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What is This?
Conquering the Castle: A Novel Technique for the Middle Fossa Approach in Facial Decompression

Erdem Eren, MD¹, M. Sinan Başoğlu, MD¹, Aslıhan Gürcan Bingölballı, MD¹, Hale Aslan, MD¹, Amaç Kiray, MD², Can Özbay, MD¹, Sedat Öztürkcan, MD¹, and Hüseyin Katılmış, MD¹

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Abstract

Objective. To describe 2 subapproaches of the middle fossa approach: the transillumination method and transection of lines using the foramen spinosum, greater superficial petrosal nerve, and trigeminal impression to locate the malleus head for safe identification and decompression of the geniculate ganglion and facial nerve.

Study Design. Cadaver study.

Setting. A tertiary university hospital anatomy laboratory.

Subjects and Methods. The present study was conducted using 7 formalin-fixed cadaver heads (14 sides). A 0° endoscope was introduced into the external ear canal toward the posterosuperior quadrant of the tympanic membrane, after which transillumination was used to locate the malleus head. The brightest point indicated the convergence of the greater superficial petrosal nerve and a line drawn along the superior semicircular canal. An additional line was drawn parallel to the petrous ridge from the foramen spinosum and along the pathway of the greater superficial petrosal nerve. A third line connected the trigeminal impression to the zygomatic root. The area posterior to the intersection of these 2 lines separately with the third line was considered the zone of location of the malleus head. Among 17 patients undergoing surgery for facial paralysis between 1993 and 2011, transillumination was used in 6 patients to identify the malleus head to locate the geniculate ganglion.

Results. These techniques were proven to be reliable in locating the malleus head to find the geniculate ganglion in 14 dissected cadaveric temporal bones.

Conclusion. Two methods of locating the malleus head for facial decompression were defined.

Keywords
middle fossa, facial decompression, transillumination, cadaver study

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The middle fossa lacks easily identifiable landmarks, which complicates the middle fossa approach and necessitates detailed knowledge of the anatomy of the temporal bone, petrous apex, and middle cranial fossa. William House¹ popularized the middle fossa approach for the resection of acoustic neuromas. Vestibular schwannomas are being diagnosed earlier as a result of increased clinical awareness and improved imaging modalities, making hearing preservation surgery a more realistic option for many patients. The middle fossa approach, one such surgical method, is one of several options for the treatment of vestibular schwannomas.

In traumatic temporal bone fractures with facial paralysis, the middle fossa approach is used when the transmastoid approach is not possible. Most techniques used to access the internal acoustic canal (IAC) are avoided when the facial nerve is the only structure to be exposed. Here, we describe 2 subapproaches to facilitate the middle fossa approach for facial decompression due to temporal bone fracture.

Materials and Methods

This study was conducted using 7 formalin-fixed adult cadaver heads (14 sides). All cadaver heads were dissected under 1× magnification. The head of the malleus (HOM) was located using the techniques described below, with distances and angles of crucial structures measured with calipers (accuracy ±0.05 mm) and goniometry (error 0.5°) independently by 2 authors. All measurements were repeated twice, and their average values were calculated. The study was approved by İzmir Katip Çelebi University Faculty of Medicine Local Ethics Committee.

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Two methods were used to locate the HOM in order to find the geniculate ganglion. In the first method, a 0° endoscope was introduced into the external ear canal toward the posterosuperior quadrant of the tympanic membrane, and transillumination was used to locate the HOM. The brightest point indicated the convergence of the greater superficial petrosal nerve (GSPN) with a line drawn along the superior semicircular canal (SSCC; Figures 1 and 2). The arcuate eminence (AE) is one of the most commonly used landmarks in the middle fossa approach but is not always prominent, necessitating the use of other landmarks. The second method began with the identification of the middle meningeal artery (foramen spinosum) and the GSPN. Lines were drawn parallel to the petrous ridge from the foramen spinosum (x) and along the pathway of the GSPN (y). A line (z) originating from the trigeminal impression and passing through the zygomatic root (inner cranial table) was drawn, and the angle between this line and the petrous ridge was measured. The area located medial to (x), lateral to (y), and posterior to the convergence of line z with line y and x separately was defined as the safe zone for dissection and the identification of the HOM (Figure 3).

We measured certain distances that may be important for the described procedures—namely, the distance between the HOM and (1) the most prominent point of the AE, (2) the foramen spinosum, (3) the horizontal semicircular canal, (4) the cochlea, (5) the geniculate ganglion, (6) the acoustic porus (AP), (7) the closest segment of the tympanic branch of the facial nerve, (8) the zygomatic root (measured from the inner cranial table), and (9) the petrous ridge.

Statistical Analysis

SPSS software (version 16.0 for Windows; SPSS, Inc, an IBM Company, Chicago, Illinois) was used for statistical analysis. The Mann-Whitney U test was used to evaluate differences between the left and right sides. A P value <.05 was considered statistically significant.

Results

We defined 2 methods to locate the HOM in order to find the geniculate ganglion for facial decompression via the middle fossa approach. We also measured distances between structures that might be important for these procedures (Table 1).

No difference in these measurements was identified between the right and left sides (P > .05). On the introduction of an endoscope into the external ear canal, the
was reached by following the tympanic segment of the facial nerve was visualized. The geniculate ganglion was identified, and a second portion of the inner ear damage and investigated the relationships among the HOM, IAC, and geniculate ganglion. They recommend the use of their technique in all cases in which surgically tracing the facial nerve to the IAC is planned through a middle fossa approach, including vestibular nerve section and intracanalicular acoustic tumor surgery. Exceptions include pediatric cases and cases with severe temporal bone fracture with ossicle dislocation.

Miller and Pensak presented reference data for locating and delineating petrous structures critical to middle fossa surgery. The intersection of two 19-mm arcs drawn from the zygomatic root and the foramen spinosum approximates the location of the HOM. Thus, they used the root of the zygoma, an extratemporal landmark, to consistently find an intratemporal landmark, the HOM. They found that a line drawn from the root of the zygoma to the HOM can be used to identify the IAC and the AP.

The AE is one of the most commonly used landmarks in middle fossa surgery. However, Kartush et al. doubted the reliability of the AE as a guide to the SSCC, stating that

### Table 1. Distances between HOM and Several Important Structures Critical for Surgical Procedures Described

<table>
<thead>
<tr>
<th>Distance Description</th>
<th>Distance, mm</th>
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<tbody>
<tr>
<td>Distance between the HOM and the most prominent part of the AE</td>
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<td>1.38</td>
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<td>Distance between the HOM and the foramen spinosum</td>
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<td>Distance between the HOM and the root of the zygoma</td>
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<td>Distance between the HOM and the petrous ridge</td>
<td>15.07</td>
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Abbreviations: AE, arcuate eminence; AP, acoustic porus; HOM, head of malleus.

### Discussion

Decompression of the facial nerve in patients with temporal bone fractures and facial paralysis using the middle fossa approach. All operations were performed by the senior author (H.K.). In the last 6 cases, the HOM was located using the transillumination method in a manner similar to other techniques described in the literature. The HOM was the primary landmark used to locate the geniculate ganglion. No cerebrospinal fluid leak, meningitis, or brain herniation was seen.

### Clinical Cases

Between 1993 and 2011, we operated on 17 patients with temporal bone fractures and facial paralysis using the middle fossa approach. All operations were performed by the senior author (H.K.). In the last 6 cases, the HOM was located using the transillumination method in a manner similar to other techniques described in the literature. The HOM was the primary landmark used to locate the geniculate ganglion. No cerebrospinal fluid leak, meningitis, or brain herniation was seen.

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Abbreviations: AE, arcuate eminence; AP, acoustic porus; HOM, head of malleus.
the AE may be featureless and difficult to identify on the middle fossa in about 15% of cases. Although the AE can be identified in 85% of patients, the SSSC deviated from the AE in 50% of cases.8

Here, we present one novel and one modified technique for the middle fossa approach. The foramen spinosum, trigeminal impression, and GSPN were used to locate the HOM. As described, 3 imaginary lines were drawn from the foramen spinosum parallel to the petrous ridge, along the GSPN, and between the trigeminal impression and the zygomatic root. The area posterior to the intersection of these 2 lines separately (the line drawn from foramen spinosum parallel to the petrous ridge and the second line along the GSPN) with the line between the trigeminal impression and the zygomatic root was proven to be a safe and reliable drilling zone in 14 dissected cadaveric temporal bones. It is important to avoid drilling medial to the imaginary line along the GSPN or lateral to the imaginary line drawn from the foramen spinosum. This technique is most useful when the AE is obscured.

The second method can be used when no landmark can be identified. A 0° endoscope is inserted into the external ear canal. The brightest point in the middle fossa approach represents the HOM topographically. This technique was first reported by Kobayashi and Nakao.2 We confirmed that the brightest point matched the location identified by the angle created by the convergence of imaginary lines drawn along the paths of the GSPN and SSSC. No such relationship was reported in Kobayashi and Nakao’s article. This convergence creates a mean (SD) angle of 124.34° (7.0°) (range, 110°-135°). We confirmed this technique in 14 dissected cadaveric temporal bones and in 6 patients in whom we used the middle fossa approach to treat temporal bone fracture with facial paralysis. As stated by Bento et al.,9 this approach avoids the risk of complications (cerebrospinal fluid leak, meningitis, brain herniation) inherent in opening a space in the tegmen tympani because it does not require entry into the dura or IAC. We encountered no such complication in our subjects.

In both techniques, knowledge of anatomic relationships is mandatory. Location of the HOM can be justified using external and internal reference points (in our study, the distance between the HOM and the root of the zygoma was 18.22 mm, the distance between the HOM and the petrous ridge was 15.07 mm, and the distance between the HOM and the foramen spinosum was 19.14 mm). Using these measurements with the techniques described makes identification of the HOM more accurate. After the HOM is exposed, avoiding complications is the main task for a surgeon. The relationships of important structures must be kept in mind (in our study, the distance between the HOM and the horizontal semicircular canal was 5.44 mm, the distance between the HOM and the cochlea was 8.9 mm, the distance between the HOM and the geniculate ganglion was 5.74 mm, and the distance between the HOM and the closest segment of the tympanic branch of the facial nerve was 3.39 mm) to avoid dreadful complications.

Although our cases consisted of patients with temporal bone fractures, the transillumination technique should be used with caution in traumatic cases because the fracture line may blur or disseminate the brightest point.

Conclusion

The middle fossa approach is a complex surgical technique, and no technique can be regarded as easy. We confirmed both techniques in 14 dissected cadaveric temporal bones and the transillumination technique in 6 patients in whom we used the middle fossa approach to treat temporal bone fracture with facial paralysis. The techniques described here simplify the middle fossa approach. Both methods can be used concurrently with the techniques in the literature for a more reliable identification of the HOM.

Author Contributions

Erdem Eren, contribution to conception and design, acquisition of data, analysis and interpretation of data, drafting the article and revising it critically for important intellectual content, approval of the final version to be published; M. Sinan Basoğlu, contribution to conception and design, acquisition of data, revising the article critically for important intellectual content, approval of the final version to be published; Ashkan Gürcan Bingölballi, contribution to conception and design, acquisition of data, revising the article critically for important intellectual content, approval of the final version to be published; Hale Aslan, contribution to conception and design, acquisition of data, revising the article critically for important intellectual content, approval of the final version to be published; Amaç Kiray, contribution to conception and design, acquisition of data, revising the article critically for important intellectual content, approval of the final version to be published; Can Özbay, contribution to conception and design, acquisition of data, revising the article critically for important intellectual content, approval of the final version to be published; Sedat Öztürkcan, contribution to conception and design, acquisition of data, revising the article critically for important intellectual content, approval of the final version to be published; Hüseyin Kâtilmuş, contribution to conception and design, acquisition of data, revising the article critically for important intellectual content, approval of the final version to be published.

Disclosures

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