Suboccipital Retrosigmoid Surgical Approach For Internal Auditory Canal—A Morphometric Anatomical Study on Dry Human Temporal Bones

Sanjeev Kolagi · Anita Herur · Mahesh Ugale ·
R. Manjula · Ashwini Mutalik

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Abstract Suboccipital retrosigmoid craniotomy with removal of posterior wall of internal auditory canal is preferred by many surgeons operating on acoustic neuromas, as it is a simple and safe approach. To study the topographic landmarks of the posterior surface of the temporal bone. We studied the surgical anatomy of 224 dry adult human temporal bones, measured the various distances on posterior wall of petrous bone relevant for suboccipital surgical approach to internal auditory canal. The internal auditory canal (IAC) lies within 32–44 mm from posterior wall of sigmoid sulcus and within 3–8 mm from the superior border of petrous bone. The point corresponding to highest point of jugular bulb was found between 4 and 9 mm away from the inferior border of IAC. The maximum distance found between bony orifice of vestibular aqueduct and IAC was 14 mm and the minimum distance was 6 mm. The vertical diameter of IAC ranged between 3 and 7 mm. These parameters may help the surgeons for better exposure of internal auditory canal and for avoiding damage to vital surrounding structures.

Keywords Retrosigmoid approach · Internal auditory canal · Acoustic neuroma · Human temporal bones

Introduction

“You will easily recognize that there is hardly another part of the body which calls for higher qualifications on the part of the operator as to anatomical knowledge than the temporal bone”—Friedrich Bezold, [1] shows the importance of anatomy of temporal bone.

Hearing preservation in acoustic neuroma surgery depends on many factors. Among them anatomical preservation of the cochlear nerve and inner ear structures are the most important. The knowledge of internal auditory canal anatomy and normal variations is therefore essential. Internal auditory canal can be approached surgically through posterior cranial fossa, i.e., retrosigmoid approach [2] or through middle cranial fossa or translabyrinthine approach. Suboccipital retrosigmoid craniotomy with removal of posterior wall of internal acoustic canal is preferred by many surgeons operating on acoustic neuromas, as it is a relatively simple and safe approach [3]. Advantages of retrosigmoid approach are

- Time taken for the surgery via this approach is very less.
- Hearing can be preserved.
- Safety of lower cranial nerves.
- Better exposure of cerebello pontine angle.
- Any size tumor can be removed.

Middle cranial fossa approach is technically more complex and anatomical landmarks are more difficult to identify than posterior cranial fossa approach and is usually limited to intracanalicular tumors. Retrosigmoid approach for internal auditory canal is safer than the retrolabyrinthine approach, since there is no risk of opening the

S. Kolagi (✉) · M. Ugale · A. Mutalik
Department of Anatomy, S.Nijalingappa Medical College,
Navanagar, Bagalkot 587103, Karnataka, India
e-mail: drsanjeevkolagi@yahoo.co.in

A. Herur
Department of Physiology, S. Nijalingappa Medical College,
Navanagar, Bagalkot 587103, Karnataka, India

R. Manjula
Department of Community Medicine, S. Nijalingappa Medical
College, Navanagar, Bagalkot 587103, Karnataka, India

endolymphatic sac, which may cause complete hearing loss [4].

There is no standard text references available on the various measurements required for retrosigmoid approach of internal auditory canal except for its dimensions. In 90% of normal subjects, the vertical diameter of IAC lies between 2 and 8 mm, average being 4.5 mm. The difference between two sides in vertical diameter does not exceed 1 mm. The average length of posterior wall was 8 mm; difference between two sides does not exceed 2 mm [5]. Radiographically, a difference in diameter of more than 2 mm between two internal auditory canals (in the same individual) is usually taken to be diagnostic of a tumor [6].

Since there is a paucity of morphometric analysis on Indian temporal bones regarding retrosigmoid approach to IAC, this study was taken up to describe the topographic landmarks on the posterior surface of the temporal bone.

Materials and Methods

Ethical clearance for the present study was obtained from the institution. Surgical anatomy of 224 dry adult human temporal bones was studied, the various distances from the posterior wall of petrous bone relevant for retrosigmoid surgical approach to internal auditory canal measured using digital calipers are shown in (Fig. 1A–E). Length of the posterior wall of the internal auditory canal was also measured.

SPSS 15.0 software was used to analyze the data.

Fig. 1 Posterior surface of right temporal bone showing various measurements. **A** From the uppermost point on posterior wall of sigmoid sulcus to lateral wall of internal auditory canal **B** Mid point of upper margin of internal auditory canal to superior border of petrous bone **C** Opening of vestibular aqueduct to lateral edge of internal auditory canal **D** Midpoint of upper margin of jugular foramen (corresponds to highest point of jugular bulb) to the level of lower margin of internal auditory canal **E** Vertical and horizontal diameters of internal auditory canal

Results

224 dry adult human temporal bones were studied for dimensions of internal auditory canal and various anatomical landmarks for surgical exposure via retrosigmoid approach.

The IAC lies within 32–44 mm from posterior wall of sigmoid sulcus and within 3–8 mm from the superior border of petrous bone. In this study, to expose the IAC supracerebellar way, up to its inferior border, required on an average 10 mm downward displacement of cerebellum (distance from superior border of petrous + vertical diameter of IAC) (Table 1), which is very minimal without much pressure on cerebellum and damage to inner ear structures can be avoided.

The point corresponding to highest point of jugular bulb was found between 4 and 9 mm away from the inferior border of IAC. This means we have, in our study, a safe area of 4 mm from inferior border of IAC which can be drilled without injury to jugular bulb. The maximum distance found between bony orifice of vestibular aqueduct and IAC was 14 mm and the minimum distance was 6 mm (Table 2).

The vertical diameter of IAC ranged between 3 and 7 mm without any significant difference between right and left sides (Table 3). There was no case in our study where there was difference in vertical diameter of more than

Table 1 Measurements (in mm) from posterior wall of sigmoid sulcus to IAC

	Right	Left
Mean	38.94	38.09
Median	39.50	38.00
S D	2.34	2.38
Range	35–44	32–43

SD Standard deviation

Table 2 Other critical measurements on posterior surface of petrous bone (in mm)

	B		D		C	
	Right	Left	Right	Left	Right	Left
Mean	5.56	5.79	6.29	6.14	10.44	10.35
Median	6	6	6	6	10	11
SD	0.959	0.997	1.115	1.018	1.828	1.432
Range	3–7	4–8	4–9	4–9	6–14	7–13

SD Standard deviation, **B** Mid point of upper margin of IAC to superior border of petrous bone, **C** Opening of vestibular aqueduct to lateral edge of IAC, **D** Midpoint of upper margin of jugular foramen (corresponds to highest point of Jugular bulb) to the level of lower margin of IAC

Table 3 Dimensions of IAC (in mm)

	Right side			Left side		
	Horizontal	Vertical	Length	Horizontal	Vertical	Length
Mean	6.5	4.18	11.18	6.44	4.14	11.56
Median	6	4	11	6	4	11
SD	1.15	0.84	1.94	1.23	0.94	1.99
Range	4–11	3–7	8–16	5–11	3–7	7–16

SD standard deviation

2 mm between right and left side of the same individual (difference of 2 mm between the two sides in the same individual in vertical diameter should be looked with suspicion of a tumor). The horizontal diameter of IAC ranged between 4 and 11 mm and the length of posterior canal wall ranged between 7 and 16 mm. In all the parameters measured above, there was no significant difference between right and left sides.

Discussion

At present, the surgery for acoustic neuroma remains one of the most complicated operations demanding for surgical skills and anatomical knowledge. Topographic landmarks on the posterior surface of the temporal bone are useful for approaching the IAC. The indication for retrosigmoid approach depends on the size of the tumor, its relationship to the fundus of IAC and preoperative hearing loss.

Drilling the internal auditory canal is an important step during surgical removal of acoustic neuromas. The jugular bulb and endolymphatic sac are very near and may get injured during drilling the internal auditory canal. It was found that 5 mm of bone could be safely drilled away from the posterior lip of internal auditory canal without damaging jugular bulb or endolymphatic sac. In 18% of the cases studied, there was a very high lying jugular bulb [7], and in 3% of cases the jugular bulb reached up to or above the level of IAC [3]. In the present study, the average distance between jugular bulb and IAC was 6 mm, similar to the study by Erdogan [8], but did not encounter a very high lying jugular bulb.

The IAC can be exposed up to its inferior border by depressing cerebellar hemispheres by 8–10 mm which is enough for some of the smaller tumor surgeries [3, 8] and this was found to be true in the present study also.

To have a direct view of IAC up to its fundus and without risk to inner ear, the craniotomy has to be placed 3–4 cm medial to sigmoid sinus [9–11]. But more medial the craniotomy for better exposure of IAC more will be the retraction of cerebellum and its problems. Therefore, an endoscope was used to check the unexposed lateral parts of IAC [12].

Measurements taken from preoperative CT scans may be used as a guide to expose the lateral aspect of the internal auditory canal and can also demonstrate other topographic variations [13].

Retrosigmoid approach for a vestibular nerve is safer than the retrolabyrinth approach, since there is no risk of opening the endolymphatic sac, which may cause complete hearing loss [4]. Critical distances were measured which are significant for preservation of hearing during retrosigmoid approach for acoustic neuromas and it was noted that the average dimensions of internal auditory canal were 9.3 mm horizontally $\times$ 4.5 mm vertically; distance from superior border of internal auditory canal to superior border of petrous was 5.5 mm, inferior border of internal auditory canal to highest point on jugular bulb was 6.6 mm and lateral wall of internal auditory canal to endolymphatic sac was 11.2 mm [4]. These findings are close to the results of the present study and almost similar results were also found in the study by Erdogan [8]. It was found from the present study that 4 mm safe area was available for drilling the IAC inferiorly and 6 mm laterally without encountering jugular bulb and endolymphatic sac, respectively.

These parameters may help the surgeons for better exposure of IAC and in avoiding damage to vital surrounding structures in Indian population.

Micro dissection of IAC posterior wall in bones and delineating the relation with inner ear structures are planned further, as continuation of this study, which will further reduce the chances of hearing loss in acoustic neuroma surgeries.

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