

Morphometric Analysis of Piriform Aperture in Human Skulls

Análisis Morfométrico de la Apertura Piriforme en Cráneos Humanos

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SUMMARY: The piriform aperture is an anatomical structure generally pear-shaped, formed by some facial bones. The knowledge of its morphological presentation is of significant importance for performing a surgical procedure. This study aimed to analyze the morphometry and shape of the piriform aperture in human skulls, considering the sexual dimorphism of this structure. One hundred (100) human skulls were evaluated. The measurements were made with a digital caliper rule. Two parameters were analyzed: the height of the piriform aperture (R-ANS) - distance between the bottom edge of internasal suture to the anterior nasal spine; width (PA-W) - the longest distance in a transverse plane. Its form was evaluated according to seven types described in the literature and the sex differentiation (based on the Vanrell frame). For data analysis between sexes, we used the Student's t-test ($p < 0.05$; CI: 95 %). In this study it was observed that the height (R-ANS) of the piriform aperture in males (31.4 mm) was higher than in females (29.4 mm), without significant differences. The width (PA-W) had equal means values for both sexes (25.7 mm). Regarding the shape of the piriform aperture, it was found that the type I (pear) is the most common in males (43.6 %) and in women the type VII (rounded) is the predominant type (36 %). When sexes were evaluated in a combined manner, it was observed that the most common was the type I (pear - 39.1 %) and the less common were type III (diamond - 0.0 %), type II (inverted heart - 1.6 %) and type IV (inverted heart - 3.1 %). Knowledge of these morphometric data and piriform aperture formats is essential for surgical procedures involving this anatomical region. The results, particularly those related to the shape of the piriform aperture in women, may contribute to future work related to this facial structure, leading to better surgical decisions.

KEY WORDS: Piriform; Human skull; Anatomy.

INTRODUCTION

The piriform aperture is an anatomical structure formed by several bones that are part of the face. 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 (Lee *et al.*, 2006; Lee *et al.*, 2008).

The knowledge of the morphometric measures is of relevance for performing a surgical procedure such as rhinoplasty, osteotomies and plastic reconstructions (Citardi *et al.*, 2000). Studies have shown that surgical and traumatic alterations of the piriform aperture may alter the respiratory mechanics (Moreddu *et al.*, 2013). Their form and size may also serve as a basis for anthropological studies of a specific population, related to ethnicity (Homerich *et al.*, 2008).

Considering the assumptions, the study aimed to analyze the morphometry and shape of the piriform aperture of human skulls. From the evaluation of the dimensions and shape of the piriform aperture in human skulls, a better anatomical understanding of this structure can be reached and, in parallel, a better understanding of the clinical implications resulting from pathological alterations, related or not, to the dimorphism presented.

MATERIAL AND METHOD

The research adopted a quantitative approach. One hundred (100) skulls were used (50 from the FIP anatomy

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laboratory – Patos/PB - and 50 from the UFPE anatomy laboratory – Recife/PE). As an inclusion criterion only skulls in perfect anatomical conditions were selected. Fractured skulls were excluded because they may alter the piriform aperture measurements.

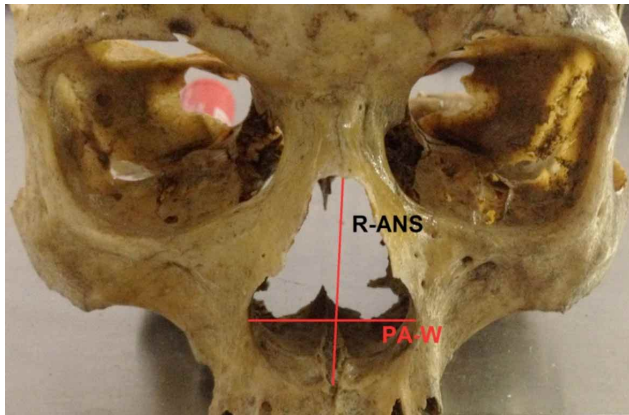


Fig. 1. R-ANS represents the height measurement and PA-W the width (Yüzbasioglu *et al.*, 2014).



Fig. 2. Piriform aperture shapes. Type I in the shape of a pear (A), type II inverted heart shape (B), type III diamond shape (D), wide type IV (E), type V oval (F), type VI rectangular and trapezoidal type VII round (G), according to the classification of Yüzbasioglu *et al.* (2014).

A digital caliper rule (Eccofer®) with a capacity of 150 (one hundred and fifty) millimeters was used for the morphometric analysis. A desktop computer (intel inside™) was used for data processing. Height, width, and shape of the piriform aperture were described. A Vanrell (Table I) was used to analyze the sexual dimorphism in human skulls (Vanrell, 2002 apud. Lira Júnior *et al.*, 2011).

For analysis of the piriform aperture morphology, the following forms were considered: pear, inverted heart below anterior nasal spine, rhomboid, inverted heart at the anterior nasal spine, oval, trapezoidal and rounded (Fig. 2. A-G) (Yüzbasioglu *et al.*, 2014).

To statistically analyze the data, we used the Student's t-test with a significance level of 95 %. The SPSS Desktop version 22.0 (IBM®) program was used for data processing. The results were presented in tables, where the sexes morphometric data were compared and the percentage distribution of the piriform aperture forms of both sexes was presented. The height of the piriform opening (R-ANS),

which is the distance between the inferior margin of the internal suture to the anterior nasal spine, and its width (PA-W), the largest distance in a transverse plane, are presented in Figure 1. The research was approved at the Integrated Colleges of Patos, Patos/PB, Brazil, by the Research Ethics Committee (CAAE n°: 48882115.0.0000.5181) according to Resolution n°: 466/2012, also approved by the Research Ethics Committee of Federal University of Pernambuco, Recife/PE, Brazil, as co-participant institution (CAAE n°: 48882115.0.3001.5208) according to the same Resolution (Brazil, 2013).

RESULTS

Of the 100 skulls evaluated from both anatomy labs, 64 skulls met the inclusion and exclusion criteria. In this study it was observed that there were no differences between R-ANS and PA-W among the studied genres. Regarding the mean height (R-ANS), males showed a larger size (31.4 mm) than females (29.4 mm), but without significant differences. When

combined the sexes the mean R-ANS was (30.6 mm). Regarding the width (PA-W), the female and the male had a mean of 25.7 mm (Table II).

Regarding the shape of the piriform opening, the type I (pear) was the most common in males (43.6 %) and type VII (rounded) was the predominant one (36.0 %) in women. When the sexes were evaluated in a combined

manner, it was observed that the most common type was type I (39.1 %). The less common forms were type III (rhombus - no skulls with this format), type II (inverted heart below the level of the anterior nasal spine - 1.6 %), and type IV (heart inverted at the level of the anterior nasal spine - 3.1 %) (Table III). The description and format of piriform aperture types can be seen in Figures 2 A-G. (Yüzbasıoglu *et al.*, 2014).

Table I. Differentiation of sexual dimorphism in human skulls.

Feature	Female Skull	Mal Skull
Front	More vertical.	More backwards inclined.
Glabella	Not protruding; continuation of the frontal-nasal profile.	Glabella and protruding superciliary arches.
Frontal-nasal joint	Curve.	Inclined.
Supraorbital margins	Cutting.	Rhombus.
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.	Larger

Table II. Mean and SD values of the piriform aperture parameters of both sexes. N=64. Source: Anatomy Laboratories - Department of Morphological Sciences (FIP and UFPE).

Parameters	MALE		FEMALE		COMBINED		p
	Min- Max	Mean (SD)	Min-Max	Mean (SD)	Min-Max	Mean (SD)	
R-ANS (mm)	25.0- 35.8	31.4 (3.3)	23.2-32.8	29.4 (3.9)	23.2- 35.8	30.6 (3.6)	0.31
PA-W (mm)	22.5- 31.0	25.7 (1.9)	20.2-30.5	25.7 (2.5)	20.2-31.0	25.7 (2.2)	0.97

R-ANS: Height measurement; PA-W: Width measurement; N: number; Min: Minimum*; Max: Maximum*; SD: standard deviation; p: level of significance.

Table III. Piriform aperture types percentage. Source: Anatomy Laboratories - Department of Morphological Sciences (FIP and UFPE). Source: Anatomy Laboratories - Department of Morphological Sciences (FIP and UFPE).

SEX	TYPES							Total n (%)
	Type I n (%)	Type II n (%)	Type III n (%)	Type IV n (%)	Type V n (%)	Type VI n (%)	Type VII n (%)	
Male	17 (43.6)	-	-	1 (2.6)	7 (17.9)	2 (5.1)	12 (30.8)	39 (60.9)
Female	8 (32.0)	1 (4.0)	-	1 (4.0)	5 (20.0)	1 (4.0)	9 (36.0)	25 (39.1)
Combined	25 (39.1)	1 (1.6)	-	2 (3.1)	12 (18.7)	3 (4.7)	21 (32.8)	64 (100)

Type I: pear shape; Type II: inverted heart shape below the level of the anterior nasal spine; Type III: diamond shape; Type IV: inverted heart shape at the level of the anterior nasal spine; Type V: oval shape; Type VI: trapezoidal shape; Type VII: round shape.

DISCUSSION

This study was performed with cadaveric skulls and a digital caliper rule. This choice yielded some advantages.

i.e.: to accurately classify the male and female sexes; the ability to increase the sample number; do not subject

individuals to radiation as in other studies (Prado *et al.*, 2011; Yüzbasıoğlu *et al.*, 2014).

The analysis of the obtained data from the piriform aperture is very important for the plastic surgery, pulmonology, buco-maxillofacial surgeries and otolaryngologists areas. It can decide the most effective procedure, for example: osteotomies (Prokop, 2000; Karadag *et al.*, 2011).

Studies have suggested that the width and shape of the piriform aperture are extremely important when it comes to good-quality nasal breathing (Prokop, 2000; Lee *et al.*, 2006). It is also known that the moistening and heating of the inspired air are better with a narrow piriform aperture, and the shape of this structure is a relevant factor for climate adaptations (Hawang *et al.*, 2005).

In our results, the R-ANS was higher than the Germans' and Koreans' papers (Lang & Baumeister, 1982, obtained from the study by Hwang *et al.*; Lee *et al.*, 2008), but lower than the Turks (Table IV) (Yüzbasıoğlu *et al.*). The width (PA-W) was wider than the Turks (Table IV) (Yüzbasıoğlu *et al.*), Korean, Caucasian, German, Austrian, Anatolian and American results, and smaller than in black people (Table IV) (Lang & Baumeister, 1982, obtained from the study by Hwang *et al.*; Hoffman *et al.*, 1991; Ofidile, 1994; Hommerich & Riegel, 2002; Karadag *et al.*, 2011).

The width of the piriform aperture increases twice in size, starting from infancy to adulthood, continuing its development even after the age of twenty (Cantín López *et al.*, 2009). In many studies, height (R-ANS) and width (PA-W) is higher in men than in women (Table IV) (Hommerich & Riegel, Erdem *et al.*, 2004; Lee *et al.*, 2008; Cantín López *et al.*). The width (PA-W) of the Korean population is narrower in women (Table IV) (Hwang *et al.*). It was

analyzed that in the black people the width (PA-W) is wider than in whites (Table IV) (Hoffman *et al.*). In our evaluation it was observed that the males mean height (R-ANS) was higher, but without significant differences, and the width (PA-W) shows equal results for both sexes (Table IV).

Regarding the shape of this facial structure, it was observed that the predominant format in African and African American individuals was oval, and triangular in the American, Indian and Austrian population (Ofidile). In Turkey the pear form was also observed for both sexes (Yüzbasıoğlu *et al.*). In our study the most present form was the pear in men and rounded in women. This last result differs from all previous studies, showing that in Brazilian Northeast this form is the most evident in female human skulls.

In view of these data, a new form of piriform aperture presentation was known in women. This finding leads to a greater knowledge of this anatomical structure, related to the sex of the individual, which may be of great relevance in the surgical decision involving this facial area.

CONCLUSION

The study concluded that, for a population from northeastern Brazil, the mean height (R-ANS) of the piriform aperture was higher in the male sex compared to the female, but without significant differences. The width (PA-W) shows an equal average for both sexes. A high percentage of the masculine pear type and female rounded type were also observed. When we combined both sexes it was observed that the pear-shape type was predominant. The results obtained in this study showed the importance of the morphological knowledge of the piriform aperture. The unusual shape found in women in our study may contribute

Table IV. Means of piriform aperture comparison.

Studies	Population	Height			Width		
		M	F	Total	M	F	Total
Our study	Brazilian	31.4	29.4	30.4	25.7	25.7	25.7
Hwang <i>et al.</i> (2005)	Korean	30.1	28	29	25.7	25.4	25.5
Lee <i>et al.</i> (2008)	Korean	-	-	-	24.34	22.82	23.5
Yüzba <i>et al.</i> (2014)	Turk	33.4	30.1	31.7	24.6	23.3	23.9
Lang & Baumeister (1982) (Apud Hwang <i>et al.</i> , 2005)	German	-	-	29.1	-	-	23.6
Hommerich & Riegel (2002)	German	-	-	-	23.6	22.6	23.1
Hoffman <i>et al.</i> (1991)	White A	-	-	-	-	-	23.7
	Black A	-	-	-	-	-	26.7
Karada <i>et al.</i> (2011)	Anatolia	-	-	-	18.83	18.19	18.5
Ofodile (1994)	Austrians	-	-	-	-	-	21.6
	Americans	-	-	-	-	-	23.4

Source: Yüzbasıoğlu *et al.* (2014). M: male; F: female; A: Americans.

as a reference for future studies related to the area and in the surgical area. Besides it may lead to valuable information to help in a better surgical decision involving osteotomies and plastic reconstructions.

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RESUMEN: La apertura piriforme es una estructura anatómica generalmente en forma de pera, formada por algunos huesos faciales. El conocimiento de su presentación morfológica es de importancia en los procedimientos quirúrgicos. Este estudio tuvo como objetivo analizar la morfometría y la forma de la apertura piriforme en cráneos humanos, teniendo en cuenta el dimorfismo sexual de esta estructura. Se evaluaron cien cráneos humanos y las mediciones se realizaron con una regla de pinza digital. Se analizaron dos parámetros: la altura de la apertura piriforme - distancia entre el margen inferior de la sutura internasal y la espina nasal anterior; ancho de la distancia mayor en un plano transversal. Su forma fue evaluada según siete tipos descritos en la literatura y la diferenciación de sexo (basada en el marco de Vanrell). Para el análisis de datos entre los sexos, se utilizó la prueba t de Student ($p < 0,05$; IC: 95 %). En este estudio se observó que la altura (R-ANS) de la apertura piriforme en los hombres (31,4 mm) era más alta que en las mujeres (29,4 mm), sin diferencias significativas. El ancho (PA-A) tenía valores medios iguales para ambos sexos (25,7 mm). En cuanto a la forma de la apertura piriforme, se encontró que el tipo I (pera) es el más común en los hombres (43,6 %) y en las mujeres el tipo VII (redondeado) es el tipo predominante (36 %). Cuando se evaluaron los sexos en conjunto, se observó que el más común fue el tipo I (pera - 39,1 %) y los menos comunes fueron el tipo III (diamante - 0,0 %), tipo II (corazón invertido - bajo la espina nasal 1,6 %) y tipo IV (corazón invertido a nivel de la espina nasal - 3,1 %). El conocimiento de estos datos morfométricos y formatos de apertura piriforme es esencial para los procedimientos quirúrgicos que involucran esta región anatómica. Los resultados, en particular los relacionados con la forma de la apertura piriforme en las mujeres, pueden contribuir al trabajo futuro relacionado con esta estructura facial, lo que llevará a mejores decisiones quirúrgicas.

PALABRAS CLAVE: Apertura piriforme; Cráneo humano; Anatomía.

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