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## MORPHOMETRIC STUDY OF PIRIFORM APERTURE AND NASAL BONE IN HUMAN DRY SKULLS

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### Abstract

**Introduction:** The measurements of PA can be an anatomical landmark used for ethnic differentiation in human identification and provide information for surgical procedures and nasal reconstruction in otolaryngology. There are many variations in nasal bone shape among the different population e.g. The nose is much broader with thickened upper nasal region in East Asians. It is longer and more prominent in Middle Eastern and Southern European populations. Most Egyptian skulls are typically North African Caucasians.

**Aim:** Morphometric study of piriform aperture and nasal bone in human dry skulls.

**Materials and Methods:** Sixty adult dried human skulls, whose age and origins were unknown, were taken from the Anatomy Department of the SSJGIMSR in Almora for observational research. All whole skulls are required for inclusion. All distorted and fractured skulls matched the exclusion criteria.

**Results:** The nasal bone's height ranges between 14.33 and 23.11 mm, with a mean of 19.26 mm and a standard deviation of 2.38 mm. The nose bone's breadth ranges from 12.3 mm to 16.48 mm, with a mean of 14.15 mm and an extremely tiny 1.04 mm standard deviation. With an average height of 27.08 mm and a standard deviation of 2.27 mm, the piriform aperture's height ranges from 23.09 mm to 30.77 mm. With a mean of 19.39 mm and a standard deviation of 1.15 mm, the upper breadth ranges from 16.81 mm to 21.2 mm. With an average width of 24.05 mm and a standard deviation of 1.57 mm, the lower width ranges 19.12 mm to 27.54 mm.

**Conclusions:** The results of the current study indicate that, although there is some gender-specific variations in the morphometric measurements of the nasal bone and piriform aperture, only the piriform aperture's height demonstrates a difference that is not statistically significant, with men having a higher mean height than women.

**Keywords:** Skull, Nasal bone, Nose, Piriform aperture, Nasal height; Nasal breadth.

## **Introduction**

The piriform aperture (PA) is the skeletal aperture located in the middle part of the face and limited by the frontal processes of the maxillary bones, the nasal bones, and the anterior nasal spine, palatal process of the maxilla inferiorly. It corresponds to the anterior limit of the skeletal nose, and a major component of the size of the nose and (1,2) the features of the piriform aperture have been reported as classic indicator of sexual differentiation. (3)

The measurements of PA can be an anatomical landmark used for ethnic differentiation in human identification and provide information for surgical procedures and nasal reconstruction in otolaryngology. There are many variations in nasal bone shape among the different population e.g. The nose is much broader with thickened upper nasal region in East Asians. It is longer and more prominent in Middle Eastern and Southern European populations. Most Egyptian skulls are typically North African Caucasians. The shape of nose in them is broad and lack of a sharp lower border. It is therefore necessary that in cases of unidentified skeletal remains, the ancestry should be estimated. (4)

It is found that racial & geographical differences in the osseous anatomy shape of the nose, the nasal aperture & nasal mucosa owing to climatic variations for adaptation. (5)

The knowledge of the morphometric measures is of immense importance for performing rhinoplasty, osteotomies and plastic reconstructions. (6)

Preoperative evaluation of nasal bone and piriform aperture will predict type of nose, soft tissue as well as skeletal changes which will further improve surgical outcome. (7)

The respiratory mechanics may be affected due to trauma to the piriform aperture. (8)

The knowledge of morphological presentations and shape of the nasal bones & piriform aperture in human skulls, are important for performing a surgical procedure. With these backgrounds in mind the objective was to study morphological features of nasal bone and piriform aperture considering the sexual dimorphism of the structures.

## **Materials and Methods**

Sixty adult dried human skulls, whose age and origins were unknown, were taken from the Anatomy Department of the SSJGIMSR in Almora for observational research.

### **Inclusion criteria:**

- All intact skulls.

### **Exclusion criteria:**

- all deformed
- Fractured skulls were excluded.

For sex determination following tabulated features were used.

**Table No. 1. Sex determining features of skull. (9)**

S.No.	Sex determining features	Male	Female
1.	Supraorbital Ridges	Prominent	Less Prominent
2.	Superior Orbital Margin	Blunt	Sharper
3.	Palate	Large	Small
4.	Teeth	Large	Small
5.	Smoothness+Ridges	Rough	Smooth
6.	Frontal Sinuses	Large	Small
7.	Mastoid Process	Large & Blunt	Small & Pointed
8.	Zygomatic Arch	Wide	Narrow
9.	Posterior End of Zygomatic Arch	Extends As Supramastoid Crest Farther	Does Not Extend
10.	Frontal And Parietal Bossing	Prominent	Less Prominent
11.	Inion	May Be More Prominent	-

After sex determination following parameters of piriform aperture & nasal bone were measured & noted through digital vernier's callipers. (10)

Parameters	Bony landmarks
• Height of nasal bone	Between nasion to rhinion
• Width of nasal bone	Between the upper points of the lateral borders of the nasal bone.
• Height of piriform aperture	Between inferior margin of the internasal suture to anterior nasal spine.
• Upper width of piriform aperture	Between the right and left naso-maxillary junction.
• Lower width of piriform aperture	Measured between the right and left margin of the anterior surface of the maxilla.
• Shape of piriform aperture	Oval      Triangular      Round

## Analysis

All data collected were thoroughly screened and entered MS excel spread sheets and analysis was carried out. Differences in male and female skull were recorded and the mean calculated. The calculated mean was analyzed using SPSS version 22 statistical software.

A statistically significant p-value was less than 0.05, while a non-significant p-value was more than 0.05.

## Result

Table no. 2. Showing Morphometric measurements of the piriform aperture and nose

S.No.	Parameters	Sample size	Min	Max	Mean $\pm$ SD
1.	Height of nasal bone (mm)	60	14.33	23.11	19.26 $\pm$ 2.38
2.	Width of nasal bone (mm)	60	12.3	16.48	14.15 $\pm$ 1.04
3.	Height of piriform aperture (mm)	60	23.09	30.77	27.08 $\pm$ 2.27
4.	Upper width of piriform aperture (mm)	60	16.81	21.2	19.39 $\pm$ 1.15
5.	Lower width of piriform aperture (mm)	60	19.12	27.54	24.05 $\pm$ 1.57

Morphometric measures of the nasal bone and piriform aperture from a sample of sixty skulls are shown in table no. 2. This is a succinct analysis of the information: With a mean height of 19.26 mm and a standard deviation of 2.38 mm, the nasal bone's height ranges from 14.33 mm to 23.11 mm. With a mean width of 14.15 mm and a very small standard deviation of 1.04 mm, the nasal bone's breadth ranges from 12.3 mm to 16.48 mm. The piriform aperture's height has a range of 23.09 mm to 30.77 mm, with a mean of 27.08 mm and a 2.27 mm standard deviation. The upper breadth has a standard deviation of 1.15 mm and a mean of 19.39 mm, ranging from 16.81 mm to 21.2 mm. The Lower width has a standard deviation of 1.57 mm and a mean width of 24.05 mm, ranging from 19.12 mm to 27.54 mm.

Table no. 3. Morphometric measurements of piriform aperture and nasal bone *in skulls of male and female.*

S.No.	Parameters	Sex	Sample size	Min	Max	Mean $\pm$ SD	T-Test	P value
1.	Height of nasal bone (mm)	Male	42	14.81	23.11	19.39 $\pm$ 2.19	0.623	0.535
		Female	18	14.33	22.5	18.97 $\pm$ 2.82		
2.	Width of nasal bone (mm)	Male	42	12.3	16.48	14.26 $\pm$ 1.10	0.197	1.302
		Female	18	12.94	15.57	13.88 $\pm$ 0.86		
3.	Height of piriform aperture (mm)	Male	42	23.1	30.77	27.53 $\pm$ 2.29	2.425	0.018
		Female	18	23.09	29.46	26.04 $\pm$ 1.89		
4.	Upper width of piriform aperture (mm)	Male	42	16.81	21.2	19.26 $\pm$ 1.18	1.100	0.275
		Female	18	18.11	21.2	19.60 $\pm$ 1.06		
5.	Lower width of piriform aperture (mm)	Male	42	19.12	27.54	23.88 $\pm$ 1.59	0.199	1.298
		Female	18	22.77	27.51	24.45 $\pm$ 1.48		

According to table no. 3, Morphometric measurements of piriform aperture and nasal bone *in skulls of male and female:*

#### Height of Nasal Bone:

Males' average height is 19.39 mm, with a standard deviation of 2.19 mm. The measures range from 14.81 mm to 23.11 mm.

- Females' average height is 18.97 mm, with a standard variation of 2.82 mm. The measurements range from 14.33 mm and 22.5 mm.
- Males have somewhat larger average nasal bone height compared to females. Females exhibit more variability, probably due to a lower sample number. The height of the nasal bone does not differ significantly between males and females. The p-value is larger than 0.05, showing that the observed difference is statistically insignificant.

#### Width of Nasal Bone:

• Males have a mean breadth of 14.26 mm and a standard variation of 1.10 mm. The range is 12.3 mm to 16.48 mm.

• Females' average width is 13.88 mm, with a standard variation of 0.86 mm. The range is 12.94 mm to 15.57 mm.

- Male nasal bones are somewhat broader on average than females, with less variability in the male group. The breadth of the nasal bone is not significantly different between males and females. The p-value of 1.302 is more than 0.05, suggesting no statistically significant difference.

#### **Height of Piriform Aperture:**

Males' average height is 27.53 mm, with a standard variation of 2.29 mm. The measures range from 23.1 mm to 30.77 mm.

- Females' average height is 26.04 mm, with a standard variation of 1.89 mm. The measurements range from 23.09 mm to 29.46 mm.
- Males have a higher average height of the piriform aperture compared to females. This is a region with significant sexual dimorphism. The height of the piriform aperture varies greatly between men and females. Males had a higher average, and the p-value (0.018) is less than 0.05, suggesting a statistically significant difference.

#### **Upper Width of Piriform Aperture:**

- Males have a mean upper breadth of 19.26 mm and a standard variation of 1.18 mm. The measures range from 16.81 mm to 21.2 mm.
- Females had a mean upper breadth of 19.60 mm (SD = 1.06 mm). The measurements range from 18.11 mm to 21.2 mm.
- Females have a slightly greater average upper breadth, although the ranges overlap.
- The upper breadth of the piriform aperture is not significantly different between males and females. The p-value of 0.275 exceeds 0.05, suggesting that there is no statistically significant difference.

#### **Lower Width of Piriform Aperture:**

Males have a mean lower width of 23.88 mm and a standard variation of 1.59 mm. The measurements range from 19.12 mm and 27.54 mm.

- Females have a mean lower width of 24.45 mm (standard deviation: 1.48 mm). The measurements range from 22.77 mm and 27.51 mm.

Observation: Females have a little bigger average lower width of the piriform aperture than males, although the difference is negligible.

There is no discernible variation in the bottom breadth of the piriform aperture between men and women. The p-value of 1.298 is much beyond the 0.05 significance level, indicating that the difference is not statistically significant.

**Showing the shape of piriform aperture:****1. Triangular:**

- Males: 16
- Females: 8
- Total: 24 (40%)

**2. Oval:**

- Males: 18
- Females: 8
- Total: 26 (43%)

**3. Pear:**

- Males: 8
- Females: 2
- Total: 10 (17%)

The most commonly seen shape is oval, followed by triangular, and finally pear.

**Discussion**

Undoubtedly it is quite indispensable to proceed Bucco-maxillofacial surgeries without the relevant anatomical knowledge of variations in nasal and piriform structures to keep the pace with certain characteristics features of ethnicity & gender. The data obtained from the studies related to it is quite important for the plastic surgery, pulmonology, buco-maxillofacial surgeries and otolaryngologist's areas & helpful to decide the most effective procedure, for example: osteotomies (7,10).

The relevant knowledge of these structural variational anatomy of nasal bone and piriform aperture is quite important to ensure that the outcome of such reconstructive or cosmetic surgeries would be acceptable and more anatomically correct to cope up with climatic and ethnical necessities of certain region. Studies have suggested that the width and shape of the piriform aperture are extremely important when it comes to good-quality nasal breathing (10,11).

In present study the mean height of piriform aperture was observed  $27.53 \pm 2.29$  in males and  $26.04 \pm 1.89$  mm in females. Joshi MM. (2021) observed mean height of piriform aperture

32.4±1.7 mm in males & 28.1±1.6 mm in females. (12) In study done by Devi D. et al (2018) on south Indian population mean height of PA is 31.3 mm male and 27.24 mm in female indicating a significant higher value in male. Asghar et al (2016) found that the mean height of piriform aperture was 31.16±3.58 mm in males and 29.57±3.28 mm in females. (13) The mean height of the piriform aperture (36.3 mm) observed by Boyan et al., (2007) it was found to be larger than that reported by Ofodile (25.8mm Ashanti; 31.4mm Austrians; 28.6mm American Indians; and 28.2mm black Americans) (17,18), and Hwang et al., (30.1mm males and 28.0mm females in Korean population). Moreduet et. al carried-out study on 3D computerized tomography scan (C.T. scan), the values were 32.54mm in females and 36.35mm in males. The nasal aperture was longer at the maximal length in the Indian group in comparison with Chinese and white groups. (8) In study done by Cantin et al on Brazilian dry skull was 50.82 mm in male 47.53mm in female. Yüzbasıoglu et. al studied skull CT on Turkish population 33.4mm and 30.1mm males and females respectively. (21)

Hommerich et al observed mean width of piriform aperture in male was 23.6mm & 22.6mm. (19) Naser et al in his study found that mean width of piriform aperture was 25.67mm and 23.77mm. (16) In study of done by Yuzbasıogalu et al observed mean width of piriform aperture 24.6mm in male and 23.3mm in females. (21) In study of Hwang et al it was observed that mean width of piriform aperture 25.7mm in male and 25.4mm in females. Karadag et al aperture 24 width of piriform aperture was 18.83mm in male & 18.19mm in female. Lee et al found in their study the mean width of piriform aperture 24.34mm in male and 22.82mm in females. (11) In the study by Prado et al findings of mean width of piriform aperture were 17.60mm in male and 17.20mm in females. (12) Asghar et al observed that the mean width of piriform aperture was 24.15±1.86 in females and 24.9±1.59mm. (14) Durga devi et al discussed in their findings about the mean width of piriform aperture were 24.03±1.4 mm in males & 24.4±2.3mm in females. (13) Joshi MM. found in their study that the mean width of piriform aperture was 17.60mm in male and 17.20mm in females.

In the present study we observed the mean upper width of piriform aperture were 19.26±1.8mm in male and 19.60±1.06mm in females. The mean lower width of piriform aperture was 23.88±1.59mm in male and 24.45±1.48mm in females.

Naser et al in his study found that mean height of nasal bone was 25.7mm in male and 23.5mm in female. In study of done by Yuzbasıogalu et al observed mean height of nasal bone was 18.7mm in male and 17.2mm in female in females. (21) In study of Hwang et al it was observed that mean height of nasal bone 25.9mm in male and 24.5 mm in females. (1) Karadag et al observed that mean height of nasal bone in male were 30.61mm and in female 29.01mm. (7)



Lee et al found in their study the mean height of nasal bone in male was 22.01mm and in female 17 mm. (11) Asghar et al observed that the mean height of nasal bone in male was 17.76mm and in female 17.25 mm. (14), Devi D. et al discussed in their findings about the mean height of nasal bone in male was  $16.3\pm 1.9$ mm and in females  $17.4\text{mm}\pm 2.3$ mm. (15) Joshi MM. found in their study that the mean height of nasal bone in male was  $16.8\text{mm}\pm 2.1$  and  $16.4\pm 1.3$ mm. (13)

In the present study we observed the mean height of nasal bone in male was  $19.39 \pm 2.19$  mm and in females  $18.97\pm 2.82$  mm.

In a study by Yüzbaşıoğlu et al width of nasal bone was 11.8 mm in male and 12 mm in female in north Indian population. (21) It was observed by Hwang et al that the mean width of nasal bone was 9.2mm and 8.8mm in female. (1) In the study by Durga D. et al width of nasal bone was  $11.3\pm 1.6$  in males and in female it was  $12.05\pm 1.7$  mm in south Indian population. (15) In the study done by Joshi MM. width of nasal bone was  $10.7\pm 1.4$  mm in male and  $10.4\pm 1.6$ mm in female. (13)

In present study shape of piriform aperture was triangular 40% oval 26% and pear shaped 17%. In study done by Joshi MM. (13) shape of piriform aperture was Triangular to Oval in 50% followed by tending to roundness 31.48%, Triangular 14.81% and Long and Narrow 3.70%. In the study by Durga Devi et al shape of piriform aperture was triangular to oval 45.09% and tending to roundness in 39.21%. (15) Asghar et al observed shape of piriform aperture triangular to oval 83.5% tending to roundness in 15%. (14)

## **Conclusion**

The current study shows that, while there are some differences in the morphometric measurements of the nasal bone and piriform aperture between genders, only the height of the piriform aperture is not statistically significant, with males having a higher mean height than females.

The oval shape of the piriform aperture is the most frequent in both males and females, with triangular and pear forms being less common. These findings provide clarification on the morphological difference of the piriform aperture, which is significant to anatomical studies, anthropology, forensic identification, forensic researchers, otorhinologists, and surgical planning. The observed gender disparities in form distribution may also be relevant to interpreting regional anatomical variances.

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## Conflicts of interest

There are no conflicts of interest.

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