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Original Article

Anatomy Section

Osteological Analysis of Hard Palate in North Indian Skulls and its Forensic Significance: A Cross-sectional Study

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ABSTRACT

Introduction: Various therapeutic procedures, such as cleft palate surgery, uvulopalatopharyngoplasty, nasopharyngoscopy, and nasogastric intubation, rely on the morphometric measurements of the hard palate. Additionally, it plays a crucial role in passive speech articulation. Therefore, understanding the morphological and osteological diversity of the hard palate holds clinical significance.

Aim: To assess the normal and aberrant morphology and morphometry of the hard palate.

Materials and Methods: The present cross-sectional study was initiated in December 2017 and completed in December 2021. It was conducted on 100 dry adult human skulls collected from the Department of Anatomy, Government Medical College, Amritsar, Punjab, India. The palate was analysed to determine the mean palatal length, breadth, and height. Additionally, the palatal index and palatal height index were calculated. Different osteological parameters of the lesser palatine foramen, including its number, distance from the greater palatine foramen, palatomaxillary suture, and interpalatine suture, were measured. Mean, standard deviation, range, and p-value were calculated for the metric parameters.

Results: The mean palatal length, breadth, and height were 46.16±4.18 mm, 33.01±2.67 mm, and 11.06±1.88 mm, respectively. In the present study, 83% of skulls belonged to the leptostaphyline type, 10% to the mesostaphyline type, and 7% to the brachystaphyline type. The number of lesser palatine foramen varied from 0-2 on both sides, with predominance of a single foramen on both sides. The distances of the lesser palatine foramen from the greater palatine foramen, palatomaxillary suture, and intermaxillary suture were found to be 3.55±1.56 mm, 11.45±2.42 mm, and 17.57±3.06 mm on the right side, and 3.38±1.57 mm, 10.90±2.39 mm, and 17.47±2.99 mm on the left side, respectively.

Conclusion: The data provided by this study will be helpful in various disciplines of medical, dental, and anthropometrical sciences.

Keywords: Brachystaphyline, Leptostaphyline, Mesostaphyline, Sexual dimorphism

INTRODUCTION

The hard palate is a vital component of the skull, formed by the premaxilla, palatine processes of the maxilla, and horizontal plates of the palatine bone. It separates the nasal cavity above from the oral cavity [1] and has an arched shape with varying depth and breadth, being widest in the molar region. The posterior part of the hard palate contains the greater and lesser palatine foramina, with lesser ones located behind the greater palatine foramen [2].

The role of palatal morphology and morphometry in forensic dentistry is widely acknowledged. Due to its location within the oral cavity, the hard palate is resistant to damage during trauma, making it a reliable structures for identifying individuals in cases involving damaged or decomposed skulls [3]. Skull morphometry is also significant in anthropological and forensic investigations to determine the age, stature, and ethnicity [3,4].

Understanding the normal anatomical features of the hard palate is essential for procedures like nasogastric intubation, nasal pharyngoscopy, and related tools [5]. Palatal morphometry is crucial for the treatment planning in orthodontic conditions, orthognathic surgeries, maxillary dental implants, and various other procedures, including cleft palate surgery [6]. Precise metric parameters of the hard palate are also valuable in denture fabrication and prosthetic restoration for speech and normal functioning [7-9].

While previous studies have explored the hard palate, a comprehensive investigation of the lesser palatine foramina and their relationship to nearby landmarks is lacking [10-13]. This study aims to provide morphometric dimensions of the hard palate, palatal indices, and examine the relationship of the lesser palatine foramen with adjacent structures. The data obtained from this research can serve as a baseline for future studies in anatomical sciences, dental sciences, forensic sciences, and anthropometric studies.

MATERIALS AND METHODS

A cross-sectional study was conducted over a period of four years, from December 2017 to December 2021, using 100 skulls obtained from the Department of Anatomy at Government Medical College Amritsar, Punjab, India. Ethical approval was obtained from the institutional ethics committee through letter number 5769 dated 23/06/17.

Inclusion criteria: Adult skulls that were non-pathological and complete in all aspects were included.

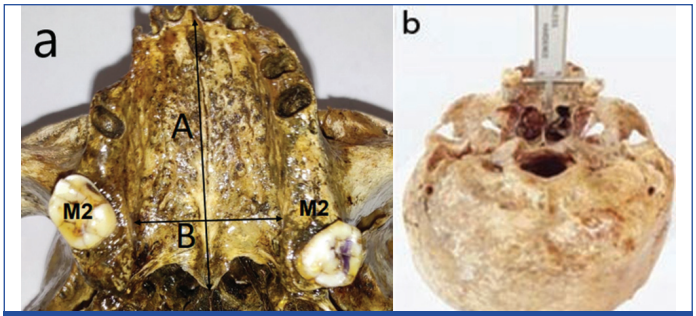
Exclusion criteria: While damaged or pathologically deformed skulls were excluded.

Procedure

Measurements were taken using a digital Vernier caliper with an accuracy of 0.01 mm. The following parameters of the hard palate were measured:

- Length: Distance between the orale anteriorly and the posterior nasal spine posteriorly (labeled as A in [Table/Fig-1a]).
- Breadth: Distance of the inner borders of the sockets of the upper 2nd molars (labeled as B in [Table/Fig-1a]).
- Height: Height of the palate from the line connecting the endomolaria (shown in [Table/Fig-1b]).
- Contribution of premaxilla: Distance between the orale and the posterior margin of the incisive fossa.
- Contribution of palatine processes: Posterior margin of the incisive fossa and posterior nasal spine.
- Palatine index: Calculated using the formula: Breadth/Length×100.
- Palatine height index: Calculated using the formula: Palatal height/Breadth×100.

The hard palates were classified into three categories based on their width: leptostaphyline (narrow), mesostaphyline (moderate),



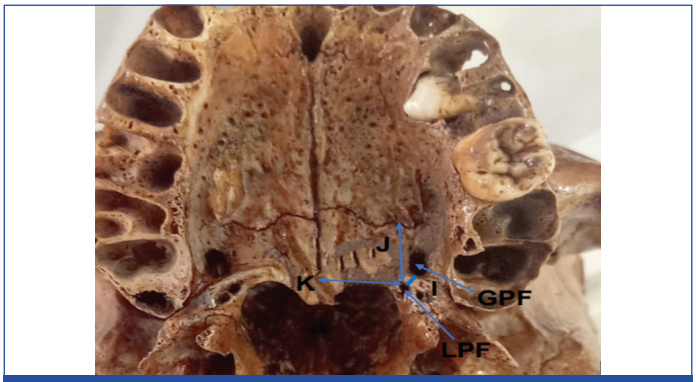
[Table/Fig-1]: a) Measurements of the hard palate: A-Palatal length, B-Palatal breadth; b) Measurement of palatal height.

and brachystaphyline (broad). The palatal height index was also calculated, and the hard palates were classified.

- Into chemostaphyline (low),
- orthostaphyline (intermediate),
- and hypsistaphyline (high/deep) types.

The study also included the evaluation of non-metric and metric parameters of the Lesser Palatine Foramina (LPF). The number of LPF was observed and noted. Additionally, the following metric parameters were measured:

- Distance of LPF from the Greater Palatine Foramen (GPF) (distance between the anterior end of LPF and the posterior end of GPF, labeled as I in [Table/Fig-2].
- Distance of LPF from the palatomaxillary suture (distance between the medial margin of LPF and the point where the palatomaxillary and intermaxillary sutures meet, labeled as J in [Table/Fig-2].
- Distance of LPF from the interpalatine distance (shortest distance between the medial margin of the lesser palatine foramen and the interpalatine suture, labeled as K in [Table/Fig-2].



[Table/Fig-2]: Measurements of the lesser palatine foramen: I) Distance between LPF and the posterior end of GPF, J) Shortest distance between the Lesser Palatine Foramen and palatomaxillary suture, K) Shortest distance between the Lesser Palatine Foramen and interpalatine suture.

The collected data and measurements will contribute to the understanding of the morphometry and relationships of the hard palate and lesser palatine foramina. This information can be utilised in anatomical sciences, dental sciences, forensic sciences, and anthropometric studies.

STATISTICAL ANALYSIS

The collected data was analysed using Statistical Package for Social Sciences (SPSS) software version 18.0 and excel 2010. Mean, standard deviation, and range were calculated for the metric parameters. A comparison between the right and left sides was made using the student's t-test. A p-value less than 0.05 was considered significant.

RESULTS

Total number of 100 skulls were considered. The mean length, breadth, and height of the hard palate, as well as the contributions from the premaxilla and palatine process, were measured and are presented in [Table/Fig-3]. The mean value of the palatine index was 71.96±7.73%. The majority of the palates (83%) were classified as leptostaphyline, while 10% were classified as mesostaphyline, and the least common type was brachystaphyline (7%) [Table/Fig-4]. In terms of palatal height, 66% of the palates belonged to the orthostaphyline type, 19% were hypsistaphyline, and 15% were chemostaphyline [Table/Fig-5].

Name of parameter	Mean±SD (mm)
Palatal length	46.16±4.18
Palatal breadth	33.01±2.67
Palatal height	11.06±1.88
Contribution from premaxilla	11.43±2.51
Contribution from palatine processes	35.64±4.62

[Table/Fig-3]: Mean and standard deviation (SD) of various metric parameters of the hard palate.

Type of palate	Range of palatine index	Number of palates (%age)
Leptostaphyline	<79.9%	83
Mesostaphyline	80-84.84.9%	10
Brachystaphyline	>85%	7

[Table/Fig-4]: Classification of the palate into leptostaphyline, mesostaphyline, and brachystaphyline types.

Type of palate	Range of palatine index	Number of palates (%age)
Chemostaphyline	<27.9%	15
Orthostaphyline	28-39.9%	66
Hypsistaphyline	40%<	19

[Table/Fig-5]: Classification of the palate into chemostaphyline, orthostaphyline, and hypsistaphyline types.

The number of lesser palatine foramina varied from 0 to 2 on both sides. They were absent in 7% of skulls on each the right and left sides. Single foramina were observed in 90% of skulls on the right side and 91% on the left side, while double foramina existed in 3% of skulls on the right side and 2% on the left side. The distances of the lesser palatine foramen from the posterior end of the greater palatine foramen, palatomaxillary suture, and interpalatine suture were measured. The mean values of these distances were higher on the right side compared to the left side, but the difference was not statistically significant [Table/Fig-6].

Name of parameter	Mean and standard deviation (mm)		Range (mm)		p-value
	Right	Left	Right	Left	
Distance of LPF-GPF	3.55±1.56	3.38±1.57	1.03-7.71	1.03-7.33	0.46
Distance of LPF-PMS	11.45±2.42	10.90±2.39	6.35-17.78	5.78-17.32	0.12
Distance of LPF-IPS	17.57±3.06	17.47±2.99	16.06-19.74	16.04-19.87	0.81

[Table/Fig-6]: Distance of the lesser palatine foramen from the posterior end of the greater palatine foramen, palatomaxillary suture, and interpalatine suture.

DISCUSSION

In the present study, the mean length of the palate was found to be 46.16±4.18 mm. Comparing this with previous data, results of the present study were close to the results of D'Souza AS et al., (49.13 mm), Jotania B et al., (49.73 mm), and Rao MJ et. al. (49.87 mm) [10-12]. The mean palatal breadth in the present study was 33.01±2.67 mm, which was close to the results of Rao MJ et al., (34.42 mm) but lower than the results of D'Souza AS et al., (40.4 mm), Jotania B et al., (37.75 mm), Shalaby SA et al., (38 mm), and Sarilita E et al., (38.68 mm) [10,11,13,14]. The mean palatal height in our study was 11.06±1.88 mm, which was consistent with the results of Shalaby SA et al., (11.5 mm) and Sarilita E and Soames R (11.8 mm) [13,14]. The mean contributions from the pre-maxilla and palatine processes to the formation of the palate were found to be 11.43 mm and 35.64 mm, respectively. This was similar to the

results reported by D'Souza AS et al., (9.4 mm and 39.76 mm) and Jotania B et al., (9.62 mm and 40.11 mm) [10,11].

In terms of palatal classification, 83% of the skulls in the present study were classified as leptostaphyline, 10% as mesostaphyline, and 7% as brachystaphyline. These results were in agreement with Sarilita E and Soames R (84% leptostaphyline) but differed from the results of D'Souza AS et al., (37.5% leptostaphyline), Jotania B et al., (70% leptostaphyline), and Rao MJ et al., (95% leptostaphyline) [10-12]. Similarly, the classification of palatal height in the present study showed that 66% were orthostaphyline, 19% were hypsistaphyline, and 15% were chemostaphyline. Results of the present study were closest to Shalaby SA et al., but differed from the results of Sarilita E and Soames R and D'Souza AS et al., [10,13,14] [Table/Fig-7].

Author (study population)	Incidence (%)		
	Chemostaphyline	Orthostaphyline	Hypsistaphyline
D'Souza AS et al., 2012 (South Indian) [10]	87.5%	12.5%	-
Shalaby SA et al., 2015 (Egyptian) [13]	36%	56%	8%
Srilita E and Soames R 2015 (Indian) [14]	32%	59%	10%
Present study, 2022 (North Indian)	15%	66%	19%

[Table/Fig-7]: Comparison of the incidence of different types of palate based on the palatal height index [10,13,14, Present study].

Regarding the lesser palatine foramina, the number of foramina varied from 0 to 2 on both sides. They were absent in 7% of skulls on each side, and single foramina were observed in 90% on the right side and 91% on the left side. Double foramina were seen in 3% on the right side and 2% on the left side. These results differed from those reported by D'Souza AS et al., (62.5% single foramina, 30% double foramina) and Jotania B et al., (0.83% absent, 48.34% single foramina, 38.33% double foramina) [10,11].

The distances of the lesser palatine foramen from the posterior end of the greater palatine foramen, palatomaxillary suture, and interpalatine suture were measured in the present study. Distance of the Lesser Palatine Foramen (LPF) from the Greater Palatine Foramen, Palatomaxillary Suture, and Inter-Palatine Suture found to be 3.55±1.56 mm, 11.45±2.42 mm and 17.57±3.06 mm on right-side and 3.38±1.57 mm, 10.90±2.39 mm and 17.47±2.99 mm on left-side, respectively. The values were higher on the right-side as compared to the left-side, but the difference was not statistically insignificant. Unfortunately, no data could be found in the available literature for comparison. However, knowledge of the relationship between these foramina is important for clinicians performing procedures in this region to avoid complications [15].

Furthermore, the morphometric features of the palate have practical implications in forensic dentistry. The palatal and dental structures are protected within the oral cavity, making them less susceptible to trauma or heat-related stresses. This allows for straightforward identification of individuals even in cases of significant tissue destruction, enabling sex estimation and individual identification [16,17].

Limitation(s)

This study was limited to 100 skulls due to the declining number of cadavers in anatomy departments. To obtain more valid results, a study with a larger sample size could be conducted.

CONCLUSION(S)

The data provided by this study will be helpful in various disciplines of medical, dental, and anthropometric sciences. The results of this study differed significantly from other studies, which may be due to differences in ethnicity and geography. The metric parameters of the lesser palatine foramina showed slightly higher values on the right side compared to the left side, although this difference was not statistically significant. However, this information is important for clinicians performing procedures in this region.

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