Role of Squamosal Suture as a Consistent Landmark for Middle Fossa Approach Craniotomy: An Anatomical Study

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J Neurol Surg B 2015;76:35–38.

Abstract

Objective To establish a consistent surface bony landmark for a middle fossa approach (MFA) lateral craniotomy represented by the squamosal suture (SS).

Methods In 60 dried skulls, we assessed the relation between the SS and the external auditory canal (EAC). The lateral portion of the middle cranial fossa floor was also assessed for a possible relation with the anteroposterior diameter (APD) of the squama temporalis (ST). Clinically, we applied our findings on the SS in MFA for different lesions.

Results A vertical line at the EAC divided the ST into the anterior part constituting 61% of the APD (i.e., two thirds) and the posterior part forming 39% (i.e., one third). The average ST height was 35.92 mm. The SS posterior limit at the supramastoid crest was located just anterior to the external projection of the petrous ridge in 35 skulls (58%) and exactly corresponded to it in 25 skulls (42%). The APD of the ST equals on average 97% of the APD of the lateral middle cranial fossa. Optimum exposure of the middle fossa was obtained without any further craniotomy extension.

Conclusion The SS serves as a consistent natural surface bony landmark for MFA. Optimum craniotomy, two thirds anterior to the EAC and one third posterior, is obtained following SS as a landmark.

Keywords

- squamosal suture
- middle fossa approach
- schwannoma

Introduction

Sandifort was the first to describe acoustic neuroma in the second half of the 18th century.¹ He documented an autopsy of finding a small adherent body attached to the auditory nerve in a deaf patient's body. Later, in 1830, Charles Bell was the first to accurately describe an acoustic neuroma in a living patient.² However, the first successful surgical removal of a vestibular schwannoma was reported by Ballance in 1907.³

Vestibular schwannomas can typically be treated via one of three main surgical approaches: the translabyrinthine, the retrosigmoid, or the middle fossa.^{4–6} Hearing preservation, tumor size and extension, and facial nerve protection are the main concerns in choosing the best treatment option. William House refined and popularized the middle fossa approach (MFA) in 1961 when it was used for decompression of the internal auditory canal (IAC) in cases of extensive otosclerosis.⁷ Subsequently, it became evident that this approach was suitable for the removal of acoustic tumors.

received

April 17, 2014

accepted

June 16, 2014

published online

September 13, 2014

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Stuttgart · New York

DOI <http://dx.doi.org/10.1055/s-0034-1390015>.
ISSN 2193-6331.

The MFA is indicated for small tumors located primarily within the IAC and offers the possibility of hearing preservation.⁸⁻¹⁰ It is an exceptional approach for small tumors that occupy the IAC with a minor element in the cerebellopontine angle (CPA). Excellent access to the lateral end of the canal can be obtained.

The goal of the MFA is to achieve exposure from the arcuate eminence posteriorly to the third division of the fifth nerve anteriorly. However, optimum middle cranial fossa exposure requires consistent surface bony landmarks that could serve as a solid reference. Several studies report the MFA craniotomy using a nonprecise description. In our study, we validate the squamosal suture (SS) as a definitive natural surface bony landmark for MFA lateral craniotomy.

Material and Methods

Anatomical Considerations

The middle fossa is narrow medially and widens laterally to the sides of the skull.¹¹ It is separated from the posterior fossa by the clivus and the petrous crest. Anteriorly, it is bounded by the posterior margins of the lesser wings of the sphenoid bone and the anterior clinoid processes. Posteriorly, it is bounded by the superior angles of the petrous portions of the temporal bones and the dorsum sellae. The greater wing of the sphenoid forms the lateral limit as it extends laterally and upward from the sphenoid body to meet the squamous portion of the temporal bone and the anteroinferior portion of the parietal bone. The eminence is an important landmark during the MFA for localization of the IAC. It represents the superior extent of the superior semicircular canal. It can be appreciated on the superior aspect of the midpetrous ridge.

The squamosphenoidal suture represents the anterior limb of the SS.¹¹ It arches backward from the pterion and connects the squama temporalis (ST) with the lower border of the parietal bone. Then it sweeps backward and downward where it meets with the parietomastoid suture, which unites the mastoid process of the temporal bone with the region of the mastoid angle of the parietal bone.

The upper edge of the zygomatic process of the temporal bone passes over and behind the external auditory canal (EAC) until it meets with the SS forming the supramastoid crest.¹² It represents the posterior root of the zygoma. Intracranially, it corresponds to the level of the middle fossa floor (tegmen tympani).

Our Study

We used 60 randomly selected dried skulls. Each side of the skull was studied separately (i.e., 120 sides). Measurements were collected by three different investigators to ensure accurate results. Our goal was to substantiate the role of SS as a definitive surface landmark for MFA craniotomy.

The height of the ST bone above the level of the external auditory meatus was measured by a vertical line between a point on the SS (point A), and a point on the supramastoid crest (point B) (i.e., A-B line) (►Fig. 1). The width of the squamous temporal bone was measured horizontally between a point at the junction of the SS with the supramastoid

Fig. 1 Dried skull lateral surface. Squamosal suture diameters measured on the temporal bone outer surface.

crest (point C), and a point on the anterior limb of the squamosal suture (point D) (i.e., C-D line) (►Fig. 1).

The intersection between both lines is represented by point E. Point E and EAC are purposefully located at the same coronal plane. The ST anterior to the EAC is measured between points D and E. The ST posterior to the EAC is measured between points E and C (►Fig. 1).

The anteroposterior diameter (APD) of the lateral part of the middle cranial fossa was measured intracranially between points F and G. Point F represents the most lateral point on the sphenoid ridge. Point G represents the most posterolateral point on the petrous edge (►Fig. 2).

We also evaluated the relation between points C and G in the coronal plane (►Fig. 3).

Results

The average height of the squamous temporal bone (A-B) was 35.43 mm on the right and 36.41 mm on the left (►Table 1).

Fig. 2 Dried skull intracranial superior view showing the anteroposterior diameter of the lateral aspect of the middle fossa.

Fig. 3 Dried skull intracranial superior view showing the close relation of the posterior limit of the squamosal suture at the supramastoid crest and the external projection of the petrous ridge.

The average C–D distance was 65 mm on the right and 64.54 mm on the left (►Table 1).

The average F–G distance was 65.9 mm on the right and 66.27 mm on the left (►Table 1). Thus the average APD of the ST equals ~97% of the APD of lateral part of the middle cranial fossa.

The average C–E distance was 23.95 mm on the right and 24.49 mm on the left (►Table 1). The average E–D distance was 41.17 mm on the right and 40.14 mm on the left. Accordingly, the E–D distance almost doubles the C–E dis-

Table 1 Anatomical variations of squamosal suture different diameters

Diameter	Average, mm	Maximum, mm	Minimum, mm
A–B			
Right	35.93	49	26
Left	36.41	47	27
C–D			
Right	65	80	52
Left	64.5	80	50
C–E			
Right	23.95	35	12
Left	24.49	35	13
E–D			
Right	41.17	53	32
Left	40.14	51	23
F–G			
Right	65.9	77	58
Left	66.2	77	57

tance. Our results correlate with the current concept of middle fossa craniotomy (i.e., two thirds anterior and one third posterior to the EAC).

The posterior limit of the SS at the supramastoid crest was found to be just anterior to the external projection of the petrous ridge in 35 skulls (58%), and it exactly corresponded to it in 25 skulls (42%) (►Fig. 3).

Discussion

The MFA, as popularized by William House, provides exceptional exposure to the IAC for the resection of small acoustic tumors with the potential for hearing preservation.⁷ Patients undergoing an MFA were more likely to retain their preoperative hearing class after surgery than those in the retrosigmoid group. The MFA allows for more extensive lateral IAC exposure than the retrosigmoid approach.¹³ This gives the advantage of direct visualization of the lateral tumor without otic capsule violation and better visualization of the lateral cochlear nerve during tumor resection. The MFA exposes the petrous apex anteriorly (anterior to the V3) to the arcuate eminence posteriorly. Anterior petrosectomy in addition to the standard MFA can provide further exposure for the resection of a variety of lesions. This extension provides an excellent option for petroclival lesions, lesions of the middle third of the clivus, and anterior inferior cerebellar artery aneurysms.^{14–16}

According to House and Shelton, “Landmarks are not as apparent as with other approaches through the temporal bone, so laboratory dissection is useful for the surgeon to become familiar with the anatomy from above.”¹⁷ The literature on MFA lacks definitive descriptions of the craniotomy boundaries. However, several reports suggested an approximate nonstandardized depiction of the craniotomy borders.^{17–19} House reported that the placement of bone flap was based on the root of the zygoma, with approximately two thirds anterior and one third posterior to the EAC.¹⁷ The flap was ~2.5 cm square. Similarly, Day et al¹⁸ followed the one third, two thirds rule but with a wider bone flap (4 × 4 cm) this time. The craniotomy has to be as low as possible and flush with the cranial base to minimize retraction of the temporal lobe.

The need to follow a precise surface landmark for an MFA lateral craniotomy became essential. Our study validates the SS as a definitive natural surface landmark. The virtual vertical line at the EAC was found to divide the APD of the temporal squama into an anterior part constituting 61% on average (i.e., two thirds) and a posterior part forming 39% (i.e., one third of the APD). Thus the SS naturally follows the one third, two thirds rule of an MFA lateral craniotomy. Moreover, the posterior limit of the SS at the supramastoid crest lies at or just anterior to the external projection of the petrous ridge. A similar observation was reported by Ribas and Rodrigues.²⁰ They indicated that the external junction of the parietomastoid and SS corresponds intracranially to the most posterolateral part of the intracranial petrous surface. Thus the posterior element of the SS represents a reliable consistent landmark.

Our experience with 100 consecutive cases of canalicular vestibular schwannoma and encephalocele has confirmed the anatomical finding. Optimum exposure of the middle fossa has been obtained using the SS as a landmark without any further extension of the craniotomy. This natural landmark has minimized operative planning and procedure time. We consider the lack of evaluation of the gender and race variation in the SS as a limitation for our study. However, we randomly selected the 60 skulls in an attempt to eliminate selection bias.

The SS serves as a definitive natural surface bony landmark for MFA. Optimum middle cranial fossa exposure, two thirds anterior and one third posterior to the EAC, is obtained following SS as a craniotomy landmark.

Conflict of Interest

None.

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