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Technique

# Middle fossa approach: microsurgical anatomy and surgical technique from the neurosurgical perspective

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**Abstract**

**Background:** The purpose of this study was to call attention to the subtemporal approach directed through the petrous apex to the IAM. We studied the microsurgical anatomy of the middle floor to delineate a reliable angle between the GSPN and the IAM to precisely localize and expose the IAM from above. A new technique for the elevation of middle fossa floor in an anterior-to-posterior direction has also been examined in cadaveric dissections and performed in surgery.

**Methods:** The microsurgical anatomy of the middle fossa floor was studied in 10 adult cadaveric heads (20 sides) after meatal drilling on the middle fossa. Five latex-injected specimens were dissected in a stepwise manner to further define the microsurgical anatomy of the middle fossa approach. The middle fossa approach is illustrated in a patient for the decompression of the facial nerve to demonstrate the surgical technique and limitations of bone removal.

**Results:** Elevation of middle fossa dura in an anterior-to-posterior direction leads to early identification of the GSPN, where the nerve passes under V3. The most reliable and easily appreciated angle to be used in localizing the IAM is between the IAM and the long axis of the GSPN, which is approximately 61°. Beginning drilling the meatus medially at the petrous ridge is safer than beginning laterally, where the facial and vestibulocochlear nerves become more superficial. The cochlea anteromedially, vestibule posterolaterally, and superior semicircular canal posteriorly significantly limit the bone removal at the lateral part of the IAM.

**Conclusions:** The surgical technique for the middle fossa approach which includes an anterior-to-posterior elevation of middle fossa dura starting from the foramen ovale and uses the angle between the IAM and the long axis of the GSPN to localize the meatus from above may be an alternative to previously proposed surgical methods.



*Keywords:* Acoustic neuroma; Facial nerve; Microsurgical anatomy; Middle fossa approach

## 1. Introduction

Since the initial description of the IAM exposure through the petrous apex for the division of the vestibulocochlear nerve in a case of tinnitus and vertigo by Parry [29] in 1904, the middle fossa approach has been an important part of an otolaryngologist's, and less frequently a neurosurgeon's, armamentarium. In 1961, William House [18], an ear-nose-throat surgeon, redefined the approach with the aid of the operating microscope for decompression of the IAM in the management of otosclerosis.

The middle fossa approach has undergone several modifications to expand its exposure along the cerebellopontine angle, petrous apex, tentorial incisura, upper clivus, and posterior cavernous sinus [2,14,15,20,22-25]. The modifications of the middle fossa approach can be classified

*Abbreviations:* GSPN, greater superficial petrosal nerve; IAM, internal acoustic meatus; MMA, middle meningeal artery; SCC, semicircular canal; V3, mandibular division of the trigeminal nerve.

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according to their extensions into various anatomical regions: the middle fossa approach to the internal auditory canal, the extended middle fossa approach with a wider opening of the posterior part of the petrous pyramid for the removal of larger acoustic neuromas, and the middle fossa anterior transpetrosal approach, so-called the Kawase's approach, which is designed for the anterior cerebellopontine angle, the ventral surface of pons, and the upper clivus. This article focuses on the subtemporal approach to the IAM (middle fossa and its extended modification), which provides exceptional exposure to the cisternal, meatal, labyrinthine, and tympanic segments of the facial nerve, the vestibulocochlear nerve, and the geniculate ganglion [9,10,12,13,17,18].

The middle fossa approach to the IAM and its extensions have been used for the removal of small acoustic tumors with the potential for hearing preservation, facial nerve exploration, and vestibular nerve section [16,17,21,35,36]. As hearing preservation is the hallmark of the middle fossa approach, a detailed knowledge of the anatomy of the middle fossa floor to define the surgical limitations, such as the inner ear structures and the ossicular chain, is mandatory for neurosurgeons [27,38]. Our purpose was to describe the microsurgical anatomy of the middle fossa approach to the IAM and to delineate the angle between the GSPN and the IAM, which can be used as a guide to accurately locate the meatus from above. We also intended to define the technical details of a modified technique, which includes the anteroposterior elevation of middle fossa dura, starting from the mandibular division of the trigeminal nerve (V3), and uses the angle between the GSPN and IAM to precisely localize the meatus on the middle fossa floor.

## 2. Materials and methods

The microsurgical anatomy of the middle fossa floor was studied and the measurements were taken in 10 formalin-fixed adult cadaveric heads (20 sides) after meatal drilling on the middle fossa. The angle between the GSPN and the IAM has been measured in 10 formalin-fixed adult cadaveric heads (20 sides), using 3 to 40 magnification, after the meatal drilling on the middle fossa. The distance between the geniculate ganglion and the point, where the GSPN passes under the mandibular nerve, has also been measured in these dissections. In addition, an extradural subtemporal middle fossa approach to the IAM was performed in 5 formalin-fixed adult cadaveric heads and the petrosal part of the temporal bone above the IAM was removed by using microsurgical techniques to demonstrate the limiting anatomical structures for the bone removal at the lateral part of the IAM. The surgical technique to elevate the middle fossa dura and to locate the IAM on the middle fossa floor was described in a case with traumatic delayed facial nerve palsy without temporal bone fracture where the hearing was preserved.

## 3. Results

### 3.1. Basic anatomical relationships

#### 3.1.1. Facial nerve anatomy

The segments of the facial nerve and its relation with the temporal bone should be thoroughly understood to clarify the microsurgical anatomy of the middle fossa floor, as the course of the nerve and its ganglion are the key landmarks during exposure of the IAM from above [3,38,40]. The facial nerve, the seventh cranial nerve of the second brachial arch, extends from the pontomedullary junction to the parotid gland and has 6 segments: cisternal, meatal, labyrinthine, tympanic, mastoid, and extracranial or intraparotid. The middle fossa approach is closely related with proximal 4 segments and the geniculate ganglion, so the microsurgical anatomy will be discussed in this regard.

#### 3.1.2. Cisternal and meatal segments

The facial nerve leaves the brain stem at the pontomedullary junction anteromedial and below the vestibulocochlear nerve (Fig. 1A). The initial cisternal segment of the facial nerve, approximately 24 mm in length, is closely related to the vestibulocochlear nerve and the nervus intermedius, or the sensory root. The meatal segment, about 8 mm in length, follows a shallow gutter in an anterosuperior aspect of the IAM (Fig. 1B and C). The positions of the facial and the vestibulocochlear nerves are most constant in the lateral portion of the IAM, which is divided into a superior and an inferior portion by a horizontal ridge, called the transverse crest. The superior compartment is further divided by a vertical crest into an anterior smaller facial and a posterior larger superior vestibular compartments. The vertical crest, also called “Bill's bar” in recognition of William House, is made up of variably ossified arachnoid tissue and usually cannot be visualized with current computed tomography technology.

#### 3.1.3. Labyrinthine-tympanic segments

The orifice of the facial canal in the IAM measures 0.68 mm in diameter [31]. The labyrinthine segment of the facial nerve, so named because of its intimate relationship to the cochlea and the superior SCC, is the narrowest (<0.7 mm) and shortest (3-5 mm) segment (Fig. 1B and C). This segment is related to the apical turn of the cochlea medially and the ampullae of the lateral and superior SCCs posterolaterally, and terminates in the geniculate ganglion.

The geniculate ganglion, a bulbous enlargement of the facial canal, contains the terminal part of the nervus intermedius, which emerges from the ganglion as the GSPN (Fig. 1). The GSPN can be identified medial to the arcuate eminence as it leaves the geniculate ganglion by passing through the sphenopetrosal groove along the middle fossa floor, immediately superior and anterolateral to the horizontal segment of the petrous carotid. In our dissections, the GSPN traveled an average of 17 mm anteriorly from the