area. Extensive drilling of the

mastoid and petrous bones provides access to such lesions without significant retraction of the neuraxis. To maintain hearing function the labyrinth should be preserved intact. The surgical fields of these approaches, however, are confined by the

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bony labyrinth. The arcuate eminence, containing the superior semicircular canal, is an obstacle when approaching laterally toward the petrous apex, with either an anterior or posterior transpetrosal exposure. The present study evaluated whether the arcuate eminence could be drilled down, without opening the membranous labyrinth, to obtain a flat view to the petrous apex.

MATERIALS AND METHODS

In this study 43 dry temporal bones and a wet specimen were used. The arcuate eminence was drilled until the superior semicircular canal was opened and three parameters were measured: (A) the distance from the upper margin of the petrosigmoid intersection to the superior semicircular canal, (B) the distance from the lower margin of the petrosigmoid intersection to the superior semicircular canal, and (C) the depth of the superior semicircular canal from the top of the arcuate eminence (Fig. 1). Because the upper and lower margins of the petrosigmoid intersection were often separated, both were measured. The wet specimen was injected with colored silicon and dissected under a surgical microscope (3x to 40x magnifica-

tion) to demonstrate the anatomical relationships between the arcuate eminence and other structures.

RESULTS

The superior semicircular canal was situated about 20 mm deep from the petrosigmoid intersection along the petrous ridge (Table 1). The depth of the superior semicircular canal from the top of the arcuate eminence was a mean of 2.0 mm (range, 0.2 mm to 4.2 mm).

DISCUSSION

The findings show that the mean depth of the superior semicircular canal is 2.0 mm, but the depth can be as shallow as 0.2 mm. Previously, we encountered a cadaveric specimen in which the top of the membranous superior semicircular canal was covered only by the dura (unpublished observation). From our experience with cadaveric dissections, we know that the otic capsule, the hardest bone in the human body,⁷ covers the semicircular canals with a thickness of approximately 1 mm. The measure-

Figure 1 Illustration shows the posterior view of the left temporal bone depicting the measured parameters. (A) Distance from the upper margin of the petrosigmoid intersection to the superior semicircular canal. (B) Distance from the lower margin of the petrosigmoid intersection to the superior semicircular canal. (C) Depth of the superior semicircular canal.

Table 1 Measurements of 43 Temporal Bones

Parameter	Mean $\pm$ SD (mm)	Range (mm)
A (n = 25)	21 $\pm$ 2	16–26
B (n = 42)	18 $\pm$ 3	12–24
C (n = 43)	2.0 $\pm$ 1.0	0.2–4.2

A, distance from the upper margin of the petrosigmoid intersection to the superior semicircular canal; B, distance from the lower margin of the petrosigmoid intersection to the superior semicircular canal; C, depth of the superior semicircular canal; n, number of specimens in which the parameter was measured. Occasionally the upper or lower margin of the petrosigmoid intersection was obscured.

ments above, along with our experience, lead us to conclude that the architecture of the top of the arcuate eminence has three patterns. The architecture consists of either (1) the otic capsule and additional overlying bone, (2) the naked otic capsule of normal thickness, or (3) the thinned otic capsule.

We estimate that in patients with type 1 architecture it may be possible to drill the arcuate eminence with meticulous manipulation until the otic capsule becomes visible, or slightly further. Obtaining a preoperative estimate with bone-image computed tomography is mandatory. A highly accurate neuronavigational system may be desirable intraoperatively to track the proximity of the drill tip to the superior semicircular canal.

Once drilling starts, however, it may be difficult to stop drilling before the labyrinth. Whether hearing is affected if the superior semicircular canal is opened has yet to be determined. It has been noticed that opening the labyrinth does not necessarily lead to hearing loss.^{8,9} Hakuba et al.³ claimed that hearing can be preserved if the vestibule only is kept intact even though the semicircular canals are removed. Hirsch et al.¹⁰ reported their successful removal of the superior and posterior semicircular canals after isolating them from the other parts of the labyrinth; hearing was preserved. The technique, however, is difficult.

The anatomical relationships between the arcuate eminence and other structures are shown in Figure 2. If the high arcuate eminence of type 1 architecture is drilled down or the superior semicir-

cular canal is to be sacrificed in either type, it is easier to remove the consecutive bony area above the internal auditory canal, which is called the posteromedial triangle, from the middle fossa.^{1,11} This maneuver provides a wider surgical field toward the petrous apex area. To obtain a similar exposure without drilling either structure, the temporal lobe must be elevated more with the tentorium while avoiding damage to the vein of Labbé.¹² Although drilling this far may seldom be required, it is worthwhile to know these anatomical characteristics of the arcuate eminence.

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COMMENTS FOR PUBLICATION

It is possible to open any of the semicircular canals without subsequent hearing loss as long as the membranous labyrinth is not injured.

The fenestration operation to restore hearing in patients with otosclerosis depends upon opening the lateral (horizontal) semicircular canal to expose the inner ear fluids to the vibrations of sound. The technique for identifying the canal (superior or horizontal) requires a blue line: A diamond burr and irrigation suction can be used to thin the compact bone carefully until the perilymph can be seen as a blue shadow through the bone.

As the authors found, the placement of the superior semicircular canal under the arcuate eminence varies greatly. In some cases, the canal has no air cells over it; in others, it is covered by a thick layer of cells. This status can be determined preop-

Figure 2 The middle fossa seen from above. The upper part of the mastoid air cells is drilled away to show the semicircular canals (SCC). The bony area, confined by the arcuate eminence (AE), superior petrosal sinus (SPS), trigeminal ganglion (V ggl.), and the greater petrosal nerve (GPN) is removed to expose the petrous portion of the internal carotid artery (ICA) and nerves VII and VIII in the internal auditory canal. The black and white arrows indicate the directions of the anterior and posterior transpetrosal approaches, respectively. Note how the arcuate eminence presents an obstacle on the way toward the petrous apex in these approaches.

eratively by computed tomography or a plain Stenvers view.

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