

Morphometric analysis of human hard palate in skulls and its clinical significance

¹Dr. Shivanee M Raval, Senior Resident, Department of Anatomy, PDU Gov. Medical College, Rajkot, Gujarat, India.

²Dr. Sarika V Bhakhar, Assistant Professor, Department of Anatomy, PDU Gov. Medical College, Rajkot, Gujarat, India.

³Dr. Dilip V Gohil, Professor, Department of Anatomy, M. P. Shah Gov. Medical College, Jamnagar, Gujarat, India.

⁴Dr. Mital M Patel, Professor, Department of Anatomy, M. P. Shah Gov. Medical College, Jamnagar, Gujarat, India.

Corresponding Author: Dr Shivanee M Raval, Senior resident, Department of Anatomy, P.D.U govt. medical college, Rajkot, Gujarat, India.

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Abstract

Background: The hard palate is an important part of the human skull located between the nasal and oral cavity.

Methods: the study sample of 40 hard palate of human dry skulls were carried out from anatomy department of M.P. Shah Govt. medical college, Jamnagar, Gujarat. Various morphometric parameters were measured like, palatine length, palatine breadth, palatine height and palatine index, palatine height index were derived. Distance between greater palatine foramen to mid maxillary line and greater palatine foramen to posterior palatine crest of right and left side.

Results: The average palatine length, breadth and height of hard palate was 46.62 ± 4.7 mm, 35.75 ± 3.8 mm and 11.97 ± 4.6 mm of respectively. In present study, 57.5% leptostaphyline type, 17.5% mesostaphyline type and 25% brachystaphyline type according to palatine

index. According to palatine height index, 37.5% chamestaphyline type, 27.5% orthostaphyline type, 35% hypsistaphyline type was present. The average distance from greater palatine foramen to mid-maxillary line was 13.99 ± 2.10 mm and 13.58 ± 1.79 mm on right and left side respectively. The average distance from greater palatine foramen to posterior palatine crest was 3.60 ± 1.16 mm and 3.68 ± 1.12 mm on right and left side respectively. There was no statistically significant difference between right and left side. (p-value > 0.05).

Conclusions: The precise knowledge on the morphometry of hard palate and location of greater palatine foramen might be useful in dental and maxillofacial surgeries, also in forensic application in aspect of anthropometric variation.

Keywords: Hard Palate, Palatine Index, Palatine Height Index, Greater Palatine Foramen, Posterior Palatine Crest.

Introduction

The palate forms the roof of mouth and consisting of bony (hard) palate anteriorly and soft palate posteriorly. The bony palate is formed by the palatine processes of maxillae anteriorly and the horizontal plates of bones which together form the cruciform suture. The greater palatine foramen is located posterolateral on either side of bony palate which represents the lower end of greater palatine canal. It transmits the greater palatine vessels and nerve from the pterygopalatine fossa¹.

The size and shape of the palate form the foundation for planning treatments for many orthognathic surgeries, placing upper jaw implants, hemi maxillectomy, handling Le fort fractures, and performing cleft palate surgery. It is also helpful for evaluating patients before they undergo uvulopalatopharyngoplasty^{2,3}.

The proper knowledge of the normal size and structure of this region is needed while performing some meticulous procedures such as nasopharyngoscopy and nasogastric intubation and also needed for the better designing of instruments⁴.

Several methods are in use to produce regional anaesthesia of the maxillary arch in which the most commonly described method is that the needle is inserted into the greater palatine foramen and injecting the local anaesthetic solution into the pterygopalatine fossa where the trunk of the maxillary nerve lies.⁵⁻⁷

Materials & Methods

Study design: An observational descriptive study.

The study sample of 40 hard palate of human dry skulls were carried out from anatomy department of M.P. Shah govt. medical college, Jamnagar, Gujarat. Various morphometric parameters were measured like, palatine length, palatine breadth, palatine height and palatine index, palatine height index were derived. Distance

between greater palatine foramen to mid maxillary line and greater palatine foramen to posterior palatine crest of right and left side.

Inclusion Criteria

Skull without any apparent congenital palatine deformities will use because its parameters are included in my research study.

Exclusion Criteria

Skull with congenital palatine deformities and juvenile skulls will not be used for study because of deformity parameters will not measure properly and in juvenile skull because it is unossified.

These following parameters were measured with scientific digital vernier caliper.⁸

Palatine Length (PL): The fixed end of vernier calliper compass was placed in the anterior border of incisive fossa, and the movable point was placed at the posterior nasal spine, and the distance measured to the nearest 0.1mm.

Palatine Width: The fixed end of calliper compass was placed at the inner border of the socket of one side maxillary second molar, and the movable point at the opposite inner border of the socket of maxillary second molar.

Palatine Height (PH): the distance of the maximum arching of the palate from the line connecting the two sides inner border of the socket of maxillary second molar, was measured to the nearest 0.1mm.

Palatine Index: The Palatine Index (PI) was calculated by:

$$\text{Palatine index} = \frac{\text{Palatine Width} \times 100}{\text{Palatine length}}$$

The palatine index (PI) is the ratio of palatine width to the palatine length expressed as a percentage.

- PI if less than 80, the palate is narrow (Leptostaphyline)
- PI if 80-85, the hard palate is intermediate (Mesostaphyline)
- PI if 85 or more, the hard palate is broad (Brachystaphyline)

Palatine Height Index

Palatine height index: $\frac{\text{Palatine Height}}{\text{Palatine width}} \times 100$

According to the palatine height index there are 3 types of hard palate.

- Chamestaphyline(low)- palatine height index<28%.
- Orthostaphyline (intermediate)- palatine height index between 28.0-40%.
- Hypsistaphyline (deep)-palatine height index>40%.

For position of greater palatine foramen (GPF): distance between GPF to mid-maxillary suture of right and left side. And greater palatine foramen to posterior palatine crest of right and left side were measured.



Figure 1: Showing parameters are measured with digital vernier caliper

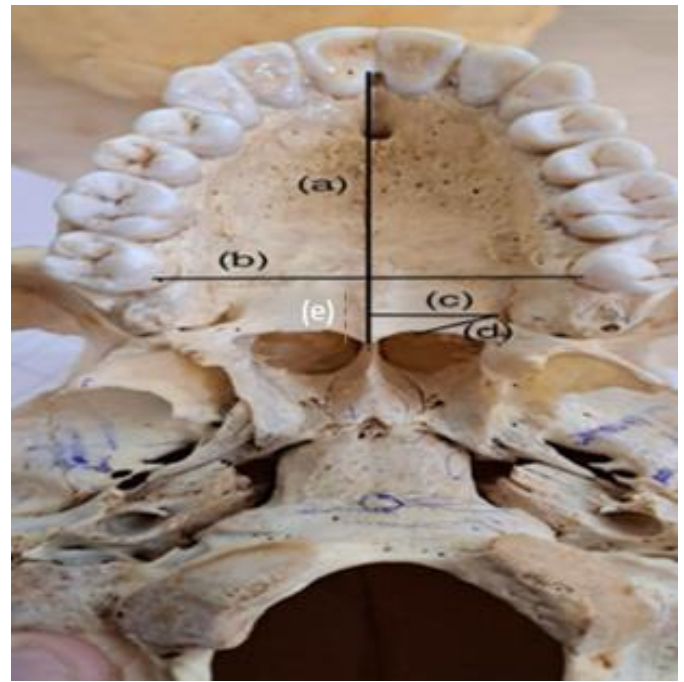


Figure 2: Schematic representation of palatal measurements

(a)-Palatine length, (b)-Palatine width, (c)-mid-maxillary line to greater palatine foramen, (d)-Greater palatine foramen to posterior palatine crest, (e)-Palatine height

Statistical Analysis

Statistical analysis was performed using Microsoft excel software. Descriptive statistics, including Mean and Standard Deviation (SD), were calculated for all continuous morphometric parameters. To compare the measurements between the right and left sides (e.g., distance from the greater palatine foramen to the mid-maxillary line and posterior palatine crest), a paired t-test was employed for normally distributed data. Categorical data, including the classifications of the Palatine Index and Palatine Height Index, were expressed as frequencies and percentages. A p-value of less than 0.05 was considered to indicate statistical significance.

Results

Table 1: Mean palatal measurements, greater palatine foramen (GPF)morphometric parameters.

Mean of Palatine Parameters	
Mean Palatine Length	46.62±4.7
Mean Palatine Breadth	35.75±3.8
Mean Palatine Height	11.97±4.6
Mean of Distance Between Right GPF To MML	13.99±2.10
Mean of Distance Between Left GPF To MML	13.58±1.79
Mean of Distance Between Right GPF To MML	3.60±1.16
Mean of Distance Between Left GPF To MML	3.68±1.12

Table 2: Palatine Index

Palatine Index	
Leptostaphyline(23/40)	57.5%
Mesostaphyline(07/40)	17.5%
Brachystaphyline(10/40)	25%

Table 3: Palatine height index

Palatine height index	
Chamestaphyline(15/40)	37.5%
Orthostaphyline(11/40)	27.5%
Hypsistaphyline(14/40)	35%

Figure 3: Pie chart showing distribution of hard palate according palatine index

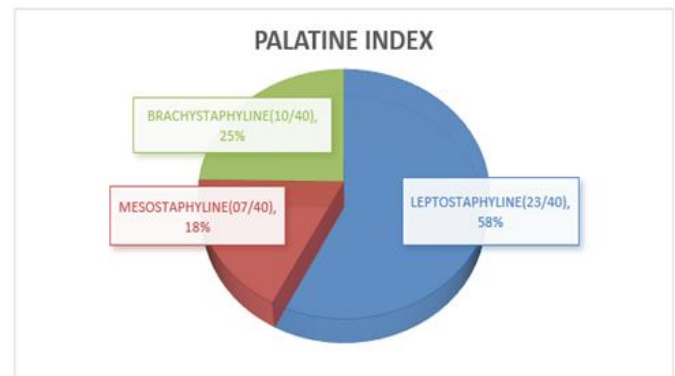
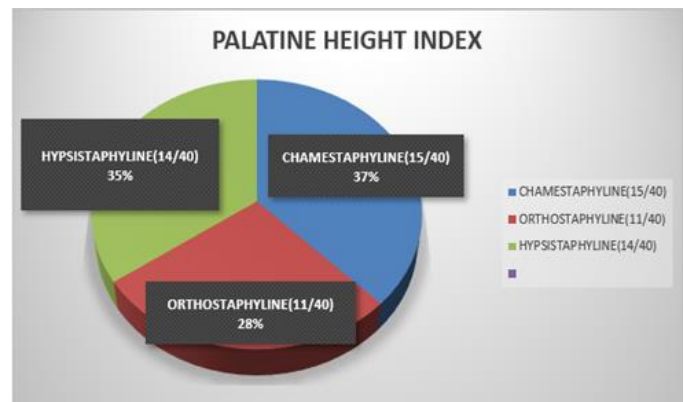


Figure 4: Pie chart showing distribution of hard palate according to palatine height index



Discussion

In the present study, the mean palatine length was 46.62±4.7 mm, the mean palatine breadth was 35.75±3.8 mm, and the mean palatine height was 11.97±4.6 mm. According to the palatine index, the majority of skulls were leptostaphyline type (57.5%), followed by brachystaphyline type (25%) and mesostaphyline type (17.5%). This predominance of leptostaphyline palate is comparable with the findings of Hassanali and Mwaniki, who reported 43.2% leptostaphyline palates, 23.7% mesostaphyline palates, and 33.3% brachystaphyline palates in Kenyan African skulls⁹. Similar predominance of leptostaphyline palate was also observed by Dave et al., Saadia et al., Erli Sarilita, Gujar et al., Rao et al., Masroor Badshah et al., Pallavi et al., and Nur Qistina Binti Ahmad Fauzi, although the reported percentages varied among different population groups^{2,8,11,14-18}. In contrast, Sushma

Khatiwada reported a higher proportion of brachystaphyline palates, suggesting population-based variation in palatal morphology¹⁹.

Based on the palatine height index, chamestaphyline type was observed in 37.5% of skulls, orthostaphyline type in 27.5%, and hypsistaphyline type in 35%. These findings differ from those of Antony Sylvan D'Souza et al., Varalakshmi et al., and Saadia et al., who reported a greater frequency of chamestaphyline or orthostaphyline palates in their respective studies^{8,10,13}. The present mean palatine height was close to the values reported by Erli Sarilita and Saadia et al., while it was higher than the values reported by Antony Sylvan D'Souza et al., Dave et al., and Varalakshmi et al., and lower than those reported by Masroor Badshah et al. and Sushma Khatiwada^{2,8,10,11,13,17,19}. Such differences may be attributed to racial, regional, genetic, and environmental variations among the studied populations.

The distance from the greater palatine foramen to the mid-maxillary line was 13.99 ± 2.10 mm on the right side and 13.58 ± 1.79 mm on the left side, with no statistically significant difference between the two sides ($p > 0.05$). These values are close to those reported by Antony Sylvan D'Souza et al., Saadia et al., Erli Sarilita, Rao et al., and Masroor Badshah et al., but lower than those observed by Gujar et al. and Pallavi et al.^{2,8,10,15-18}. Similarly, the distance from the greater palatine foramen to the posterior palatine crest was 3.60 ± 1.16 mm on the right side and 3.68 ± 1.12 mm on the left side, and this difference was also statistically insignificant ($p > 0.05$). The values were comparable with those reported by Saadia et al.⁸. These morphometric observations are clinically important because accurate localization of the greater palatine foramen helps in administering maxillary nerve blocks and in planning dental, maxillofacial, palatal, and reconstructive surgical procedures⁵⁻⁷.

Table 4: Comparison of palatal parameters like palatine length, palatine width and palatine index

Author's name	Palatine index (%)	Palatine length (mm) (mean $\pm$ sd)	P- Value	Palatine width (mm) (mean $\pm$ sd)	P-Value
Present study	L-57.5% M-17.5% B-25%	46.62 $\pm$ 4.7		35.75 $\pm$ 3.8	
Hansalini et al.,1984 ⁹	L-43.2% M-23.7% B-33.3%	49.2 $\pm$ 2.3	<0.05	40.2 $\pm$ 3	<0.05
Manmohan Patel et al., 2012 ⁴	-----	49.56 $\pm$ 3.95	<0.05	36.65 $\pm$ 3.03	>0.05
Antony Sylvan D'Souza 2012 ¹⁰	L-37.50%, M-22.50% B-40%	49.13mm,	-----	4.04mm	-----

Mitesh dave2013 ¹¹	L-63%, M-24% B-13%	43.5 ± 0.28	<0.05	33.83± 0.20	<0.05
Vasudha Kulkarni 2013 ¹²	L-86.9% M-1.4% B-11.6	40.42±0.4	<0.05	44.15±0.37	<0.05
Varalakshmi KL2015 ¹³	L-66% M-18.5% B-15.5%	48.47±4.46	<0.05	36 ± 4.41	>0.05
Saadia A et al.,2015 ⁸	L-64% M-24% B-12%	51.65 ± 4.7	<0.05	38.68 ± 2.9	<0.05
Erli Sarilita 2015 ²	L-84.1% M-7.9% B-7.9%	52.2 ± 3.2	<0.05	37.97± 3.32	<0.05
Nur Qistina Binti Ahmad Fauzi 2017 ¹⁴	L-73.33% M-16.67% B-10%	-----		-----	
Subash M. Gujar, et al., 2017 ¹⁵	L-34(68%) M-10(20%) B-6(12%)	47.10±3.34	>0.05	36.26± 2.55	>0.05
M. Janardharn Rao, et al., 2017 ¹⁶	L-(95%) M-(5%) B-0%	49.87±3.54	<0.05	34.42± 2.09	<0.05
Masroor Badshah et al.,2018 ¹⁷	L-65% M-9% B-6%	51.89mm	----	38.04mm	----
Pallavi et al.,2020 ¹⁸	L-94.64%, M-5.35% B-0	47.28±1.55	>0.05	36.01± 1.27	>0.05
Sushma Khatiwada 2020 ¹⁹	L-10.61%, M-4.55% B-84.85%	41.58±3.48	<0.05	40.63± 3.76	<0.05

{L= Leptostaphyline, M=Mesostaphyline, B=Brachystaphyline},[P- value <0.05 =significant, P- value >0.05= not significant]

Table 5: Comparison of palatal parameters like palatine height and palatine height index

Author's Name	Palatine Height(mm)(mean±sd)	P- Value	Palatine Height Index(%)
Present study	11.97±4.6		C-37.5% O-27.5% H-35%
Antony Sylvan D'Souza 2012 ¹⁰	0.8mm	----	C-87.50% O-12.50% H-0%
Mitesh dave2013 ¹¹	9.87±0.23	<0.05	C-42% O-54% H-4%
Erli Sarilita 2015 ²	11.54±2.4	>0.05	C-32% O-59% H-10%
Varalakshmi KL2015 ¹³	8.62±2.76	<0.05	C-72.30% O-26.10% H-1.60%
Saadia A et al.,2015 ⁸	11.8±2.7	>0.05	C-36% O-56% H-8%
Masroor Badshah et al.,2018 ¹⁷	14.16mm	-----	C-8% O-33% H-28%
Sushma Khatiwada 2020 ¹⁹	14.90±2.04	<0.05	C-4.56% O-71.21% H-24.2%

{C= Chamestaphyline, O=Orthostaphyline, H=Hypsistaphyline} [P- value <0.05 =significant, P- value >0.05= not significant]

Table 6: Comparison of distance between greater palatine foramen to mid maxillary line on both sides.

Author's name	Right GPF to MML (mm)(mean±sd)	P-value	Left GPF to MML (mm) (mean±sd)	P-value
Present study	13.99±2.10		13.58±1.79	
Antony Sylvan D'Souza 2012 ¹⁰	14.6±1.47	>0.05	14.4±1.404	<0.05
Saadia A et al.,2015 ⁸	14.25±1.7	<0.05	14.17±1.6	>0.05
Erli Sarilita 2015 ²	14.02±1.4	>0.05	13.57±1.5	>0.05
Subash M. Gujar, et al., 2017 ¹⁵	16.55±1.17	<0.05	16.57±1.19	<0.05
M. Janardharn Rao,et al., 2017 ¹⁶	14.78±1.08	<0.05	14.75±1.03	<0.05
Masroor Badshah et al.,2018 ¹⁷	14.40 mm		14.39 mm	
Pallavi et al.,2020 ¹⁸	18.03±0.68	<0.05	17.98±0.63	<0.05

{GPF=Greater palatine foramen, MML=Mid maxillary line},[P- value <0.05 =significant, P- value >0.05= not significant]

Table 7: Comparison of distance between greater palatine foramen to posterior palatine crest on both sides.

Author's name	Right GPF to PPC (mm)(mean±sd)	P-value	Left GPF to PPC (mm)(mean±sd)	p-value
Present study	3.6±1.16		3.68±1.12	
Saadia A et al.,2015 ⁸	3.89±0.9	>0.05	3.99±0.9	>0.05

{GPF=Greater palatine foramen, PPC=Posterior palatine crest} [P- value <0.05 =significant, P- value >0.05= not significant]

Conclusion

Morphometric knowledge of hard palate is important for anatomists, surgeons, anthropologists and forensic experts. Detailed anatomical study of hard palate is helpful for dentists, anaesthetics and maxillofacial surgeries for various procedure and surgeries related to hard and soft palate. Hard palate is used as donor graft in various surgeries of face reconstruction such as lower lip, lower eyelid, nasal ala. Resection of the hard palate is done for management of benign and malignant tumours. Knowledge of location of location of greater palatine foramen is important when administrating of local anaesthesia in surgeries of palate. Morphometric measurements are very much essential while performing orthognathic surgeries, cleft palate surgeries for pre-operative evaluation of patient with uvulopalatopharyngoplasty, nasopharyngoscopy and

nasogastric intubation. The precise knowledge on location of greater palatine foramen is essential for various diagnostic and therapeutic purposes.

Declarations

Ethical approval: Approved.

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