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NORMAL VARIATION AND ASYMMETRY OF INTERNAL AUDITORY CANAL IN THE INDIAN POPULATION: A CT STUDY

Radio-Diagnosis

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ABSTRACT

Understanding internal auditory canal (IAC) variation is crucial for healthcare professionals. Malignant neoplasms in the head and neck frequently exhibit perineural spread (PNS), affecting structures like the IAC. While MRI is preferred for PNS diagnosis, CT is valuable for evaluating foramina morphology and distinguishing tumor from inflammatory conditions. Normal nerves can show asymmetric enhancement on MRI, potentially leading to misinterpretation. Variability in IAC size and morphology across demographics emphasizes the need to comprehend normal variations. This manuscript explores IAC morphology's impact on imaging and pathology, addressing the importance of recognizing asymmetries and variations for accurate diagnoses in head and neck neoplasms.

KEYWORDS

Internal Auditory Canal, Imaging, Anatomy, Tomography.

INTRODUCTION:

Understanding the variation and asymmetry of internal auditory canal (IAC) is crucial for radiologists, neurosurgeons, and pathologists (1). Skull base foramina exist in primitive cartilage, with nerves and vessels forming before chondrification, prompting cartilage and bone development around them. Malignant neoplasms in the head and neck region range from 4.4% to 17.6%, with known perineural spread (PNS) in cancers like squamous cell carcinoma and adenoid cystic carcinoma (2,3). PNS involves invasion in, around, and through nerves, distinct from microscopic perineural invasion, often visible as widened neural foramina on CT due to osteolysis (4-5). While MRI is preferred for PNS diagnosis, CT excels in foramina morphology assessment and distinguishing tumor from inflammatory pathologies (6-7). Normal nerves exhibit enhancement due to perineural vessels, causing occasional asymmetric enhancement potentially leading to misdiagnosis on MRI (8). Variability in IAC size and morphology across age, gender, and genetics underscores the need for understanding normal variations in specific demographics, such as the IAC for a certain age group and gender.

AIM AND OBJECTIVE:

1. The objective is to ascertain the typical size variations of the internal auditory canal (IAC) within specific age groups and genders.
2. The aim is to establish the typical differences in asymmetry within the internal auditory canal (IAC) across particular age groups and genders.

METHOD AND MATERIAL:

This non-interventional cross-sectional observational study, spanning a 12-month period and taking place at the Department of Radiology within a Tertiary care hospital, aims to investigate the normal variations in size and asymmetry of the IAC among specific age groups and genders. The study will involve a cohort of approximately 200 cases, a novel initiative for the Indian population, as no similar research has been documented in existing literature. The sample size determination was based on practical considerations, including the daily number of head and neck CT scans conducted in the Radiology department and the patients meeting the inclusion/exclusion criteria. Inclusion criteria encompass adult patients, regardless of sex, aged over 1 year, registered at the hospital, advised CT scans by their physicians, and free from prior head and neck surgeries or pathologies disrupting skull base anatomy. Exclusion criteria pertain to patients unwilling to participate, pregnant females, those under 1 year of age, individuals with pathology distorting skull base anatomy, and those with a history of head and neck surgeries. This comprehensive approach seeks to provide insights into normative IAC variations tailored to the Indian demographic.

Proper informed consent will be obtained from each patient after a detailed explanation of the examination's risks and benefits. Essential clinical history will be gathered during the CT scan procedure. Study-related data will be collected concurrently with the routine CT scans for the patient's medical or surgical condition, eliminating the need for additional visits or scans specifically for the study. All imaging studies will be conducted using the Philips 64-slice Brilliance Computed Tomography scanner.

The CT scan parameters for data acquisition will have a field of view of 250mm, a slice thickness of 2mm with a 1mm increment, Bone [D] filter, window width of 2000, window length of 700, and a matrix size of 512 x 512. An age-adjusted standard low-dose CT protocol (Kv-120; Mas/slice-400) will be employed, covering from the vertex to the base of the neck for plain scans. The image data will be electronically transmitted to a Philips Tera-reccon workstation for analysis.

Each scan will be evaluated to determine the size of the specified foramina in each hemicranium. The cross-sectional area of each foramen will be calculated using the formula $A = \pi \times (L/2) \times (S/2)$, where L represents the long-axis diameter and S represents the short-axis diameter of the respective foramen. This calculation can be simplified further as $A = L \times S \times 0.785$ for ease of analysis and interpretation.

The foramina were measured across various sections along different axes, tailored to the orientation of each specific foramen. The long axis diameter was determined as the longest line connecting diagonally opposite points, while the short axis diameter was identified as a line perpendicular to the long axis.

The internal auditory canal exhibits a medial, cranial, and posterior orientation (Figure 1). Notably, the obliquity of the canal is more pronounced in younger age groups. As a result, utilizing Multi-Planar Reconstruction (MPR) becomes crucial during measurements to avoid inaccurately elevated values. Measurements were conducted in the mid-portion of the internal auditory canal, as the proximal segment typically displays irregularities and widens into the cranium.

Fig. 1: HRCT Temporal bone. A. sagittal, B. axial and C. coronal sections, showing the orientation of the internal auditory canal.

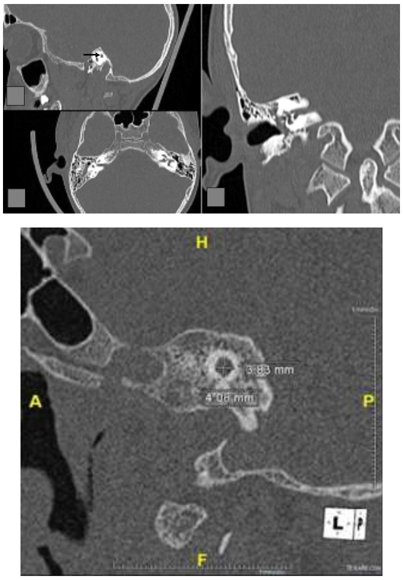

Fig. 2: HRCT Temporal bone, sagittal section, showing the method of measuring the diameters of internal auditory canal.

Similar to the internal auditory canal, the hypoglossal canal is positioned obliquely in the anterior, lateral, and superior directions within the three standard planes. Utilizing Multi-Planar Reconstruction (MPR) formatting becomes essential for obtaining precise measurements in this spatial orientation.

STATISTICAL METHODS:
All the data will be recorded in a case record form and analysed using descriptive statistics.

1. INTERNAL AUDITORY CANAL

TABLE 1:STATISTICAL ANALYSIS OF CROSS-SECTIONAL AREA OF INTERNAL AUDITORY CANAL IN DIFFERENT AGE GROUPS

MEAN		S.D.	MEDIAN	RANGE
1-18 years	13.27	5.36	12.05	5.28-26.12
18-40 years	13.36	4.47	12.41	7.42-23.03
40-60 years	12.98	3.57	12.54	6.82-21.76
> 60 years	11.53	2.72	11.33	7.21-19.58

The data was following non-parametric distribution. Hence, it was analysed using Kruskal Wallis test and the level of significance of the difference of values between different age groups were obtained, which are as follows:

AGE GROUPS	P-VALUE	COMMENT
1-18 years vs 18-40 years	P > 0.05	Not significant
1-18 years vs 40-60 years	P > 0.05	Not significant
1-18 years vs > 60 years	P > 0.05	Not significant
18-40 years vs 40-60 years	P > 0.05	Not significant
18-40 years vs > 60 years	P > 0.05	Not significant
40-60 years vs > 60 years	P > 0.05	Not significant

TABLE 2: STATISTICAL ANALYSIS OF CROSS-SECTIONAL AREA OF INTERNAL AUDITORY CANAL IN MALES AND FEMALES

MEAN		S.D.	MEDIAN	RANGE
MALES	13.47	4.51	12.57	7.12-23.08
FEMALES	11.72	3.29	10.97	5.29-18.72

The data was following non-parametric distribution. Hence, it was analyzed using Mann Whitney test. The P-value thus obtained was 0.0008 suggesting that the difference of values between males and females are extremely significant.

TABLE 3: STATISTICAL ANALYSIS OF THE DIFFERENCE IN THE CROSS-SECTIONAL AREA OF INTERNAL AUDITORY CANAL ON THE TWO SIDES IN DIFFERENT AGE GROUPS

MEAN		S.D.	MEDIAN	RANGE
1-18 years	2.13	2.66	1.35	0-4.98
18-40 years	1.81	1.93	1.28	0-4.49
40-60 years	1.88	1.81	1.23	0-5.6
> 60 years	1.52	1.41	1.01	0-4.07

AGE GROUPS	P-VALUE	COMMENT
1-18 years vs 18-40 years	P > 0.05	Not significant
1-18 years vs 40-60 years	P > 0.05	Not significant
1-18 years vs > 60 years	P > 0.05	Not significant
18-40 years vs 40-60 years	P > 0.05	Not significant
18-40 years vs > 60 years	P > 0.05	Not significant
40-60 years vs > 60 years	P > 0.05	Not significant

The data was following non-parametric distribution. Hence, it was analysed using Kruskal Wallis test and the level of significance of the difference of values between different age groups were obtained, which are as follows:

TABLE 4: STATISTICAL ANALYSIS OF THE DIFFERENCE IN THE CROSS-SECTIONAL AREA OF INTERNAL AUDITORY CANAL ON THE TWO SIDES IN MALES AND FEMALES

MEAN		S.D.	MEDIAN	RANGE
MALES	1.93	2.15	1.24	0-5.6
FEMALES	1.63	1.48	1.29	0-4.46

The data was following non-parametric distribution. Hence, it was analyzed using Mann Whitney test. The P-value thus obtained was 0.6131 suggesting that the difference of values between males and females are not significant.

DISCUSSION:

ANATOMY:
The internal auditory canal (IAC) presents as a conical structure, with its medial end wider than the lateral end. Within the canal reside the seventh and eighth cranial nerves, nervus intermedius, and the internal auditory artery. The porus acusticus, the medial opening, is situated close to the centre of the posterior side of the petrous bone, while the lateral end, known as the fundus, is adjacent to the labyrinth. At the lateral end, a vertical bony plate separates the fundus from the vestibule, featuring perforations for nerve fibres to pass through.

The fundus is partitioned by the crista falciformis, a horizontally positioned bar, into a smaller upper compartment and a larger lower compartment. Within the upper compartment, a vertical crest further divides it into an anterior section that accommodates the facial nerve and a posterior section facilitating the passage of the superior vestibular nerve. The superior vestibular nerve supplies fibres to the superior and lateral semi-circular canals and the utricle. The lower compartment harbors the cochlear nerve anteriorly and the inferior vestibular nerve posteriorly, with the latter providing innervation to the saccule and the posterior vestibular nerve. The nerve supplying the posterior semi-circular canal then travels through a distinct channel known as the singulate canal. The normal diameter described in literature, varies from 4-8mm and if it is below 2mm, the canal is considered stenotic (9).

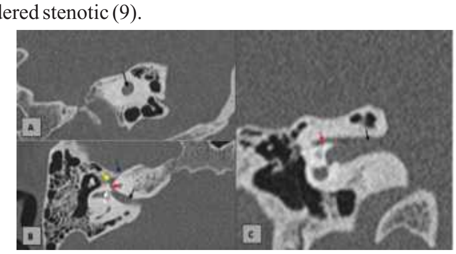

Fig. 3: HRCT temporal, bone algorithm; A. sagittal; B. axial at the level of upper compartment of IAC and C. coronal sections, showing IAC (black arrow), canal for labyrinthine segment of facial nerve (red arrow) and superior vestibular nerve (white arrow). The greater superficial petrosal nerve is seen arising from the geniculate ganglion

(yellow arrow) and exiting the petrous temporal bone via the facial hiatus (blue arrow).

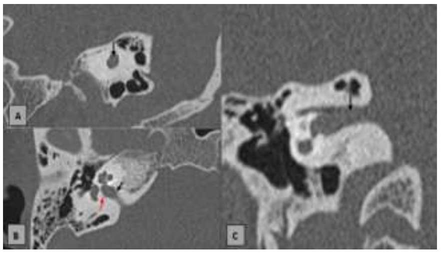

Fig. 4: HRCT temporal bone, bone algorithm; **A.** sagittal; **B.** axial at the level of lower compartment of IAC and **C.** coronal sections, showing IAC (black arrow), canal for cochlear nerve (white arrow) and singulate canal (red arrow).Variability in both morphology and morphometry of neural foramina is a common observation within the normal population, differing not only from their contralateral counterparts but also among individuals. This study aimed to investigate this phenomenon further. In clinical practice, the analysis of skull base foramina plays a crucial role in identifying abnormalities in size, particularly for diagnosing perineural spread and other pathologies highlighted in the literature review. While MRI is typically the preferred diagnostic imaging modality for perineural spread, certain clinical scenarios may preclude its use, as previously discussed. In such instances, CT scans become vital for detecting perineural spread, with the most commonly used sign being the widening of neural foramina. However, the absence of established normal values for neural foramina size in the literature leads to subjective assessments of abnormal widening, contributing to significant interobserver variability and potential misinterpretations.

By establishing normal values for the internal auditory canal (IAC) area and assessing the asymmetry between both sides, the aim is to introduce objective criteria that can enhance the confidence in identifying IAC widening as a sign of perineural spread. This study revealed that the length and area measurements of the foramina are reliably achievable using high-quality CT scanners. Notably, a statistically significant difference in the area of the IAC was observed between the two sides, particularly notable in the left IAC. There were differences in the area of a foramen amongst different age groups. The age group of 1-18 years was showing statistically significant difference with other age groups, the maximum number of times. The IAC did not show statistically significant difference when compared amongst different age groups. Similarly, we compared the area and difference in the area on the two sides between male and female participants. The result was statistically significant for area of IAC.

There are many studies done on skull base foramina. However, very few have analysed the foramen based on its area. Majority of the study have used maximum diameter alone or in combination with the minimum diameter to analyse the foramina. We believe that analysis based on area, rather than diameter is better indicator as the disease process affects the foramina circumferentially, thus the sensitivity of the area showing presence of disease should be more than the individual diameters. The mean area for the internal auditory canal found by Barrera-Flores et al was 17.65 ± 4.27 mm^2, while the same found in our study was 12.80 ± 4.08 mm^2 for the right side and 13.28 ± 4.5 mm^2 for the left side. The discrepancy in the value obtained in the study could be because of the site of measurement. Also, the involvement of paediatric age group in our study, which was not included in the conducted by the Barrera-Flores et al, could be atleast partly responsible for the lower value in our study.

Berlis et al studied skull base foramina and canals in 60 European skull using direct measurement, followed by measurement using CT scan(1). They found the mean for the height of IAC as 3.95 ± 0.75 mm on CT scan and 3.70 ± 0.71 mm on direct measurement. Similarly, for the breadth of the canal, they found a mean of 3.87± 0.80 mm on CT scan and 4.11 ± 0.69 mm on direct measurement. Marques et al studied the internal auditory canal in 110 CT scans in Brazilian population (93). They found a mean anteroposterior diameter of IAC in children as 4.82 ± 0.13 mm and in adult as 4.47 ± 0.10 mm. Vadagaonkar et al analysed internal acoustic meatus in 27 disarticulated temporal bones and 35 dry skulls (10). They found average width of the internal acoustic meatus as 4.52 mm. The mean of the long axis and short axis diameter for IAC found in our study was 4.31 ± 0.69 mm and 3.77 ± 0.67 mm, respectively, which is similar to the results of the studies mentioned above.

CONCLUSION

The study highlighted significant variations in foramen sizes among different age groups, with the 1-18 age group showing notable differences. While the Internal Acoustic Canal (IAC) did not exhibit significant variability across age groups, gender-based differences in foramen sizes were observed. The research emphasized the importance of analyzing foramina based on area rather than diameter to detect disease presence more sensitively. Reference to various studies underscored the diversity of measurement outcomes across populations. Overall, the findings suggest that area-based analysis of foramina provides valuable insights into anatomical variations and pathological implications, contributing to a comprehensive understanding of cranial structures.

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