International Journal of Anatomy and Research,
Int J Anat Res 2019, Vol 7(2.1):6397-03. ISSN 2321-4287
DOI: https://dx.doi.org/10.16965/ijar.2019.125

Original Research Article

A STUDY OF PALATAL INDICES AND FORAMINA IN THE HARD PALATE OF ADULT HUMAN SKULLS IN CENTRAL INDIA REGION

Abhilasha M. Wahane [1], Rajeshree A. Nandanwar *[2].

[1] Associate professor, GMC, Nagpur, India.

*[2] Associate professor, LSBRKM, GMC, Jagdalpur, India.

ABSTRACT

Aim of study: Aim of study: The aim of the study is to determine morphometric indices of hard palate, position and location of greater palatine foramen (GPF) in relation to maxillary molars and number of lesser palatine foramen (LPF).

Materials and methods: 100 adult skulls (65 males and 35 females) were obtained from the Department of Anatomy. The parameters of hard palate like length, breadth and height were measured and palatine indices were calculated. Observations were made on the position and relation of GPF with maxillary molar and number of LPF. There were highly significant differences between both the sexes in Palatal length, breadth and height. The palatine index indicated that majority (61%)of skulls had narrow palate (Leptostaphyline).The palatine height index showed that majority (69%) of skulls had high arched or deep palate.(Hypsistaphyline). The greater palatine foramen was at the level of third molar in 50%, in between second and third molar in 35.5%, and at the level of second molar in 14% . In majority of skulls (71%) one lesser palatine foramen was observed and about (35%) of skulls had two LPF and (2.5%) of skulls had three LPF, and in about (5.5%) absence of LPF was observed.

Conclusion: Thorough anatomical study of hard palate is useful in ethnic and racial classification of crania, anthropological studies, fabricating complete maxillary dentures for edentulous patients and performing certain surgical procedures in hard palate and soft palate. Knowledge of palatal indices would be helpful to the anatomists, anthropologists, and forensic experts and surgeons during repair of the cleft palate and lip.

KEY WORDS: Hard palate, palatine index, Greater palatine foramen, Lesser palatine foramen.

Address for Correspondence: Dr. Rajeshree A. Nandanwar, 34/A, RBI colony, near NIT garden, Katol Road, Nagpur-440013, India. Mobile no. – 7796106126 **E-Mail:** rajeshreedng@yahoo.com

Access this Article online	Journal Information
Quick Response code	**International Journal of Anatomy and Research**
	ICV for 2016 90.30
	ISSN (E) 2321-4287 | ISSN (P) 2321-8967
	https://www.ijmhr.org/ijar.htm
	DOI-Prefix: https://dx.doi.org/10.16965/ijar
DOI: 10.16965/ijar.2019.125	**Article Information**
	Received: 28 Jan 2019 Accepted: 07 Mar 2019
	Peer Review: 28 Jan 2019 Published (O): 05 Apr 2019
	Revised: None Published (P): 05 Apr 2019

INTRODUCTION

The roof of the mouth and floor of nasal cavities is formed by palate. It is divisible into two regions namely the hard palate in front and soft palate behind. The palatine process of the maxilla and the horizontal plates of palatine bones united by cruciform sutures forms the hard palate [1].

The hard palate and its sutures are structures of the utmost importance as they are subjected to a cleft palate related defect of the maxilla and palatine bones [2]. Precise knowledge of normal structure and dimensions of these regions is required for procedures such as nasopharyngoscopy and nasogastric intubation and for meticulous manipulation and better designing of instruments [3]. In prehistoric period measurements of palate have been gained attention in various anthropological studies because of its relation to masticatory, dietary, and technological changes. Assessment of hard

palate has wide applications in the fields of orthodontic surgeries, forensic anthropology, palatal implants, repair of cleft palate, and treatment of obstructive sleep apnoea syndrome [4].

The greater palatine foramen transmit greater palatine nerves and vessels and lesser palatine foramen transmit lesser palatine nerves and vessels. The greater palatine nerve and vessels supply the mucosa of hard palate where it anastomoses with the nasopalatine nerves and vessels and supply the area of anterior palatal mucosa between two canines. The soft palate is contributed by the lesser palatine nerves and vessels [5]. A good knowledge of the location and morphology of the palatine foramen is required for oromaxillofacial surgeons and dentists while conducting localised anaesthesia of the maxillary teeth before procedures to avoid injury to the nerves and blood vessels of the hard palate for eg. Upper tooth extraction, maxillary dental implants, hemi-maxillectomy, orthognathic surgery, Le Fort fracture management, and cleft palate surgery [6].

Matsuda (1927) was the first to mention on the localization of the GPF [7]. Most of the textbooks still locate the GPF in a very general way e.g. near the lateral or posterolateral border of palate, opposite or medial to the third maxillary molar (M3) [8]. Textbooks of anaesthesia seem to be more specific in loosely positioning the GPF in relation to the maxillary molars [9]. Difference in opinion in anatomy textbooks regarding the precise location of the GPF as well as other details of palate structures, was the basis for this study examining the hard palate measurements. Moreover this is population based study which may provide an essential data for the comparative analysis of different populations. Hence the present study was conducted to determine the length, breadth, height of the palate, palatal size, palatine index, and palatine height index.

MATERIALS AND METHODS

The study was conducted on 100 adult skulls (65 males and 35 females) obtained from the Department of Anatomy, GMC Nagpur, Maharashtra, India as well as the first year MBBS medical students of the same college. The skulls with broken palates, anomalies, or any pathology were excluded from the study. The parameters were measured by two observers independently with predetermined procedures to prevent inter- observer and intra- observer error. With the help of digital Vernier callipers following measurements were taken.

Palatine length: Distance between the orale anteriorly (point at the anterior end of incisive suture located between the sockets of two medial maxillary incisors) to posterior nasal spine posteriorly.

Palatine breadth: Distance between the inner borders of the sockets of the upper second molars (endomalaria).

Palatine height: Maximum arching of palate from the line connecting the two endomalaria.

The following indices were calculated according to the method followed by Hassanali and Mwaniki [10].

Palatine index (PI) : was calculated by using the formula:

Palatine breadth*100/ Palatine length

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

1) When the range of PI was 79% or less, the hard palate was narrow (Leptostaphyline).

2) When the was 80-84.9%, the hard palate was intermediate (Mesostaphyline).

3) When the range of PI was 85% or more, the hard palate was wide (Brachystaphyline).

Palatine height index (PHI): was calculated by using the formula:

Palatine height x 100/ palatine breadth

The palatine height index (PHI) is the ratio of the palatine height to the palatine breadth expressed as a percentage. It indicates the characteristic arching of the palates.

1) If the PHI was 27.9% or less, the hard palate was low (chamestaphyline)

2) If it was 28-39.9% , the hard palate was intermediate (Orthostaphyline)

3) If it was 40% or more, the hard palate was deep (Hypsistaphyline).

In addition to the above indices the position of

the greater palatine foramen (GPF) in relation to the maxillary molars and the number of the lesser palatine foramen (LPF) was also noted.

Statistical analysis:

The values were analysed using Graph pad prism 6. The mean, SD, and range for each of the measurements were assessed. A Comparison of the values of all measurements was made in terms of the sides in each subject, as well as between sexes. The data were analyzed using student's t-test and p values less than 0.01were accepted as statistically significant.

Fig. 1: AB showing palatal length, CD showing palatal breadth.

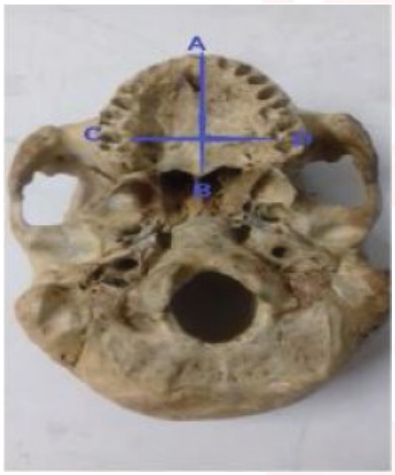


Fig. 2: EF showing palatal height.

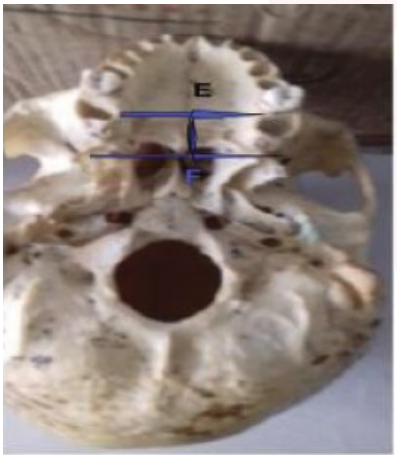


Fig. 3: Illustrate the number of lesser palatine foramen. Arrow marked on picture. A- Absent, B- Single, C-Paired, D- Tripal.

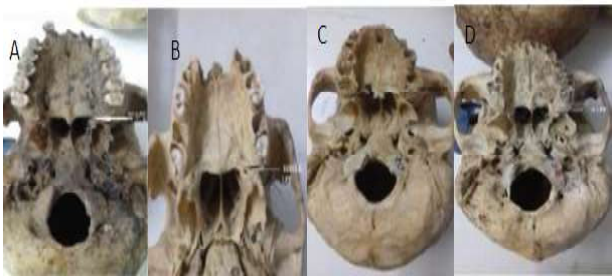
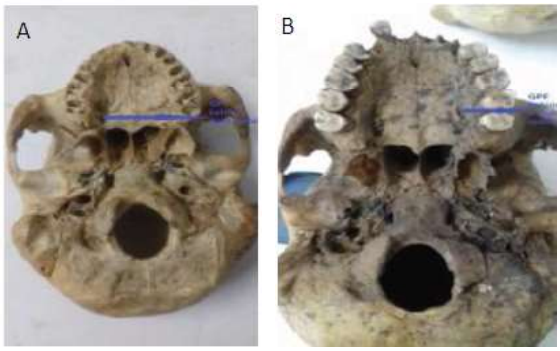


Fig. 4: Illustrate the position of GPF A- GPF behind third molar, B- GPF behind second molar.



RESULTS

Table no. 1 shows the values of (Palate length, breadth and height) in the study. The values in Male were more {palatal length (49.9 ±0.60), breadth (38.04 ± 0.55), and even height (16.92 ± 0.21)}.whereas in females the values were {length (46.06±0.77), breadth (33.70 ± 0.86) and height was (13.12 ± 0.45)} with significant statistical differences between both sexes.

The palatine index (PI) showed 64.61 %narrow palate (Leptostaphyline), 30.76% intermediate palate (mesostaphyline) and of 4.61 % male skulls had wide palate (Brachystaphyline). Whereas in female skulls 54.28% showed narrow palate (Leptostaphyline), 28.57% intermediate palate (mesostaohyline) and17.14% of total female skulls had wide palate (Brachystaphyline).There was no significant statistical difference between both sexes.

The palatine height index (PHI) showed that none of the male skull had low or flat palate (Chamestaphyline), 15.38 % had intermediate arching palate (orthostaphyline) and 84.61 % male skulls had high arched or deep palate (Hypsistaphyline). Whereas in female skulls 22.85 % had low or flat palate (Chamestaphyline), 37.14 % had intermediate arching palate (orthostaphyline) and 40 % female skulls had high arched or deep palate (Hypsistaphyline). There was significant statistical difference between both sexes. (p=< 0.001)

All the skulls showed presence of Greater palatine foramen (GPF) one on each side on the posterolateral aspects of the hard palate. There was a variable relationship of the GPF to the maxillary molars. (Table no.4). In most of the skulls total right and left GPF (50%) were opposite to third molar, whereas 35.5% showed GPF

Table 1: The parameters and indices of palate.

Parameter	Sex				P value
	Male (N=65)		Female (N=35)		
	Range (min-max)	Mean ±SD	Range (min-max)	Mean ±SD	
Palatine length	40.64 - 62.13	49.9 ±0.60	37.46 - 53.94	46.06±0.77	0.0011**
Palatine breadth	30.32- 48.89	38.04 ± 0.55	29.12 - 44.12	33.70 ± 0.86	0.0458*
Palatine height	13.70- 20.21	16.92 ± 0.21	9.060 - 19.32	13.12 ± 0.45	0.0001****
Palatine index	66.26- 89.44	76.44 ± 0.74	29.12 - 86.72	73.54 ± 1.80	0.7150 ns
Palatine height index	36.37- 57.44	44.68± 0.54	25.98 -65.76	39.83 ± 1.84	0.0011 **

P ≤ 0.01 is considered as significant value

Table 2: The frequency of types of hard palate according to Palatine Index.

P ≤ 0.01 is considered as significant value

Types	PI (%)	Male (N(%))	Female (N (%))	Total (N(%))	P value
Leptostaphylline	≤79.9	42/65 (64.61 %)	19/35 (54.28%)	61/100 (61 %)	0.7150 ns
Mesostaphylline	80-84.9	20/65 (30.76 %)	10/35 (28.57%)	30/100 (30 %)	
Brachystaphylline	≥85	03/65 (4.61 %)	6/35 (17.14%)	9/100 (9 %)	

Table 3: The frequency of types of hard palate according to palatine height index.

P ≤ 0.01 is considered as significant value

Types	PHI (%)	Male (N(%))	Female (N(%))	Total (N(%))	P-value
Chamestaphylline	≤27.9	0/65 (0%)	8/35 (22.85 %)	8/100 (8 %)	0.0011 **
Orthostaphylline	28-39.9	10/65 (15.38 %)	13/35 (37.14 %)	23/100 (23 %)	
Hypsistaphylline	≥40	55/65 (84.61 %)	14/35 (40%)	69/100 (69 %)	

Table 4: The relation of greater palatine foramen in maxillary molars.

Relation to maxillary molars	Right side N (%)	Left side N (%)	Total side N (%)
Opposite to 2nd molar	15(15%)	14 (14%)	29 (14%)
Between 2nd & 3rd molar	35(35%)	36 (36%)	71 (35.5%)
Opposite to 3rd molar	50 (50%)	50 (50%)	100 (50%)
Retromolar(behind third molar)	0	0	0

Table 5: The number of lesser palatine foramen (LPF) in hard palate.

Number of LPF	Numbers of skulls having LPF		
	Right side N (%)	Left side N (%)	Total side N (%)
0	05 (5 %)	06 (6%)	11 (5.5%)
1	73(73%)	70 (70%)	143 (71%)
2	20 (20%)	21 (21%)	20.5 (35%)
3	02 (02%)	03 (03%)	05 (2.5%)

Table 6: comparison of present study with other studies regarding relation of GPF to maxillary molars.

s.no.	Relation of GPF to maxillary molars	Opposite to 2nd molar	Between 2nd & 3rd molar	Opposite to 3rd molar	Beyond 3rd molar (Retromolar)
1	Jotania et al.(2013)	4.17	17.5	78.33	-
2	Dave et al.(2013b)	1	3	87.5	8
3	Ikuta et al(2013)	3	53	39	5
4	N imigean et al.(2013)	9	15	73	3
5	Renu (2013)	9	25.5	47.5	18
6	Sharma and Garud (2013)	7.9	35.25	38.13	17.99
7	Anjankar VP et al (2014)	6.98	16.27	73.26	3.49
8	Tomaszewska et al.(2014)	16.3	6.8	74.7	2.2
9	Sushobhana et al (2015)	14	10	76	-
10	Sarilita and Roger(2015)	4	37.3	58.7	-
11	Anil kumar et al (2016)	4.6	35.46	58.71	1.16
12	Present study (2019)	14	35.5	50	--

between second and third molar. In 14% of skulls the GPF was located at the level of second molar.

There was a variation in the number of Lesser palatine foramina (LPF) on both the sides from one to three. About 73% on right side and 70% on left side had one (LPF). The number of LPF was two in 20% on right side and 21% on left side. Whereas three LPF were present in 2% of right side and 3% of left side. (Table no. 5)

DISCUSSION

The anterior part of base of skull is the hard palate which is an important part [22]. Embryologically, hard palate consist of two parts, the primitive palate and permanent palate. The primitive palate is formed by the fusion of the globular swelling of medial nasal process and maxillary process. The permanent palate is developed from the fusion of palatine process of both maxilla across the midline [23]. In adults, the junction between primitive and permanent palate is represented by incisive fossa which may be changed in condition like cleft palate. In the present study the mean values of maximum palatal length, breadth and height in male skulls was higher than those in female skulls. The mean palatal length and breadth are sexually dimorphic. This finding is similar to that of Bigoni et al, who noted significant sex differences in the region of palate [24]. Rogers (2005) has numbered palate size/shape as sixth among the morphological features of the skulls used for sexing unknown skeletal remains.[25] Johnson et al (1989) selected palatal length as one of the best variables for sex determination of caucasiod skulls [25].

Shalaby et al reported that external palate breadth has been found to be the best sex determinant subsequent to statistical analysis of the five hard palate variables by logistic regression [27]. Gangrade et al also mentioned that external palate breadth alone correctly classified 66.7% of the sample size [28].

In the present study when the comparison of means of the palatine height was made it showed a statistically significant difference ($p< 0.01$) between male and female groups. The mean palatal height in male skull ranged from13.70- 20.21mm and in female it was 9.060 - 19.32 mm. When determined in previous studies, mean palatal height also showed a wide range of values (9.87 to 13.1 mm), with that in present study being close to Hassanali and Mwaniki and Tomaszewska et al (2014) [18].

Palatal index in our study showed that 61% of the skulls had narrow (leptostaphylin), 18% had intermediate (mesostaphylin), and 1% had wide (brachystaphylin) type, with no significant statistical difference between the two. Similar findings were reported by Dave et al. (2013a) [12]. They found 63% of skulls had narrow palate (leptostaphylin), 24% had intermediate palate (mesostaphylin), and 13% had wide (brachystaphylin) type. A study by Anil kumar et al. Showed that that 58% of the skulls had narrow (leptostaphylin), 27% had intermediate (mesostaphylin), and 15% had wide (brachystaphylin) type [21]. The knowledge of palatine index is important because high and narrow palate has been associated with many syndromes such as Apert syndrome, Turner's syndrome, Marfan syndrome,Franceschetti-treacher-collins syndrome [2].

In the present study Palatal height index in 8% had low palates (Chamestaphyline), 23% had intermediate (Orthostaphyline), and 69% had highly arched palate (Hypsistaphyline). The study differs from D'Souza et al. who found low palate (Chamestaphyline), to be most common (87.5%) and 12.5% had intermediate one (Orthostaphyline) [29].

Knowledge of palatine index and palatine height index will be helpful in comparing the Indian skulls with those from various other regions as well as skulls of different races [12].

Hard palate is preserved even in severe damages to the skull for studying sexual dimorphism. Taking into consideration the general morphometric features, male palates analysed in this study were Longer, narrower and deeper than the female ones, which coincides with the of other author findings.

The present study found the GPF to be opposite the upper maxillary third molar tooth in the most of skulls (50%). The majority of the studies conducted to observe the location of the GPF (Table 7d) found it to be opposite the third

molar tooth. Dave et al. observed this location in 87.5% of Indian skulls [12], whereas Sharma and Garud reported the same location in only 38.13 % [16]. In the present study the GPF was found between the 2nd and 3rd molar in 35.5% which coincides with the studies done by Sharma and Garud Sarilita [19] and Roger [24], and Anil kumar et al. [21] The GPF was opposite the 2nd molar in 14% that coincides with the study done by Sushobhana et al (2015) [18].

The number of LPF showed bilateral symmetry in majority of the skulls. In the remaining skulls the number varied from one to three or even may be absent. There were no LPF in 5.5% of skulls, single LPF in 71%, double LPF in 20.5%, and three LPF in 2.5%. Jaffar and Hamadah (2003) [30] observed that in 55% of the sides of the skulls (right or left) there were multiple LPF, in 41% there was only one LPF, whereas on 4% of the sides of the skulls there were no LPF. Absence of minor foramen bilaterally was observed in one skull (2%).However, the absence of LPF , as it was found in our study may cause the lesser palatine nerve to exit through the GPF, and thus be prone to anaesthesia when blocking the greater palatine nerve. The importance of knowing that individuals may have more than a single LPF is that the lesser palatine nerves may be unintentionally blocked if the needle tip is located posterior to the greater palatine foramen, resulting in anaesthesia of the soft palate and inducing gag reflex [10].

CONCLUSION

Thorough anatomical study of hard palate is useful in ethnic and racial classification of crania, anthropological studies, fabricating complete maxillary dentures for edentulous patients and performing certain surgical procedures in hard palate and soft palate. Knowledge of palatal indices would be helpful to anatomists, anthropologists, and forensic experts as well as the surgeons during repair of the cleft palate and lip. Awareness regarding the exact location of GPF can be useful for giving local block of greater palatine nerves. An understanding of the anatomy in depth will allow for careful planning and execution of anaesthesiological and surgical procedures involving the maxillary nerve and its branches in cluding greater palatine foramina.

Conflicts of Interests: None

REFERENCES

[1]. Standring S. The skull. In: Standring S, eds. Gray's anatomy. The Anatomical Basis of Clinical Practice. 40th ed. Edinburgh: Elsevier, Churchill Livingstone; 2005: 459.

[2]. Tangugsorn V, Skatvedt O, Krogstad O, Lyberg T. Obstructive sleep apnoea: a cephalometric study. Part-I. Cervico-craniofacial skeletal morphology. Eur J Orthod. 1995; 17(1):45-6

[3]. Patel M. A study of the hard palate in the skulls of central Indian population. Int J Pharma Bio Sci. 2012; 3(2):527-33.

[4]. Sylvian, A.D., Mamtha, H., Nayak, J. Morphometric analysis of hard palate in South Indian skulls. Biomed Res, 2012; 23: 173 - 175.

[5]. Moore KL, Dalley AF, Agur AM. 2013. Clinically oriented anatomy: Lippincott Williams & Wilkins p 934, 996-1000

[6]. Das S, Kim D, Cannon TY, Ebert CS, Senior BA.2006. High-resolution computed tomography analysis of the greater palatine canal. Am J Rhinol 20: 603-08

[7]. Matsuda Y. Location of the dental foramin in human skulls from statistical observations. Int J Orthod Oral Surg 1927;13: 299-305.

[8]. Romanes GJ (1981). Cunningham. Textbook of Anatomy 12th edition Oxford University Press New York 166.

[9]. Shane SME (1975). Principles of Sedation Local and General Anaesthesia in Dentistry. 1st edition Illinois: Charles C Thomas 173-176.

[10]. Hassanali J, Mwaniki D. Palatal analysis and osteology of the Kenyan African skulls. Ant Rec. 1984; 209:273-280.

[11]. Jotania B, Patel S, Patel S, Patel P, Patel S, Patel K. Morphometric analysis of hard palate. Int J Res Med 2013; 2: 72-75

[12]. Dave MR, Gupta S, Vyas KK, Joshi HG. A study of palatal indices and bony prominences and grooves in the hard palate of adult human skulls. NJIRM 2013; 4: 7-11.

[13]. Ikuta CRS, Cardoso CL, Ferreira-Júnior O, Lauris JRP, Souza PHC, Rubira-Bullen IRF. 2013. Position of the greater palatine foramen: an anatomical study through cone beam computed tomography images. Surg Radiol Anat 35: 837-42.

[14]. Nimigean V, Nimigean VR, Buþincu L, Sãlãvãstru D, Podoleanu L. 2013. Anatomical and clinical considerations regarding the greater palatine foramen. Rom J Morphol Embryol 54: 779-83.

[15]. Renu C. The position of greater palatine foramen in the adult human skulls of North Indian origin. J Surg Acad 2013;3:54-57.

[16]. Sharma NA,Garud RS. Greater palatine foramen : key to successful hemimaxillary anaesthesia a morphometric study and a report of a rare aberration : Singapore medical journal 2013:54:152-9

[17]. Anjankar VP, Gupta S, Nair S, Thaduri N, Trivedi G, Budhiraja V. Analysis of position of greater palatine foramen in central Indian adult skulls: a consideration for maxillary nerve block.Indian J Pharm 2014;2: 51-54

[18]. Tomaszewska IM, Tomaszewski KA, Kmiotek EK, Pena IZ, Urbanik A, Nowakowski M, Walocha JA. Anatomical landmarks for the localization of the greater palatine foramen–a study of 1200 head CTs, 150 dry skulls, systematic review of literature and meta analysis. J Anat 2014;225: 419-35

[19]. Sushobhana, Mishra SR, Singh S, Passey J, Singh R, Sinha P. Anatomical study and clinical considerations of greater palatine foramen in adult human skulls of north Indian population. International Journal of Anatomy, Radiology and Surgery. 2015; 4(4): 41-46

[20]. Sarilita, Roger Soames MORPHOLOGY OF THE HARD PALATE: A STUDY OF DRY SKULLS AND REVIEW OF THE LITERATURE Rev Arg de Anat Clin; 2015;7 (1): 34-43 24.

[21]. Anil Kumar et al / Morphological and morphometric study of hard palate in Indian population International Journal of Biomedical Research 2016; 7(11): 778-784

[22]. Datta AK. Part 2. Head and neck. In: Datta AK, eds. Essentials of Human Anatomy. 5th ed. Kolkata: Current Books International; 2009: 54.

[23]. Moore KL, Persaud TVN. The developing human. In: Moore KL, Persaud TVN, eds. Clinically Oriented Embryology. 6th ed. Philadelphia: W.B. Saunders Company; 1998: 245-252.

[24]. Bigoni L, Veleminska J, Bruzek J. Three dimensional geometric Morphometric analysis of cranio-facial sexual dimorphism in a central European sample of known sex. Homo 2010; 61:16–32.

[25]. Rogers TL. Determining the sex of human remains through cranial morphology. Journal of Forensic Science 2005; 50(3): 493-500

[26]. Johnson DR, Higgins PO, Moore WJ and McAndrew TJ. Determination of race and sex of the human skull by discriminant function analysis of linear and angular dimensions. Forensic Science International 1989; 41 41-53

[27]. Shalaby SA, Eid EM, Sarg NA, Sewilam AM. Morphometric analysis of hard palate in Egyptian skulls. Benha Med J 2015; 32:59-72.

[28]. Gangrade P, Babel H, Saini R, Vyas A. Sexing of skull through the morphometric of hard palate. Int J Curr Res Rev 2012; 4:168.

[29]. D'Souza A S, Mamatha H., Nayak J. Morphometric analysis of hard palate in south Indian skulls. Biomedical Research. 2012; 23(2): 173-175.

[30]. Jaffar AA, Hamadah HJ. An analysis of the position of the greater palatine foramen. J Basic Med Sci. 2003; 3: 24-32.

How to cite this article:

Abhilasha M. Wahane, Rajeshree A. Nandanwar. A STUDY OF PALATAL INDICES AND FORAMINA IN THE HARD PALATE OF ADULT HUMAN SKULLS IN CENTRAL INDIA REGION. Int J Anat Res 2019;7(2.1):6397-6403. **DOI:** 10.16965/ijar.2019.125