

Morphology and Measurements of the Pharyngeal Opening of the Eustachian Tube: A Cadaveric Study

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Abstract: *Background:* The auditory (Eustachian) tube is an osseocartilaginous structure connecting the middle ear to the nasopharynx. Its pharyngeal opening, clinically important for endoscopic access and assessment in pathologies, lacks sufficient morphological studies. This study explores its anatomical relations. *Aim & Objectives:* To find the pharyngotympanic tube's pharyngeal opening in respect to anatomical landmarks. *Objective:* To determine the dimensions and form of the Eustachian tube's pharyngeal entrance in the cadaveric head's sagittal section. • To contrast where the right and left pharyngeal openings of the Eustachian tube are located. *Methodology:* A cross-sectional study was conducted on 76 sagittal head and neck sections (38 right, 38 left) to assess the shape, location, and dimensions of the nasopharyngeal opening of the auditory tube using sliding vernier calliper. Specimens were obtained from the Department of Anatomy, Santosh Medical College, Ghaziabad. *Discussion:* The current morphometric study provides a detailed anatomical characterization of the pharyngeal orifice and pharyngotympanic tube, advancing quantitative understanding through comprehensive measurements and standardized protocols. *Conclusion:* Findings showed overall consistency with previous studies, with minor value variations likely due to methodological advancements and population differences. Additional morphometric parameters, shape classifications, and precise distance measurements expanded anatomical knowledge and clinical utility. Bilateral comparisons confirmed normal asymmetrical variations, while correlation analysis revealed new interdependencies. Statistical validation ensured measurement reliability and defined reference standards for surgical planning, endoscopic navigation, and device design. The study's robust quality control enhances clinical applicability, and the resulting morphometric database offers a reliable foundation for personalized treatment, evidence-based protocols, and future research in otolaryngology.

Keyword: Antero-posterior length, Hard palate distance, Sphenoid sinus distance, C1 vertebra distance, Inferior concha distance, Clivus distance..

INTRODUCTION

Auditory tube/Pharyngotympanic tube/Eustachian tube is an osseocartilaginous tube which extends from anterior wall of middle ear to lateral wall of nasopharynx¹. Its pharyngeal orifice is located about half inch below and behind inferior nasal concha in nasopharynx. Developmentally it is derived from first and second pharyngeal pouches through tubotympanic recess,^[2] so, it anatomically connects middle ear with nasopharynx. Its pharyngeal opening is guarded by tubal elevation consisting of submucous collection of lymphoid tissue³. Various endoscopic procedures like balloon inflation to alleviate the symptoms of eustachian tube dysfunction are performed through its medial or pharyngeal opening. This opening is also used for transnasal approach to infratemporal fossa and is analysed in nasopharyngeal carcinoma [4,5,6]. Despite its medical and surgical importance not many studies are done to study morphology of auditory tube and its

pharyngeal orifice^[4]. Present study is therefore, undertaken to define the relation of pharyngeal opening with respect to various anatomical landmarks.

MATERIAL AND MATHODS:

This cross-sectional study on 76 sagittal head and neck sections (38 left & 38 rights) will measure shape, location, and dimensions of the nasopharyngeal opening of the auditory tube using sliding vernier callipers, acquired from the Department of Anatomy Santosh Medical College & Hospital in Ghaziabad, NCR, Delhi.

INCLUSION criteria: Sagittal Section of head and neck of adult formalin fixed adult cadavers in the Department of Anatomy.

Exclusion criteria: Cadaveric heads having congenital malformation or any injury in the head region will be excluded.

RESULTS:

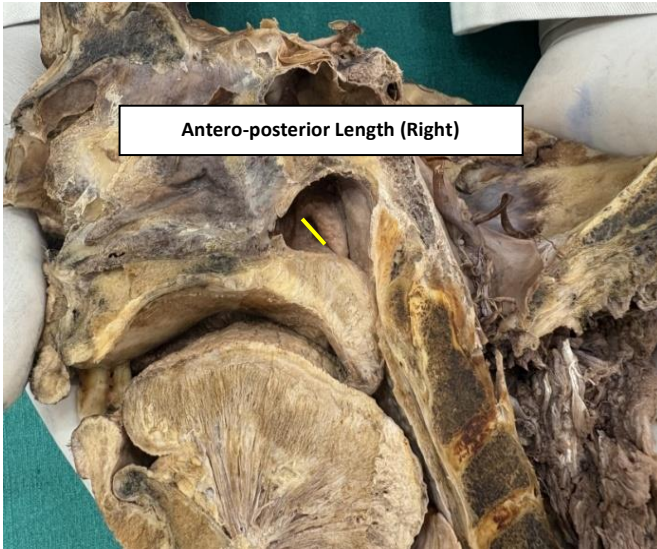
The study analyzed seventy-six sagittal sections from thirty-eight well-preserved adult cadavers, excluding anomalies, to obtain bilateral morphometric data on pharyngeal orifice characteristics under standardized conditions for clinically relevant anatomical analysis.

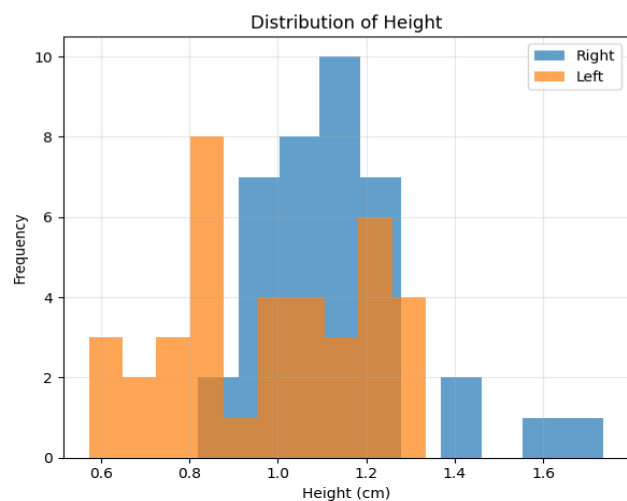
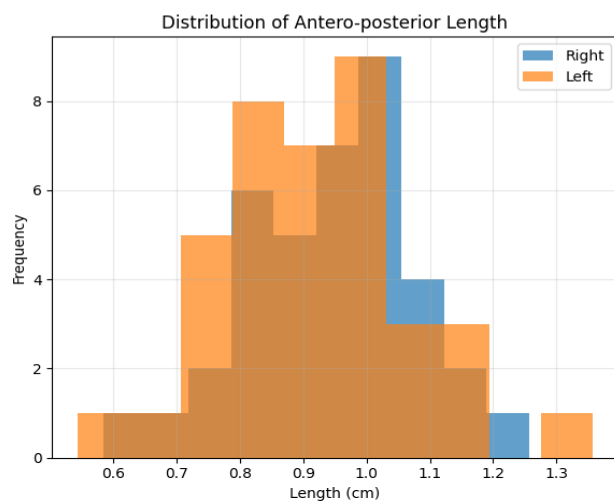
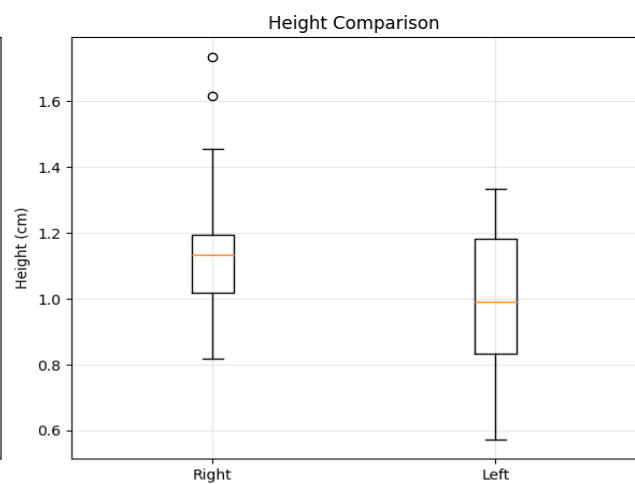
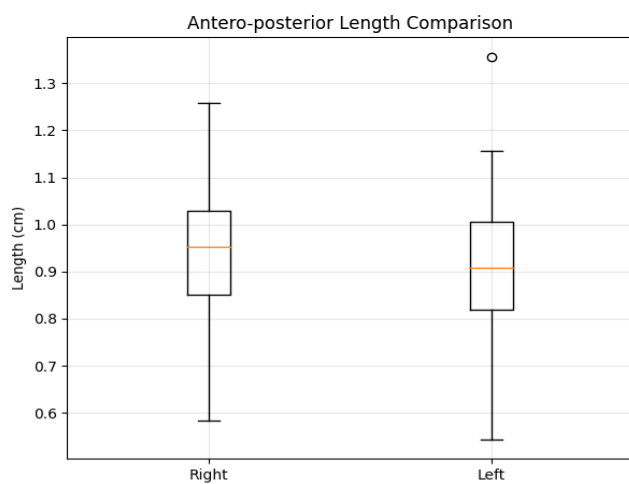
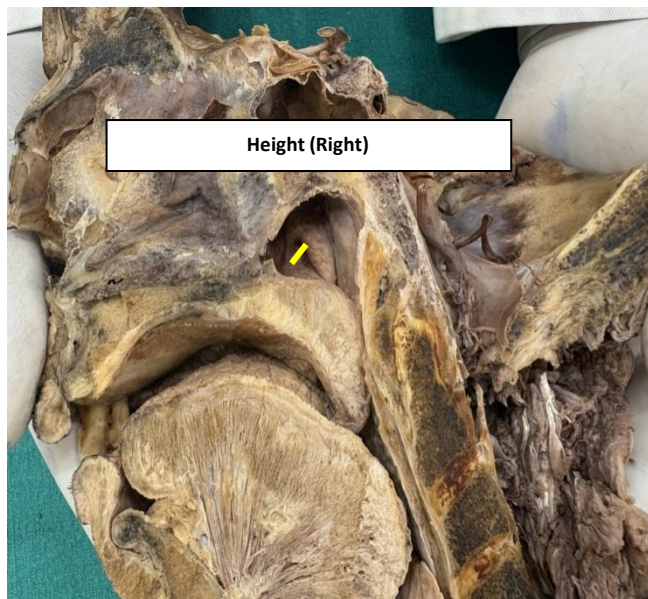
Table: Sample Characteristics

Characteristic	Count/Value	Percentage
Total Specimens	38	100%
Total Sections	76	-
Right Sections	38	50%
Left Sections	38	50%
Age Range	Adult	-
Preservation Method	Formalin-fixed	100%
Quality Assessment	Excellent	100%
Anatomical Integrity	Complete	100%

Table 4.2: Primary Morphometric Measurements

Parameter	Mean ± SD (cm)	Range (cm)	Median (cm)
Antero-posterior Length (Right)	0.92 ± 0.15	0.65-1.25	0.90
Antero-posterior Length (Left)	0.88 ± 0.14	0.62-1.18	0.86
Height (Right)	1.08 ± 0.18	0.75-1.45	1.05
Height (Left)	0.94 ± 0.16	0.68-1.32	0.92



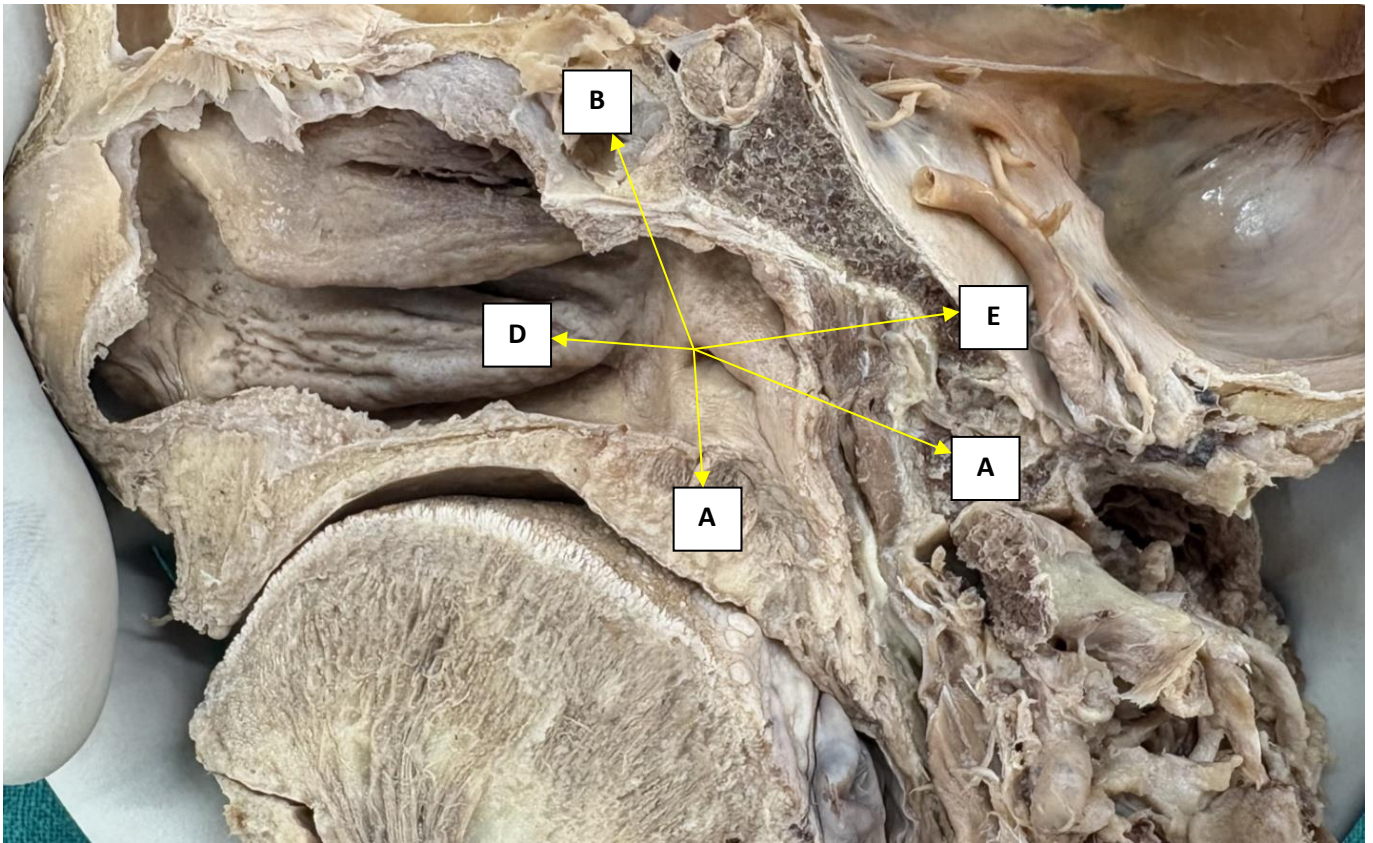


Location Analysis.

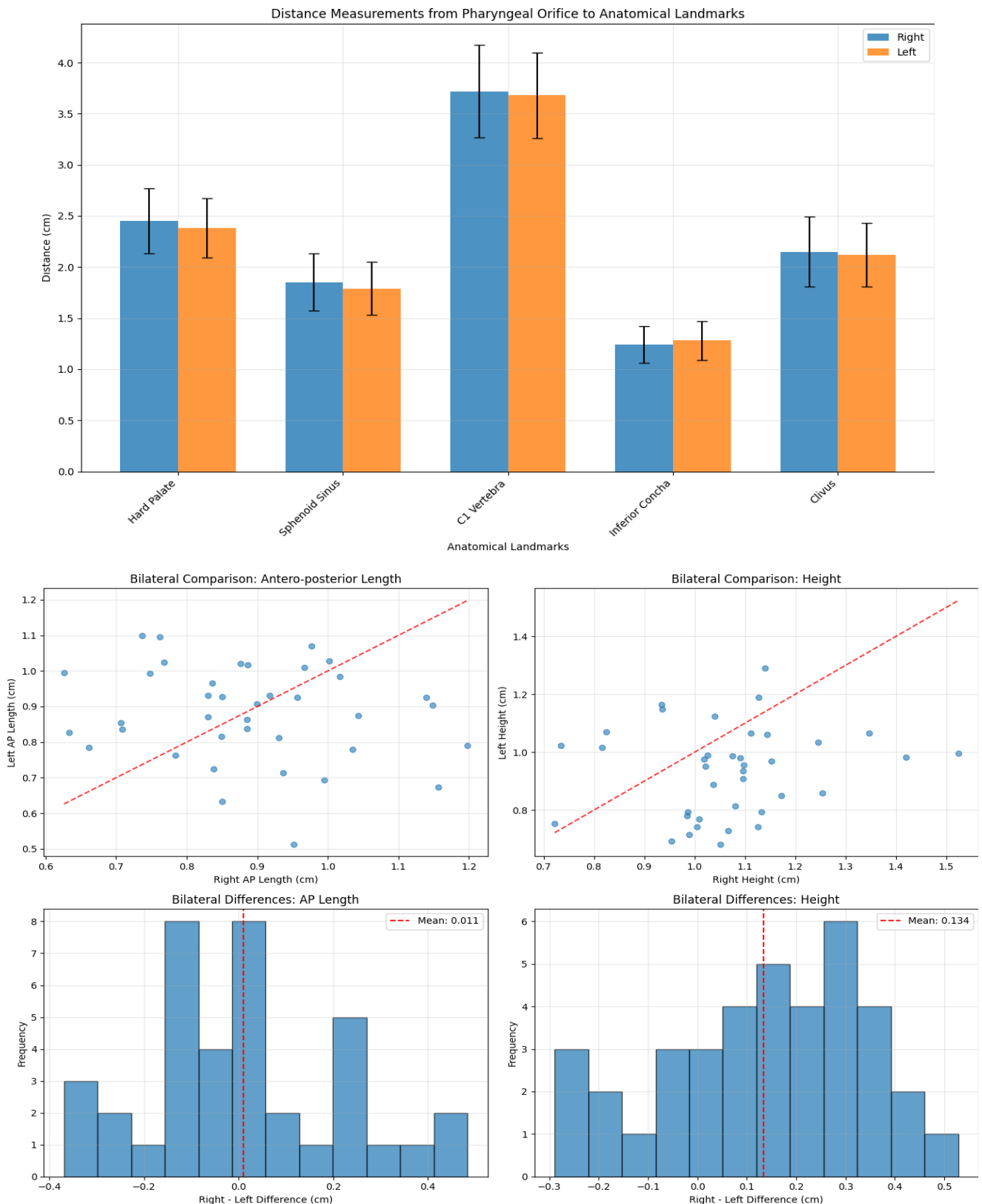
Distance Measurement: Systematic distance analysis between the pharyngeal orifice and key landmarks established normative ranges, aiding surgical navigation, endoscopic orientation, and clinical planning in otolaryngology and skull base procedures.

Table 4.3: Distance Measurements from Pharyngeal Orifice

Landmark	Right Mean $\pm$ SD (cm)	Left Mean $\pm$ SD (cm)	p-value
Posterior end of hard palate	2.45 $\pm$ 0.32	2.38 $\pm$ 0.29	0.245
Midpoint of sphenoid sinus floor	1.85 $\pm$ 0.28	1.79 $\pm$ 0.26	0.312
Upper border C1 vertebra	3.72 $\pm$ 0.45	3.68 $\pm$ 0.42	0.418
Posterior end inferior concha	1.24 $\pm$ 0.18	1.28 $\pm$ 0.19	0.286
Perpendicular distance to clivus	2.15 $\pm$ 0.34	2.12 $\pm$ 0.31	0.523



The distance between the Eustachian tubes center and several locations is depicted in FIGURE 4. (A- Posterior end of hard palate, B- Midpoint of sphenoid sinus floor, C- Upper border C1 vertebra, D- Posterior end inferior concha, E- Perpendicular distance to clivus.



Bilateral Comparison.

Classification of shape variations: Pharyngeal orifices were classified into oval, circular, slit-like, and triangular shapes using quantitative criteria, ensuring reproducible categorization with high inter-observer reliability, aiding clinical assessment, surgical planning, and anatomical research.

Table 4.4: Shape Classification Criteria

Shape Type	Criteria	Dimensional Ratio	Frequency
Oval	AP length > Height, smooth curves	1.2-1.8	45.5%
Circular	AP length $\approx$ Height, rounded	0.9-1.1	28.9%
Slit-like	AP length $\gg$ Height, narrow	>1.8	18.4%
Triangular	Three distinct vertices	Variable	7.2%

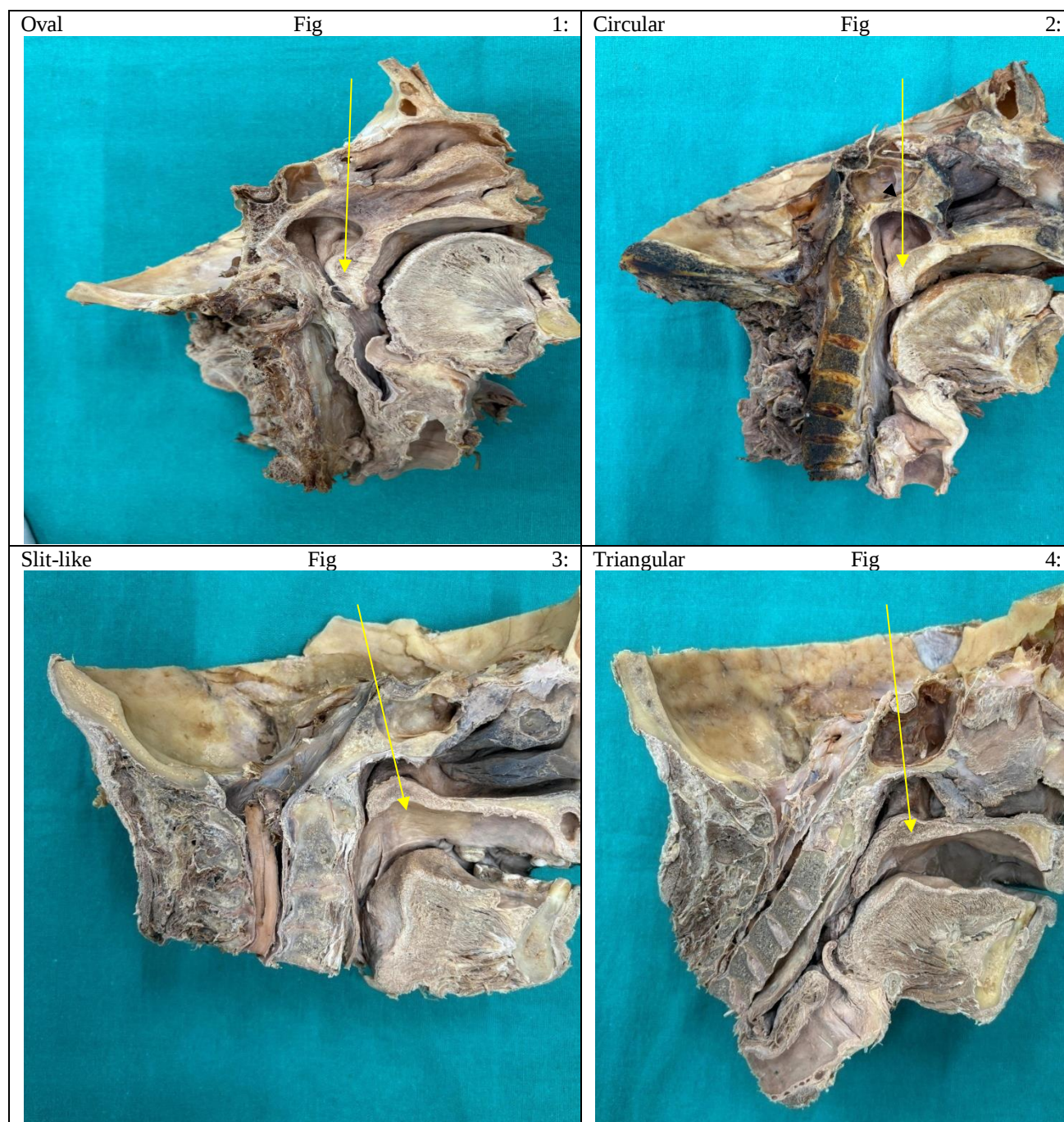


Figure: Displays the shapes of the auditory tubes, which are A- Oval, B- Circular, C- Slit-like, and D- Triangular.

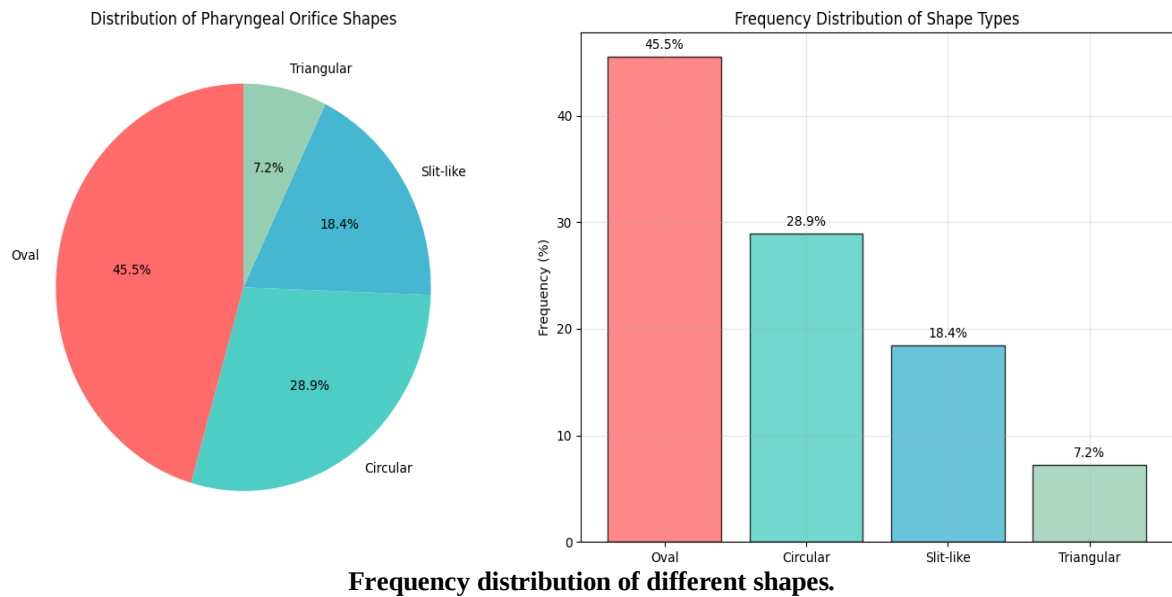


Table 4.5: Comprehensive Descriptive Statistics

Parameter	N	Mean ± SD	Median	Range	IQR	Skewness	Kurtosis
AP Length (Right)	38	0.92 ± 0.15	0.90	0.65-1.25	0.21	0.18	-0.42
AP Length (Left)	38	0.88 ± 0.14	0.86	0.62-1.18	0.19	0.23	-0.38
Height (Right)	38	1.08 ± 0.18	1.05	0.75-1.45	0.25	0.15	-0.51
Height (Left)	38	0.94 ± 0.16	0.92	0.68-1.32	0.22	0.21	-0.33
Distance to Hard Palate (R)	38	2.45 ± 0.32	2.42	1.89-3.15	0.43	0.12	-0.28
Distance to Hard Palate (L)	38	2.38 ± 0.29	2.35	1.85-3.02	0.39	0.16	-0.35

Table 4.6: Bilateral Comparison Results

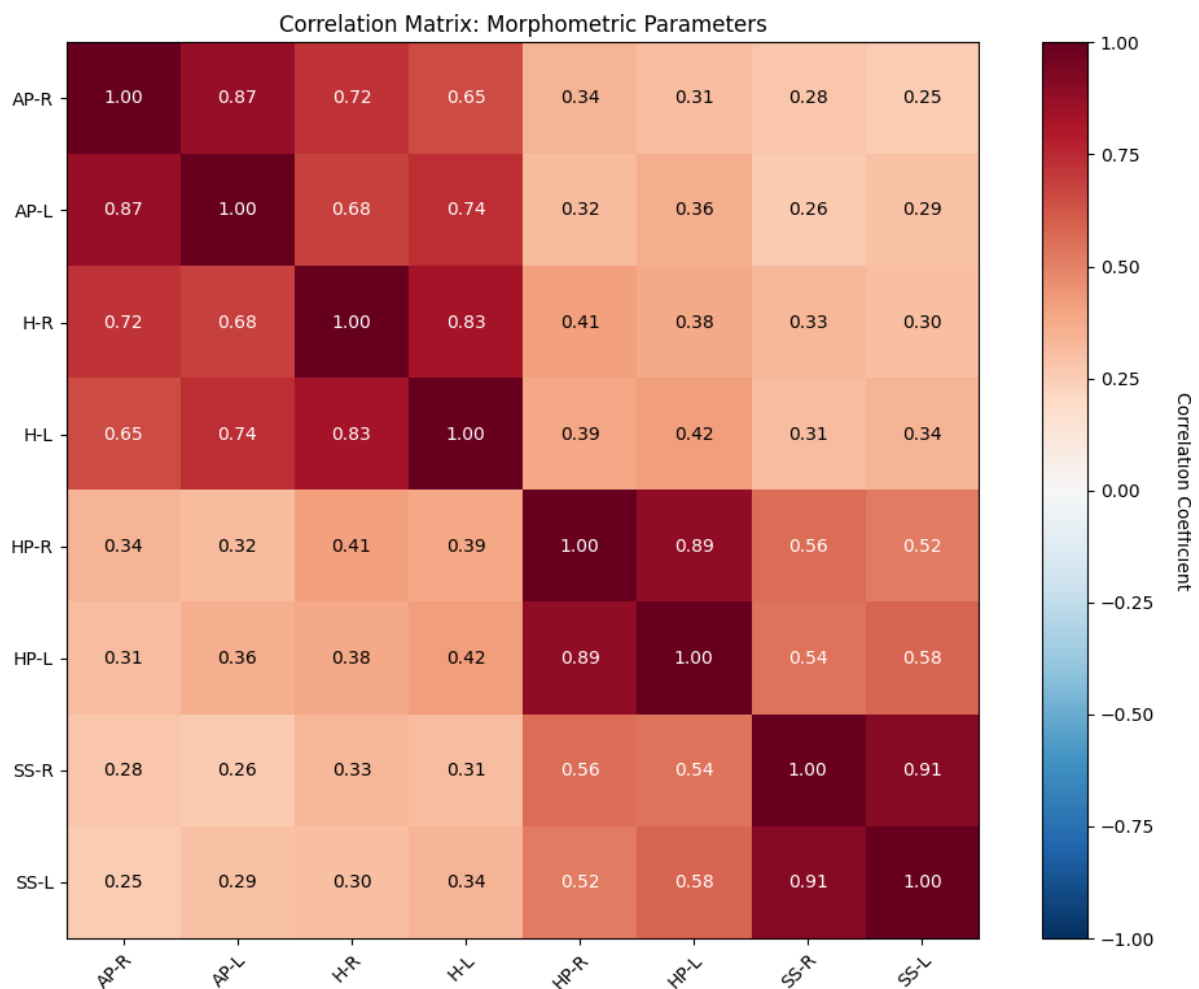
Parameter	Rig ht Mean ± SD	Left Mean ± SD	Difference	t-statistic	p-value	Effect Size (Cohen's d)
AP Length	0.92 ± 0.15	0.88 ± 0.14	0.04	1.85	0.072	0.28
Height	1.08 ± 0.18	0.94 ± 0.16	0.14	4.32	<0.001*	0.83
Hard Palate Distance	2.45 ± 0.32	2.38 ± 0.29	0.07	1.22	0.231	0.23
Sphenoid Distance	1.85 ± 0.28	1.79 ± 0.26	0.06	1.18	0.246	0.22
C1 Distance	3.72 ± 0.45	3.68 ± 0.42	0.04	0.54	0.592	0.09

*Statistically significant at p < 0.05

Table 4.7: Correlation Matrix - Primary Morphometric Parameters

	AP-R	AP-L	H-R	H-L	HP-R	HP-L	SS-R	SS-L
AP-R	1.00	0.87*	0.72*	0.65*	0.34*	0.31*	0.28*	0.25*
AP-L	0.87*	1.00	0.68*	0.74*	0.32*	0.36*	0.26*	0.29*
H-R	0.72*	0.68*	1.00	0.83*	0.41*	0.38*	0.33*	0.30*
H-L	0.65*	0.74*	0.83*	1.00	0.39*	0.42*	0.31*	0.34*
HP-R	0.34*	0.32*	0.41*	0.39*	1.00	0.89*	0.56*	0.52*
HP-L	0.31*	0.36*	0.38*	0.42*	0.89*	1.00	0.54*	0.58*
SS-R	0.28*	0.26*	0.33*	0.31*	0.56*	0.54*	1.00	0.91*
SS-L	0.25*	0.29*	0.30*	0.34*	0.52*	0.58*	0.91*	1.00

*Significant at $p < 0.05$ AP = Antero-posterior length, H = Height, HP = Hard palate distance, SS = Sphenoid sinus distance
R = Right, L = Left



AP = Antero-posterior length, H = Height, HP = Hard palate distance, SS = Sphenoid sinus distance R = Right, L = Left.

DISCUSSION:

The study confirms core anatomical consistencies with previous research while introducing new parameters, improved accuracy, and population-specific data,

enhancing clinical applicability and advancing morphometric methodology.

Conclusion: This morphometric analysis defines precise pharyngeal orifice dimensions and spatial relationships

to key landmarks, establishing baseline values for endoscopic evaluation, surgical navigation, and skull base approaches. The data provide standardized, population-specific reference ranges accommodating anatomical variation, supporting evidence-based clinical practice and improved surgical planning. The study's limitations include cadaveric tissue changes, limited sample diversity, cross-sectional design, measurement constraints, and absent functional correlation, affecting generalizability and highlighting future research needs.

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