ORIGINAL RESEARCH PAPER

Radiology

MORPHOMETRIC ANALYSIS AND GEOMETRIC VARIATIONS OF THE INTERNAL ACOUSTIC MEATUS IN THE SOUTH INDIAN POPULATION: A CT IMAGING STUDY

KEY WORDS: IAM- Internal acoustic meatus, morphometry, CT- Computed Tomography

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ABSTRACT

Background: The internal acoustic meatus (IAM) is a bony canal located between the labyrinth and the posterior cranial fossa. Understanding its normal dimensions and morphology is essential for evaluating skull trauma, identifying congenital anomalies that may affect individual nerves, and preparing for ear surgeries. This study aims to determine the normal dimensions and morphology of the IAM using Computed Tomography(CT), creating a morphological database specific to the South Indian population. **Objective:** To determine the morphometry and shapes of internal acoustic meatus in healthy south Indian population aged between 10-60 years. **Materials And Methods:** This study which was a retrospective study, was carried out from the 500 healthy subjects (214females;286 males) aged 10-60 years. Subjects had undergone routine CT brain in the Radiology Department. **Results:** The study comprised 359 males and 141 females. The average IAM measurements were as follows: for males, the length was 9.19 mm on the right and 9.25 mm on the left; the width measured 3.7 mm on the right and 3.77 mm on the left; and the height was 4.1 mm on the right and 4.06 mm on the left. For females, the corresponding measurements were 9.4 mm (right) and 9.28 mm (left) for length; 3.7 mm (right) and 3.8 mm (left) for width; and 4.1 mm (right) and 4.06 mm (left) for height. A significant difference was noted in the length of the internal acoustic meatus between males and females on the right side ($p = 0.034$). The other parameters did not show significant differences ($p > 0.05$). **Conclusion:** These measurements offer a normative reference for the internal acoustic meatus in the South Indian population. Understanding the normal dimensions and shapes is crucial for assessing clinical conditions and tumor processes. A narrow internal acoustic canal is associated with unilateral and bilateral congenital sensorineural hearing loss and cochlear nerve hypoplasia, while a dilated canal may indicate expansion due to an acoustic neuroma or other lesions.

INTRODUCTION

The internal auditory canal (IAC), alternatively termed the internal acoustic meatus, occupies a crucial space within the temporal bone. Acting as a conduit between the inner ear and the posterior cranial fossa, it serves as a passageway for essential anatomical components[1-3]. Within this canal, pivotal structures like the vestibulocochlear nerve (CN VIII), the facial nerve (CN VII), the labyrinthine artery, and the vestibular ganglion find their passage, coordinate the functions related to hearing, balance, and intricate neural connections.[2,3]

During embryonic development, a layer of mesoderm surrounds the vestibulocochlear complex. This mesoderm layer undergoes a process where it turns into cartilage and later transforms into bone, forming the internal acoustic canal (IAC)[5,6]. Auris interna is interconnected by this canal with fossa cranii posterior. The IAM lies laterally for nearly 1 cm within the temporal bone petrous part. The IAM's opening is located at the posteromedial part of the temporal bone and the internal acoustic meatus is closed by thin perforated plate of bone that separates this meatus from the internal ear[2-4].

In the studies of internal acoustic meatus' morphometry and anatomy, the differences between races were reported. The volume, shape, and dimensions of the normal adult internal auditory meatus (IAM) exhibit considerable variation, even within the same individual when comparing the right and left sides[4,6]. Additionally, the development and formation of the eighth (8th) cranial nerve can influence the internal auditory canal. A narrowed internal acoustic canal or meatus has been associated with both unilateral and bilateral congenital sensorineural hearing loss, as well as cochlear nerve hypoplasia. Conversely, a dilated internal acoustic meatus suggests expansion, possibly secondary to the presence of an acoustic neuroma or another occupying lesion. This diversity in IAM characteristics underscores the importance of considering individual anatomical variations in clinical assessments and radiological interpretations[5,8,11].

However, few studies about internal acoustic meatus or canal height, length and width measurements in dry Indian cadaver skull. No studies regarding age wise changes and shape of IAC by using CT brain were found in Indian population. Knowledge of the normal dimensions of the internal acoustic canal is more important for determination of the clinical and tumor processes. We aimed to evaluate the normal dimensions about internal acoustic meatus dependent on age and gender in south Indian healthy population by using NCCT brain.

MATERIALS AND METHODS

The study included 500 healthy adults (141 females, 359males) aged 10-60 and took place in the Department of Radiology at Mandya institute of medical sciences, Karnataka. It was a retrospective observational study conducted from January to December 2023. All CT scans were obtained using a 160-slice multidetector CT (United imaging uCT 780). The mid-sagittal and axial image was used to obtain the Internal acoustic meatus length, width, and height. Healthy adult subjects were chosen based on optimal health criteria. The main exclusion criteria included a history of brain or ear tumors and any ear pathology.

Patients with no past medical history or clinical signs and symptoms related to ear diseases, and those with no significant abnormalities on CT brain, were included. Individuals under 10 years old or over 60 years old were excluded. The subjects were further categorized into five groups based on 10-year intervals, and the division was also made by gender for all subjects.

PROCEDURE OF THE TESTS

The data were categorized into two groups based on gender (healthy adult females and males) and five age groups (Group I, 10-20 years; Group II, 21-30 years; Group III, 31-40 years,

Group IV, 41-50 years and Group V, 51-60 years). Shape of internal acoustic canal measured in axial plane. Measurements, expressed in millimetres, were conducted bilaterally.

These parameters were as follows:

- The Internal Acoustic Meatus (IAM) height: Vertical diameter of the IAM at its middle part. (Figure 2)[13].
- The Internal Acoustic Meatus width: Horizontal diameter of IAM at the middle part of the meatus. (Figure 1)[13].
- The Internal Acoustic Meatus length: The distance from the lateral margin of internal acoustic pore. (Figure 1)[13].

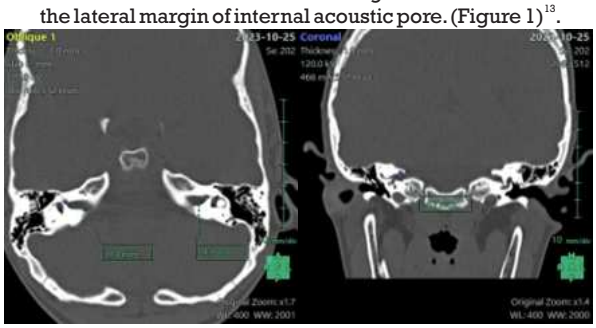
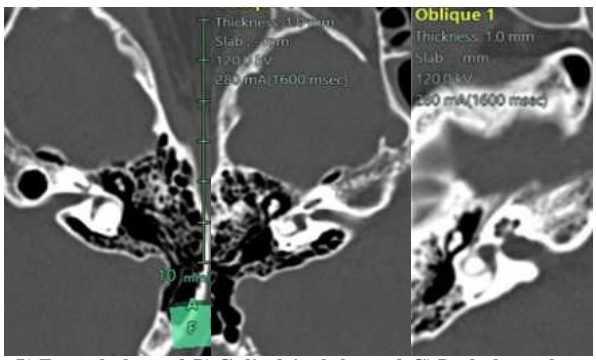


Figure 1. The width and length measurements Internal acoustic meatus.

Figure 2. The height measurements of the internal acoustic meatus.



A) Funnel-shaped, B) Cylindrical shaped, C) Bud-shaped
Figure 3 Shapes of internal acoustic canal in CT images

Statistical Analysis

Statistical analysis of the measurement results was conducted using the SPSS 21.0 program. Means, standard deviations (SD), minimum and maximum values were calculated from the measurements. In all statistical analyses, a p-value under 0.05 was considered statistically significant. Additionally, to assess the normal distribution of the data, ANOVA from parametric tests was employed to determine the significance between different age groups IAM parameters. Furthermore, Test was utilized to evaluate the differences between the right and left side parameters among male and females.

Parameter (mm)	Male (n-359)	Female (n-141)	P* value	t-test
IAM Length (Right)	9.19±1.185	9.44±1.179	0.034	-2.127
IAM Length (Left)	9.25±1.034	9.28±1.029	0.759	-0.307
IAM width (Right)	3.70±0.605	3.70±0.620	0.909	0.114
IAM width (Left)	3.77±0.570	3.80±0.516	0.369	-0.899
IAM Height (Right)	4.10±0.591	4.16±0.564	0.362	-0.913
IAM Height (Left)	4.06±0.523	4.06±0.595	0.974	0.033

*t test, SD; Standard Deviation, Min-Max; Minimum-Maximum. All values are given as Mean ± SD (Min.-Max.)

Parameter (mm)	Group I (n=100) (10-20yrs)	Group II (n=100) (20-30yrs)	Group III (n=100) (30-40yrs)	Group IV (n=100) (40-50yrs)	Group V (n=100) (50-60)	F Value	P* Value
IAM Length (Right)	9.57±1.207 (8-12)	9.20±1.181 (7-12)	9.27±1.448 (6-12)	9.05±1.306 (6-11)	9.21±0.844 (5-11)	2.627	.034
IAM Length (Left)	9.21±0.913 (8-13)	9.10±1.040 (7-12)	9.47±1.251 (7-12)	9.42±1.199 (7-11)	9.07±0.555 (8-11)	3.198	.013
IAM width (Right)	3.76±0.534 (3-5)	3.73±0.679 (2-5)	3.75±0.626 (2-5)	3.56±0.656 (2-5)	3.70±0.522 (3-5)	1.805	.127
IAM width (Left)	3.89±0.490 (3-5)	3.80±0.569 (3-5)	3.78±0.645 (3-5)	3.62±0.565 (3-5)	3.81±0.465 (3-5)	3.220	.130
IAM Height (Right)	4.16±0.564 (3-6)	4.16±0.598 (3-6)	4.14±0.620 (3-5)	3.90±0.611 (3-5)	4.23±0.468 (4-6)	4.846	.100
IAM Height (Left)	4.00±0.550 (3-5)	4.10±0.541 (3-5)	4.03±0.540 (3-5)	4.01±0.502 (3-5)	4.15±0.575 (3-5)	1.417	.227

*ANOVA test, SD; Standard Deviation, Min-Max; Minimum-Maximum; All values are given as Mean ± SD (Min.-Max.).

RESULTS

The study includes 359 males and 141 females. The overall means of the IAM measurements were: the internal acoustic meatus length 9.19mm (R) and 9.25mm (L); the internal acoustic meatus width 3.7mm (R) and 3.77 mm (L); the internal acoustic meatus height 4.1mm (R) and 4.06mm (L) in males, respectively. The same dimensions were found 9.4 mm (R) and 9.28mm (L); 3.7mm (R) and 3.8mm (L); 4.1mm (R) and 4.06mm (L) in females, respectively. There were found significant difference in internal acoustic meatus length measurements between females and males on right side (0.034). Other parameters show significant difference between male and female (P>0.05) (Table 1).

There were found significant difference in internal acoustic meatus height measurements between females and males (Table 1). Moreover, there were found significant difference between age groups in four parameters such as internal acoustic meatus length in different age groups. (p=0.34®; p=0.13(L)].

There was no significant difference in internal acoustic meatus width measurements [p=0.127 (R); p=0.130 (L)] and height [p=0.415 (R); p=0.475 (L)] in different age groups (Table 2).

The shapes of IAC observed in right side are funnel-shaped (79.2%), cylindrical (16.4%) and bud-shaped (4.4%) in this population. On left side funnel-shaped (79.6%), cylindrical (16.4%) and bud-shaped (4.0%).

DISCUSSION

The internal acoustic canal (IAC), also known as the internal auditory meatus or meatus acousticus internus, is a bony canal located in the petrous part of the temporal bone. It serves as a passageway for crucial neurovascular structures[1-3]. The internal acoustic canal serves as a conduit for essential structures, including the vestibulocochlear nerve (CN VIII), facial nerve (CN VII), labyrinthine artery, and vestibular ganglion. These structures play pivotal roles in hearing, facial expression, inner ear blood supply, and maintenance of balance[2,3].

Studying the size and structure of the internal acoustic meatus (IAM) is crucial for precise microsurgery in the cerebellopontine angle and for dealing with issues like acoustic neuroma. Knowing the normal values and IAM

anatomy is essential for addressing problems such as temporal bone trauma, congenital anomalies, and nerve-related conditions affecting the ears. This understanding plays a key role in guiding successful surgeries and improving the management of various ear and neurological disorders[6,6,7,8].

A narrow internal acoustic canal is linked to both unilateral and bilateral congenital sensorineural hearing loss, as well as cochlear nerve hypoplasia. On the other hand, a dilated internal acoustic meatus suggests expansion, often due to an acoustic neuroma or another occupying lesion. The stenosis of IAM is defined as a loss of 3mm or more in the vertical diameter of IAM or a meatus smaller than 2mm[5,7].

Sema Polat et al study on Turkish population with CT brain shows overall means of the measurements in the internal acoustic meatus length 9.71 mm (R) and 9.92 mm (L). In females, the internal acoustic meatus exhibited lengths of 9.71 mm (R) and 9.92 mm (L), widths of 3.97 mm (R) and 3.95 mm (L), and heights of 4.65 mm (R) and 4.66 mm (L). In males, corresponding measurements were 9.61 mm (R), 9.87 mm (L) for length, 4.18 mm (R), 4.15 mm (L) for width, and 5.13 ±0.85 mm (R), 5.13±0.90 mm (L) for height[8]. Another study by farahani RM et al on Iranian cadavers, the mean of the IAM height was found as 4.04 mm and mean width was 3.96mm[12].

Mamatha et al conducted a study involving 40 adult temporal dry Indian skulls and utilized a casting method. Their findings revealed that the mean height of the internal acoustic canal (IAC) was 3.52 mm on the right side (ranging between 2.5 mm and 4.9 mm) and 3.44 mm on the left side (ranging between 2.5 mm and 5.1 mm). The mean width was measured at 3.37 mm on the right side (ranging from 2.00 mm to 5.08 mm) and 3.47 mm on the left side (ranging from 2.2 mm to 4.8 mm) and superior length of the IAM were measured as 9.89 mm and 9.94 mm on right and left side, whereas inferior length of the IAM was 8.43 mm and 8.59 mm, in right and left side[6].

Prashaanthi and Krishnamoorthy studied with Indian cadavers means of height of the IAC were found as 3.8 mm and 3.6 mm in right and left side, respectively. Mean width of the IAC was measured as 6.4 mm and 6.9 mm in right and left side[4].

A study conducted in Brazil by Marques SR et `al shows the shapes of internal acoustic canal children and adults were funnel-shaped (74% and 58.3%, respectively), cylindrical (22% and 30.9%, respectively) and bud-shaped (4% and 10.8%, respectively)[9].

In 1972, a Greek study looked at 242 human temporal bones from people aged 16 to 93. They found differences in shape on both sides of the bones within the same person. In 1975, the same group checked again, this time categorizing the sample by age and gender. Surprisingly, they didn't find any big differences in shape. This suggests that the shape of temporal bones stays quite consistent, regardless of age or gender[10,11].

In comparison to our study, figures variations in sizes and variation in shape may be due to differences in race and sex.

CONCLUSION:

- These measurements should provide a normative reference of the internal acoustic meatus in south Indian population.
- Knowledge of the normal dimension and shapes of the internal acoustic meatus is more important for determination of the clinical and tumour processes.
- Narrow internal acoustic canal or meatus were related with both unilateral and bilateral congenital sensorineural hearing loss, and cochlear nerve hypoplasia.
- Dilated internal acoustic meatus indicates to expansion secondary to an acoustic neuroma or other occupying lesions.

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