ORIGINAL ARTICLE

Normative Morphometric Study of Nasal Bones and Piriform Aperture in Human Dry Skulls: Establishing Baseline Data with Clinical Insights

Yasmeena Akhter[1], Manmeet Kour[2], Uzma Shanthoo[3], Ghulam Mohammad Bhat[4], Bashir Ahmad Shah[5], Mohd Irshad[6], Zafarullah[7]

ABSTRACT

Background and aim: The piriform aperture (PA) is the skeletal aperture located in the middle part of the skull in norma frontalis. The dimensions of piriform aperture and nasal bones are important in different medical fields and this study aims to develop normative data and find gender differences of piriform apertures in northern Indian population which can provide valuable inputs in different clinical scenarios both in medical and surgical fields. **Materials & Methods:** A cross-sectional observational study was done over a period of 3 months after clearance from institutional ethical committee wherein 40 dry intact and properly maintained skulls were studied for nasal bone and piriform aperture dimensions by using calibrated vernier callipers and data was recorded in predesigned proforma and subjected to statistical analysis. **Results:** The most common shape of PA found in male and female genders was triangular to oval and triangular respectively. The mean nasal bone length and breadth in males and females was (15.4 $\pm$ 2.9 and 11.8 $\pm$ 2.8 with P<0.001) and (8.3 $\pm$ 2.3 and 6.9 $\pm$ 1.0 with P value of <0.026) respectively which is statistically significant. Significant differences were also found in PA breadths (males with 27.5 $\pm$ 2.2 and females with 24.3 $\pm$ 1.6 with P value <0.001) and piriform aperture index (PAI) (male with 85.3 $\pm$ 7.4 and female with 77.4 $\pm$ 7.2 with P value of <0.002). There was no statistically significant difference in PA lengths amongst different gender. **Conclusion:** Morphometric data obtained from our study may serve as base line data for comparison among different ethnicities and genders besides being valuable for various reconstructive procedures of nose.

KEY WORDS: Piriform aperture, Nasal bone, Piriform aperture index, Skull.

Background and Aim

The bony external nose is formed by the nasal bones and maxillae. It terminates in front and below as piriform aperture of nose called anterior nasal aperture which is bounded above by the nasal bones and below and on each side by nasal notches of the maxillae.[1] It usually has a pear-shape appearance, anatomically formed in its upper portion by the nasal bone, palatal process of the maxilla inferiorly and laterally by the frontal process of the maxilla.[2] The piriform aperture is located at the most anterior side of the bony nasal airway.[3] The region of the piriform aperture is the narrowest portion of the bony nasal airway, and this region constitutes 2/3 of the total nasal resistance in the bony cavum.[4] The nasal bones articulate in the midline with each other at internasal suture, posteriorly with frontal process of maxilla and superiorly with frontal bone at the frontonasal suture. Anterior nasal spine is a sharp

Access this article online

Quick Response Code:

Website: www.jmsh.ac.in

Doi: 10.46347/jmsh.v11.i1.24.261

[1]Tutor/Demonstrator, Department of Anatomy, GMC Srinagar, Jammu and Kashmir, India, [2]Assistant professor, Department of Anatomy, GMC Srinagar, Jammu and Kashmir, India, [3]Medical officer NRC, NHM GMC Baramulla, Jammu and Kashmir, India, [4]Professor & Head, Department of Anatomy, GMC Srinagar, Jammu and Kashmir, India, [5]Professor, Department of Anatomy, GMC Srinagar, Jammu and Kashmir, India, [6]Assistant professor, Department of Pediatrics, GMC Kanth Bagh, Baramulla, 193101, Jammu and Kashmir, India, [7]Assistant professor, Department of ENT, GMC Baramulla, Jammu and Kashmir, India

Address for correspondence:
Mohd Irshad, Assistant professor, Department of Pediatrics, GMC Kanth Bagh, Baramulla, 193101, Jammu and Kashmir, India.
E-mail: drirshadnabi@gmail.com

bony projection which marks meeting of two maxilla in the lower boundary of the anterior nasal aperture.[1] Differences between male and female human skull are expressed in size and shape.[5] It is one of the upper respiratory passages, involved in warming, filtration, moistening and guiding the incoming air. A good knowledge of this element is fundamental in understanding these nasal functions. However, the articles published in the literature mainly correlate the functional problems of the nose to the nasal mucosa or cartilages, but few of them study the role of the piriform aperture, except for the well-described pediatric stenosis of the PA.[6]

Material & Method

This cross-sectional observational study was conducted over a period of 3 months in postgraduate department of anatomy in a medical college using 40 dry human skulls after ethical clearance from institutional ethical committee. All apparently abnormal shaped skulls either because of trauma or otherwise were meticulously excluded and rest were marked from 1-40. The sex determination was done using standard criteria as shown in Table 1[7] and it was validated by using two independent anatomists from our department to separately perform gender identification of skulls and only those skulls were enrolled in our study where sex determined was same among both the observers.

The dimensions of piriform aperture and nasal bone were measured by using highly accurate digital Vernier calliper after assessing landmarks around the piriform aperture on the norma frontalis by two independent postgraduates after properly labelling each skull to ensure reliability. The height of the piriform aperture was taken from the lowest point of internasal suture called rhinion to upper most point of nasomaxillary suture which is site of anterior nasal spine while as width was taken exactly at widest point in transverse diameter and PA index was calculated. The length of nasal bones was taken from nasion to rhinion, and breadth was taken at widest point of nasal bones. All the measurement were recorded in standard predesigned proforma, and student t-test was used for comprehensive statistical analysis.

Table 1:

Feature	Female skull	Male skull
Mastoid process	Less developed, when the skull is placed on a plane surface, it rests on the maxilla and the occipital bones, with less stability.	Prominent, serving as support points making the skull more stable when placed on a plane surface
Weight	Lighter skull	Heavier skull
Occipital condyles	Short and wide	Long and narrow
Mastoid and styloid processes	Smaller & pointed	Larger & blunt
Supra-orbital margins	Sharper-cutting	Prominent-rhombus
Glabella	Not protruding	Protruding
Muscle ridges	Less prominent	More prominent
Teeth	Smaller	Larger especially canines
External occipital protuberance	Less prominent	More prominent

Results and analysis

Shape of piriform aperture (PA)

Out of 40 skulls studied in our study, 24 skulls were of males and 16 were of females. Morphologically most common type of piriform aperture in both genders was triangular to oval (III) in 24 followed by triangular (II) in 11 while as tending to roundness (IV) and long & narrow (I) piriform aperture were found in 3 and 2 respectively. The most common type of piriform aperture in males and females together was triangular to oval (III) (in 79.2%) and triangular (II) (in 56.3%) respectively as tabulated in Table 2.

Table 2: Distribution of skull according to Shape of Piriform Aperture a nd Gender

Shape of PA	Males (n=24)		Females (n=16)		Total (n=40)	
	No.	%	No.	%	No.	%
Long & narrow (I)	1	4.2%	1	6.3%	2	5.0%
Triangular (II)	2	8.3%	9	56.3%	11	27.5%
Triangular to oval (III)	19	79.2%	5	31.3%	24	60.0%
Tending to roundness (IV)	2	8.3%	1	6.3%	3	7.5%

Piriform aperture index (PAI)

The mean piriform aperture index (PAI) in long & narrow, triangular, triangular to oval and tending

to roundness was 64±4.2, 77.2±5.7, 85.0±6.1 and 89.3±9.3 respectively as shown in Table 3.

Table 3: Statistics of Piriform Aperture Index according to Shape of Piriform Aperture

Shape of Piriform Aperture	Piriform Aperture Index (PAI)		
	Minimum	Maximum	Mean±SD
Long & narrow(I)	61	67	64.0±4.2
Triangular (II)	69	87	77.2±5.7
Triangular to oval (III)	72	100	85.0±6.1
Tending to roundness (IV)	83	100	89.3±9.3

Nasal bone and piriform aperture morphometry

The mean nasal bone length in males and female skulls was 15.4±2.9 and 11.8±2.8 with p value of less than 0.001 which is statistically significant while as mean nasal bone width was 8.3±2.3 and 6.9±1.0 in males and females respectively with p value of 0.026 as shown in Table 4. No statistically significant difference was found in mean PA length among two genders but statistically significant difference with p value of less than 0.001 and 0.002 was found in PA width and PAI in male and female skulls.

Table 4: Morphometric measurements of nasal bones and Piriform Aperture (PA) in different genders

	Males (Mean±SD)	Females (Mean±SD)	p value
Nasal Bone Length (mm)	15.4±2.9	11.8±2.8	<0.001
Nasal Bone Width (mm)	8.3±2.3	6.9±1.0	0.026
PA Length (mm)	31.9±2.2	31.4±3.7	0.610
PA Width (mm)	27.5±2.1	24.3±1.6	<0.001
PAI	85.3±7.4	77.4±7.2	0.002

Figure 1: Measurement of width/breadth of piriform aperture

Figure 2: Measurement of length/height of piriform aperture

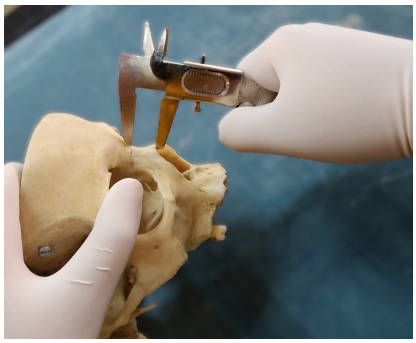

Figure 3: Measurement of length of nasal bone

Discussion

This study describes the distribution of skull according to the shape of the piriform aperture (PA) amongst different genders, provides descriptive statistics of the piriform aperture and nose with comparison among male and female skulls.

Shape of PA and gender

The distribution of skull shapes reveals significant variation between genders. The most prevalent PA shape among males is ”triangular to oval,” accounting for 79.2%, while females predominantly exhibit a ”triangular” shape at 56.3%. Notably, the ”long & narrow” and ”tending to roundness” shapes are the least common in both genders, indicating a lower frequency of these PA configurations in the studied population. Similar findings were reported by Asgar et al[8] who found triangular to oval in 83.5% of skulls followed by tending to roundness in 15% of skulls.The most common type of piriform aperture in males and females was triangular to oval (III) in 79.2% and triangular(II) in 56.3% respectively

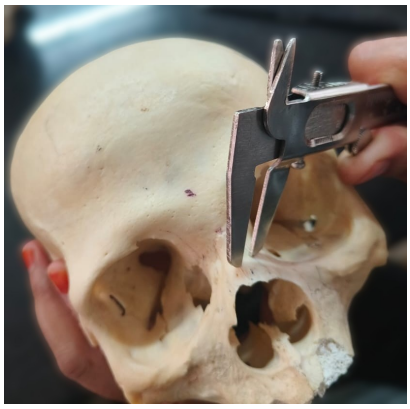

Figure 4: Measurement of width of nasal bone

matching with Ofodile et al[9] study, who found oval (equivalent to types III and IV) in Ashanti, triangular (type II) in Austrians and American Indians, and varied from oval to triangular in black Americans (type III).

The PAI provides further insight into the structural dimensions of the PA. The ”long & narrow” shape has the lowest mean PAI (64.0 ± 4.2), highlighting a narrower aperture relative to other shapes. In contrast, the ”tending to roundness” shape exhibits the highest mean PAI (89.3 ± 9.3), indicating a broader aperture. The ”triangular” and ”triangular to oval” shapes display intermediate PAIs, with means of 77.2 ± 5.7 and 85.0 ± 6.1, respectively. These findings underscore the significant variability in PA dimensions across different shapes, potentially influencing nasal airflow and respiratory functions.

Morphometric Measurements of nasal bones

Males exhibit significantly longer nasal bone lengths (15.4 ± 2.9 mm) compared to females (11.8 ± 2.8 mm), with a highly significant p-value (<0.001). This difference may be attributed to sexual dimorphism in craniofacial growth patterns. Similarly, males have wider nasal bones (8.3 ± 2.3 mm) than females (6.9 ± 1.0 mm), with a p-value of 0.026, further supporting the presence of gender-specific morphological traits. In study by Durga Devi G et al[10] length and width of nasal bone was 16.3± 1.9 and 11.3 ±1.6 mm in male and 17.4± 2.3 and 12.05 ± 1.7 mm in female which was comparable to ours in males only. Hwang[11] found length and width of nasal bone in Korean origin 25.9±3.8mm & 9.2±2.4mm in male and 24.5±3.7mm &8.8±2.6mm in female. Lang[12] worked on German origin and found mean nasal length and width 24.9±3.2 & 13±2.4 respectively. Karadag et al[13] studied 80 Anatolian patients and reported the mean nasal bone length of 30.6 mm in males and 29.01mm in females. None of studies showed significant sexual differences in contrast to ours which may be due to regional variations.

Morphometric measurements of piriform aperture

The PA dimensions also vary significantly between genders. While PA length does not differ markedly between males (31.9 ± 2.2 mm) and females (31.4 ± 3.7 mm) with P value of<0.610, PA width is significantly greater in males (27.5 ± 2.1 mm) compared to females (24.3 ± 1.6 mm) with a p-value of <0. 001.This is like studies done by Adil Asghar et al[8] who found mean nasal bone breadth of 24.9±1.59mm & 22.77±1.57mm in males and females with p value of<0.0105 and Moreddu et al[14] who reported mean PA width as 24.00 mm (±1.77) in females and 25.32 mm (±1.86) in males with p value <0.001. Yuzbasioglu et al[15] found greater mean width of 24.6mm in males than 23.3mm in females although of lesser statistical significance. Consequently, the PAI is higher in males (85.3 ± 7.4) than in females (77.4 ± 7.2), with a p-value of 0.002, indicating broader PA’s in males similar to Adil Asghar et al[8] (mean PAI of 79.91±11.55 and 77±9.64 in males and females with p value of <0.041).De Araujo et al[7] also found higher length and breadth in Brazilian males than female although of lesser statistical significance(length of 31.4±3.3 in males vs 29.4±3.9 in females and breadth of 25.7±1.9 in males vs 25.7±2.5 in females).

Conclusion

The normative morphometric analysis of the nasal bones and piriform aperture in dry human skulls provides critical insights into the anatomical variations of these structures besides establishing normative values that can be utilized in clinical, forensic, and anthropological scenarios. Significant variations in the dimensions of the nasal bones and piriform aperture were observed, potentially attributable to demographic factors such as sex, age, and ethnic background. In conclusion, this study highlights significant gender differences in PA shape and morphometric measurements having several implications for understanding craniofacial morphology and its variations across genders. Further research should explore the hormonal and environmental factors contributing to these morphological differences.

The high degree of reproducibility and reliability in measurements, achieved through multiple obser-

vations by independent observers, reinforces the validity of our data. These findings underscore the importance of considering individual variations in clinical practices, particularly in reconstructive surgeries and forensic identification. However, the study is limited by its sample size, the non-availability of demographic details and non-availability of data on classification of nasal bones due to time constraints which could have provided more granular insights into the observed variations.

Acknowledgement
All acknowledgement to department of anatomy for providing skulls and necessary instrument for this study.

Aim of study
The knowledge of the morphometric measurements is of relevance for performing surgical procedures such as rhinoplasty, osteotomies and plastic reconstructions besides being useful in sex, race ethnic determination.

References
1. Faruqi NA. Human Osteology: A Clinical Orientation. 3rd ed. CBS Publishers & Distributors. 2017. Available from: https://books.google.co.in/books/about/Human_Osteology.html?id=x_s0swEACAAJ&redir_esc=y.
2. Lee JC, Yang CC, Lee KS, Chen YC. The measurement of congenital nasal piriform aperture stenosis in infant. International Journal of Pediatric Otorhinolaryngology. 2006;70(7):1263–1267. Available from: https://doi.org/10.1016/j.ijporl.2006.01.005.
3. Roy S, Iloreta AM, Bryant LM, Krein HD, Pribitkin EA, Heffelfinger RN. Piriform aperture enlargement for nasal obstruction. Laryngoscope. 2015;125(11):2468–2471. Available from: https://doi.org/10.1002/lary.25343.
4. Papesch E, Papesch M. The nasal piriform aperture and its importance. Otolaryngology–Head and Neck Surgery. 2016;1(4):89–91. Available from: https://www.oatext.com/pdf/OHNS-1-122.pdf.
5. Sarač-Hadžihalilović A. Anatomically-anthropological significance of the skull. Medical Faculty, University of Sarajevo. 2017;66:66, 69–71, 74, 76.
6. Burstein FD, Cohen SR. Piriform aperture stenosis: a rare cause of neonatal airway obstruction. Annals of Plastic Surgery. 1995;34(1):56–58. Available from: https://pubmed.ncbi.nlm.nih.gov/7702302/.
7. De Araújo TMS, Silva CJTD, De Medeiros LKN, Estrela YCA, Silva NA, Gomes FB, et al. Morphometric analysis of piriform aperture in human skulls. International Journal of Morphology. 2018;36(2):483–487. Available from: http://dx.doi.org/10.4067/S0717-95022018000200483.
8. Asgar A, Dixit A, Rani M. Morphometric Study of Nasal Bone and Piriform Aperture in Human Dry Skull of Indian Origin. Journal of Clinical and Diagnostic Research. 2016;10(1):05–07. Available from: https://doi.org/10.7860/jcdr/2016/15677.7148.
9. Ofodile FA. Nasal bones and piriform apertures in blacks. Annals of Plastic Surgery. 1994;32(1):21–26. Available from: https://doi.org/10.1097/00000637-199401000-00005.
10. Devi D, Archana R, Johnson WMS. Morphometric study of nasal bone and piriform aperture in human dry skull of South Indian origin. International Journal of Anatomy and Research. 2018;6(4.3):5970–5973. Available from: https://www.ijmhr.org/ijar.6.4/IJAR.2018.386.pdf.
11. Hwang TS, Song J, Yoon H, Cho BP, Kang HS. Morphometry of the nasal bones and piriform apertures in Koreans. Annals of Anatomy - Anatomischer Anzeiger. 2005;187(4):411–414. Available from: https://doi.org/10.1016/j.aanat.2005.04.009.
12. Lang J, Baumeister R. Uberdas Postnatale Wachstum der Nasenhöhle. Gegenbaurs Morphol Jahrb. 1982;128:354–393. Available from: https://pascal-francis.inist.fr/vibad/index.php?action=getRecordDetail&idt=PASCAL82X0287144.
13. Karadag D, Ozdoll NC, Beriat K, Akinci T. CT evaluation of the bony nasal pyramid dimensions in Anatolian people. Dento-maxillofacial Radiology. 2011;40(3):160–164. Available from: https://doi.org/10.1259/dmfr/35578628.
14. Moreddu E, Puymerail L, Michel J, Achache M, Dessi P, Adalian P. Morphometric measurements and sexual dimorphism of the piriform aperture in adults. Surgical and Radiologic Anatomy. 2013;35(10):917–924. Available from: https://doi.org/10.1007/s00276-013-1116-2.
15. Yüzbaşioğlu N, Yilmaz MT, Çicekcibasi AE, Eeker M, Sakarya ME. The Evaluation of Morphometry of Nasal Bone and Piriform Aperture Using Multidetector Computed Tomography. The Journal of Craniofacial Surgery. 2014;25(6):2214–2219. Available from: https://doi.org/10.1097/scs.0000000000001063.

How to cite this article: Akhter Y, Kour M, Shanthoo U, Mohammad Bhat G, Ahmad Shah B, Irshad M, Zafarullah . Normative Morphometric Study of Nasal Bones and Piriform Aperture in Human Dry Skulls: Establishing Baseline Data with Clinical Insights. J Med Sci Health 2025; 11(1):55-59

Date of submission: 13.08.2024
Date of review: 26.08.2024
Date of acceptance: 15.01.2025
Date of publication: 14.02.2025