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Three-Dimensional Anatomical Landmarks of the Sphenoid Ostium for a Safer Transsphenoidal Approach

Daha Güvenli Bir Transsfenoidal Yaklaşım için Sfenoid Deliklerin Üç Boyutlu Anatomik Kılavuz Noktaları

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ABSTRACT

AIM: The sphenoid ostium (SO) is an anatomical reference in transsphenoidal approach surgery.

MATERIAL and METHODS: The morphological features of the SO were studied in 352 skull base by 3D-Doctor Demo version.

RESULTS: The mean diameters of the SO were measured as 5.8 ± 1.3 mm (right) and 5.9 ± 1.2 mm (left), respectively. The mean distance from the SO to the midline was measured as 2.3 ± 1.1 mm (right) and 1.8 ± 0.9 mm (left), respectively. 8 bones had SO on one side, whilst 4 bones had no SO. In 5 bones there was a double SO structure on one side. 74.4% of ovoid SO specimens have the largest perimeter, therefore, allow the highest degree of surgical success. It was noted that they were not symmetrical (21.8%). Openings were found to be at different distances from the midline, some at different distances from the floor; in addition, differently shaped openings, as well as those with an opening absent on one side or with double openings, were observed.

CONCLUSION: Separate coordinates and safe routes must be calculated for right and left openings. The SO analysis could eliminate some of standardization measurements of an exposed surgical area.

KEYWORDS: Sphenoid ostium, Sphenoid sinus, Transsphenoidal approach

ÖZ

AMAÇ: Sfenoid ostium (SO), transsfenoidal yaklaşımlı cerrahide anatomik bir referanstır.

YÖNTEM ve GEREÇLER: SO morfolojik özellikleri 3D-Doctor Demo versiyonu ile 352 kafa kaidesinde çalışıldı.

BULGULAR: Ortalama SO çapı 5,8 ± 1,3 mm (sağ) ve 5,9 ± 1,2 mm (sol) olarak ölçüldü. SO'dan orta hatta kadar ortalama mesafe 2,3 ± 1,1 mm (sağ) ve 1,8 ± 0,9 mm (sol) olarak ölçüldü. 8 kemikte SO tek taraflı iken 4 kemikte SO yoktu. 5 kemikte bir tarafta çift SO yapısı bulunmaktaydı. Ovoid SO numunelerinin %74,4'ü en büyük perimetreye ve böylece en yüksek cerrahi başarı derecesine sahipti. Bunların simetrik olmadığı (%21,8) görüldü. Açıklıklar orta hattan farklı mesafelerde ve bazıları zeminden farklı mesafelerdeydi; ayrıca farklı büyüklükte şekiller ile birlikte bir tarafta açıklık olmayanlar veya çift açıklığı olanlar gözlendi.

TARTIŞMA: Sağ ve sol açıklıklar için farklı koordinatlar ve güvenli yollar hesaplanmalıdır. SO analizi, açığa çıkarılmış bir cerrahi alanın standardizasyon ölçümlerinin bazılarını ortadan kaldırabilir.

ANAHTAR SÖZCÜKLER: Sfenoid delik, Sfenoid sinus, Transsfenoidal yaklaşım

INTRODUCTION

The sphenoid sinuses border the hypophysis from the nasal cavity (4, 5, 8, 13, 15). The trans-sphenoidal approach is the most frequently used surgical procedure in determining sellar tumors. While following this approach, the surgeon, before entering the sphenoid sinus, checks some of the details about the location of the trajectory whether it is placed at or very near to the midline, or is located at the level of the sella turcica. The surgeon will depend on both sphenoid ostiums (SOs) for orientation (12, 17, 18).

In literature, there are a number of anatomical studies which have submitted variable measurements on the sphenoid sinus and the SO (7, 8, 11, 12, 14, 17). Most researchers have been concerned with the distances in reaching the sphenoid sinus and have conducted studies on this subject. There have been a substantial number of studies dealing with the subject of measurements between the SO and the nostrils.

The interest in the trans-sphenoidal approach requires knowledge regarding the morphometric aspects of the SO and structures around it (1, 4, 5, 11, 13, 16, 17). The main problem is whether the shape, size, and angle of the SO alter the surgical technique (12, 16). Even though studies regarding the importance of anatomical features of the SO serve as milestones in pituitary surgery, more detailed studies are required (4, 8, 12, 16). There are only a few studies examining the location of the SO and their related structures in detail. This study has been proposed as the determination of the shape, length, width and some distances of the SOs are crucial in assessing the orientation point in cases requiring pituitary surgery. The superior limit of the SO along the anterior sphenoidal wall, dimensions of the opening, their location on the wall, and the opening type and asymmetry are important for the safety of the trans-sphenoidal approach.

MATERIAL and METHODS

The measurements of the dimensions and localization of the SO were based on 144 crania, 208 sphenoidal bones, 704 parts of adult dry skulls of unknown age and sex obtained from the Turkish population.

The photographs were taken with the macro mode of a Sony DSC H1 5.1 megapixel camera. The photos were taken in aperture priority mode, with f3.5 diaphragm clarity and at 4 zoom adjustment. The skulls were fixed horizontally. Then, the shots were made by fixing the camera 37.5 cm away from the SO by means of a tripod at an angle of 78º with the horizontal surface. The photos were then uploaded onto a computer and the specific software 3D-Doctor V 3.5.050402 Demo version program was studied to calculate the surface areas of the reflections of the SO (Figure 1). With the aided software, their contours of the SOs were manually limited and their perimeter, shape, area and relation with the other structures were evaluated on the right and left sides separately.

Some of measurements of the SOs are presented on the photo in Figure 2. The measured distances between two different points were as following (Figure 2):

1. The length of the SO,
2. The width of the SO,
3. The perimeter of the SO,
4. The area of the SO,
5. The distance of the opening from the midline,
6. The upward displacement of the ostium,
7. The downward displacement of the ostium.

The statistics were calculated for all the parameters. Divergence in the data of skull measurements was examined by using the Student t-Test. The Pearson correlation test was applied in the statistical analysis that was derived from four values (the length and area; the width and area; the perimeter and area, and the diameter and area). For all the analyses, $p<0.05$ was accepted as statistically significant, while $p<0.01$ was accepted as highly significant.

Macroscopic morphology of the SO and its classification types according to its shape are as follows (Figures 1-6):

1. Ostium size (a. absent, b. single, c. double).
2. Location (a. normal, b. high, c. at different levels).
3. Location on the midline (a. zero distance, b. equal distance, c. different distance).
4. Shape (a. oval, b. round, c. fusiform).

RESULTS

The SOs were located laterally to the sphenoidal crest. The SOs were ovoid shape and convex downward, face downward laterally. Their long axes were directed forward and laterally. The greater diameter of SO was more often vertical than oblique or horizontal. The sinuses communicated with the nose via the sphenoethmoidal recess. This recess was bounded by the bone septum medially, the upper and supreme turbinate laterally, and the roof of the nasal cavity superiorly (Figures 1; 2; 3A,B; 4A-C; 5A-C; 6A-C).

Measurement: The largest diameters of the SO were found to be 5.8 ± 1.3 mm (right) and 5.9 ± 1.2 mm (left), respectively.

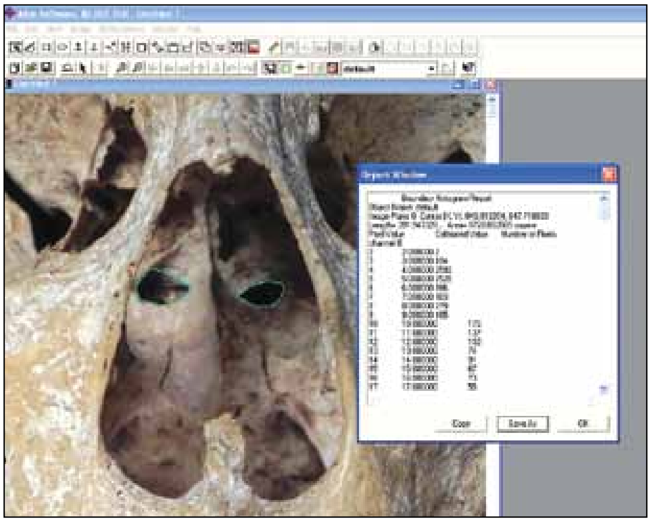

Figure 1: Perimeter measurement of the sphenoid ostium using Able Software Corporation 3D-Doctor V 3.5050402 Demo version.

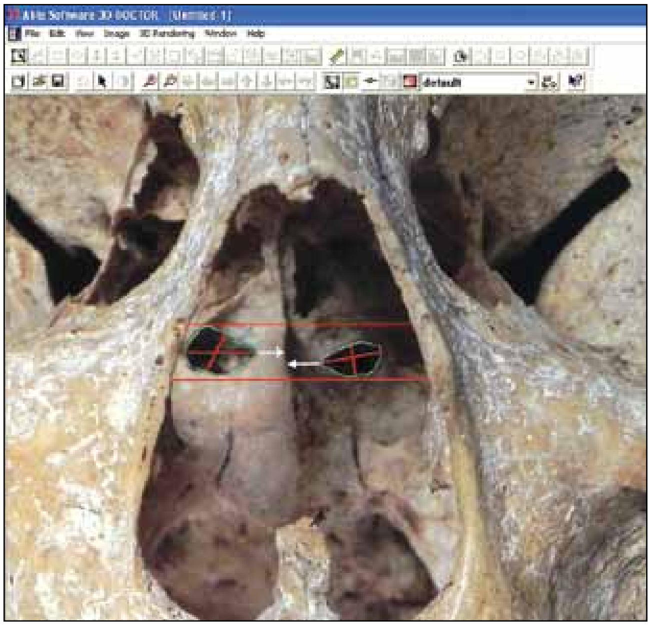

Figure 2: Calculation of some of the measurements made of the sphenoid ostium.

The mean distance from SO to the midline was measured as 2.3 ± 1.1 mm (right) and 1.8 ± 0.9 mm (left), respectively. At the superior margin of the opening, an upward displacement of 1.22 ± 0.2 mm and downward displacement of 1.15 ± 0.3 mm were found. The results have been presented in Table I. The circumference of SO was found to be 18.31 ± 3.27 and 18.44 ± 3.53 mm in the right and left, respectively. The area of SO was measured as 18.9 ± 7.01 and 19.79 ± 7.78 mm^2 in the right and left, respectively. There was no statistically significant difference between the left and right sides.

Opening size: Opening types observed were no opening; single opening; one on each side; and unilateral double opening. Out of a total of 352 bones, single bilateral SO structures were observed in 335(95.2%). In 8 (2.3%), an SO was absent on one side (Figure 4B), in 4 (1.1%) no SO was found (in either opening) (Figure 4A). Whilst in 5 bones (1.4%), a double so structure on one side was noted (Figure 4C).

Location: In 284 skulls, the inferior and superior edges of both SO were found at the same height (Figure 5A). It was

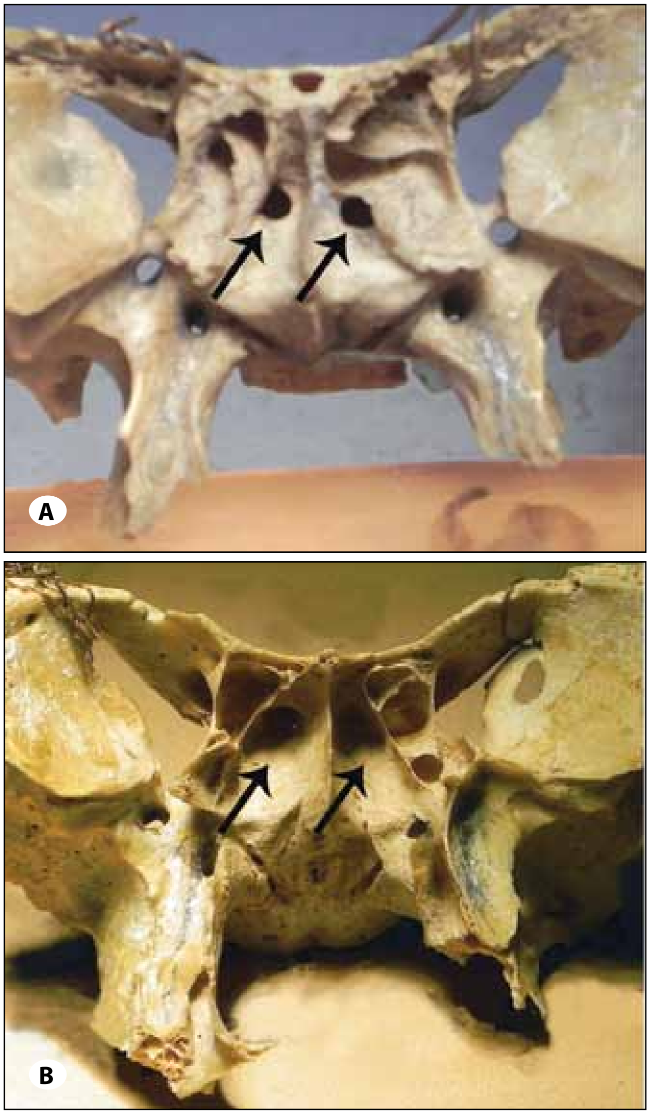

Figure 3: Sphenoid ostium located on the anterior wall of the sphenoidal sinus, **A)** an ostium with normal location, **B**) ostium with high location.

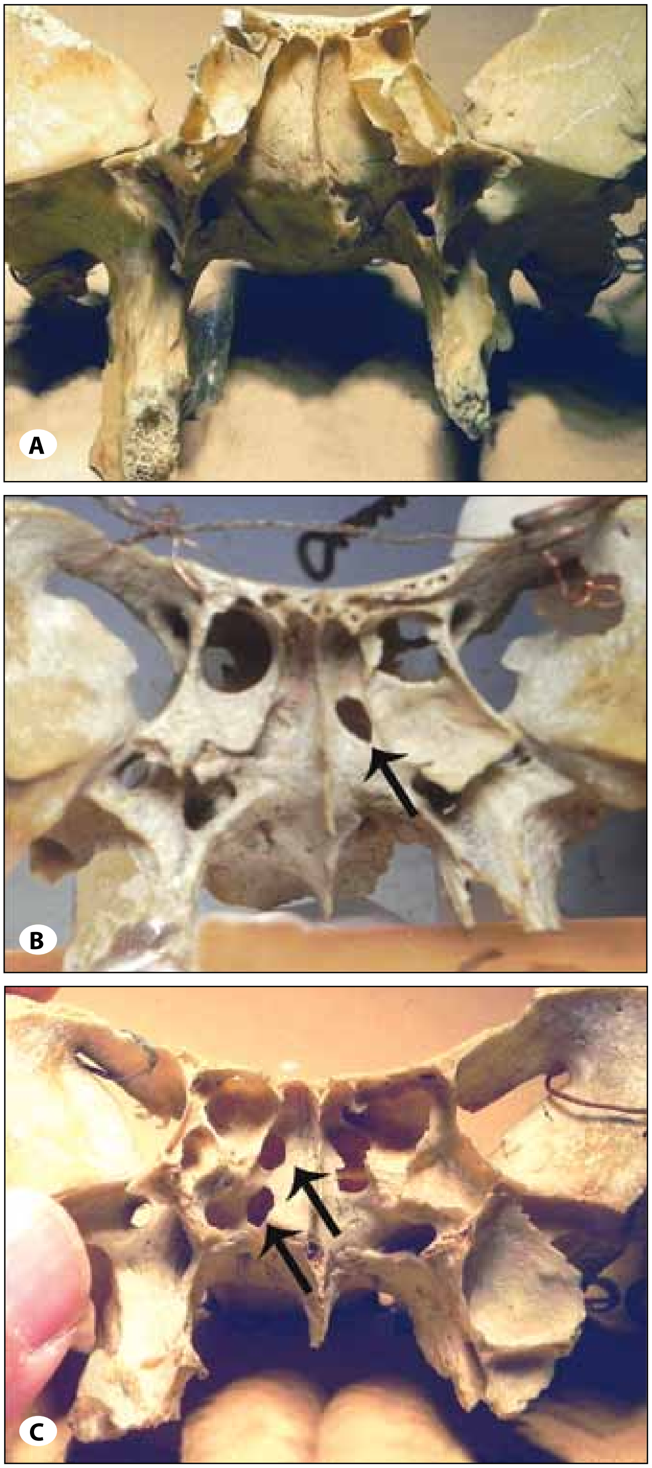

Figure 4: Different sphenoid ostium types, **A)** the absence of bilateral hole, **B**) the presence of one-sided hole, **C)** a double hole on the right side.

Table I: Comparison Between Both Sides for the Values of Distances (mm)

Measurement	Right side			Left side			t	p
	Mean	Standard deviation	Minimum-Maximum	Mean	Standard deviation	Minimum-Maximum		
Diameter great	5.77	1.30	3.49 - 9.59	5.93	1.19	3.93 – 9.1	-1.909	0.066
Diameter small	4.15	1.27	1.27 - 8.17	4.06	1.07	1.82 – 6.83	-1.129	0.268
Perimeter	18.31	3.27	11.03 - 27.03	18.44	3.53	11.86 - 27.31	-1.909	0.066
Square	18.9	7.01	6.98 – 39.75	19.79	7.78	7.18 - 43.05	-1.254	0.219
Distance from midline	2.03	1.09	0.38 - 4.8	1.79	0.91	0.38 - 4.07	-0.435	0.667
Upward displacement	1.22	0.24	0.75 - 1.83	1.42	1.2	0.6 – 1.5	0.753	0.458
Downward displacement	1.15	0.33	0.12 - 1.66	1.14	0.2	1.1 – 2.6	-1.233	0.227

determined that both openings were at equal distances from the base and top of the sphenoid bone. In these samples, the SO could easily be seen on the anterior surface of the sphenoid body. The superior edges of both SO were found to be high and the same height in 35 skulls (10.1%). In the 35 samples, it was determined that the upper margins of the openings were very high (Figure 3B). Thus, in 29 skulls (8.3%) the lower and upper margins of both SO were situated at different levels (Figure 5C). The border displacement of the edges between the upper margins of openings at different levels in the same skull were calculated as 1.22 ± 0.24 mm on average (range: 0.75 - 1.83). As for the difference in levels between the lower margins of the openings, it was measured as 1.15 ± 0.33 mm (range: 0.12 - 1.66).

Location relative to the midline: The distance from the internal edge of the right and left SO to the midline was 2.03 ± 1.1 mm and 1.79 ± 0.9 mm on average (Figure 2). In 214 skulls (61.5%), the SO was located within the 1.1 - 4.7 mm range. There were 62 SOs that were closer than 1 mm to the midline, an incidence of 17.8%. In 72 skulls (20.7%), the SOs were situated at different heights on each side; also a great variability in the distance from the midline was found (Figure 5C).

Shape: Upon examination of the shapes of the openings, it was calculated that 78.2% of them were symmetrical, whilst 21.8% were asymmetrical. Their shapes were determined as oval, round and fusiform. The SO was ovoid in 74.4% (Figure 6A), round in 15.4% (Figure 6B), and there was a fusiform opening in 10.2% (Figure 6C).

DISCUSSION

Most of the transsphenoidal approaches necessitate location both of sphenoid sinus and morphometrical analysis of the SO (2, 12, 16). There are many articles that have focused on the anatomy of the sphenoid sinuses, based on their shapes and the diameters of their cavities (1, 4, 5, 14-16). Nevertheless it has been observed during surgery that the pattern of the SO in the transsphenoidal approaches was not as plain as had been reported by a number authors (1-5, 10, 13-16). Most researchers have been concerned with distances in reaching the sphenoidal sinus and have conducted studies on this (6, 8, 16, 17). What has been overlooked and neglected is the anatomy of the opening. There is a substantial amount of data regarding diameter measurement values. It is a fact that in previous studies some standardization errors have been made in the area of measurement procedures. In our study a clear standardization has been achieved. The findings were data obtained through computer-assisted three-dimensional landmarks for use in three-dimensional planning.

The SOs are situated in the longitudinal axis at the middle level of the floor of the sphenoid sinus. Therefore, they are good landmarks for the surgeon to determine the orientation of the approach (4, 5). Kim et al. asserted that the best anatomical reference enabling the identification of the SO is the posteroinferior end of the superior turbinate, where each cavity is located medially and superiorly (12). In addition, they found that both openings were situated halfway between the superior and inferior margin of the sphenoid sinus anterior wall. Similar to Lang, Enatsu et al. propounded that both SOs were located almost halfway on the anterior aspect of the sphenoid bone vertically; they also alleged that the spatial orientation of both relative to the carotid artery and the optic nerve showed no remarkable variation in their study (9, 13). They resolved, however, that vertical and horizontal data of each SO varied significantly (9).

Our study aims to present a systematic and comprehensive classification of the SO, based on its shape, and reveal the SO anatomy. An evaluation was made of the number of openings, their location, and distances from the midline and floor (Figure 2). Various SO types and shapes have been described, including bilateral absent SO, SO close to the midline, SO at differing distances from different levels and fusiform opening shapes. The most common opening shape of the SO was ovoid (74.4%).

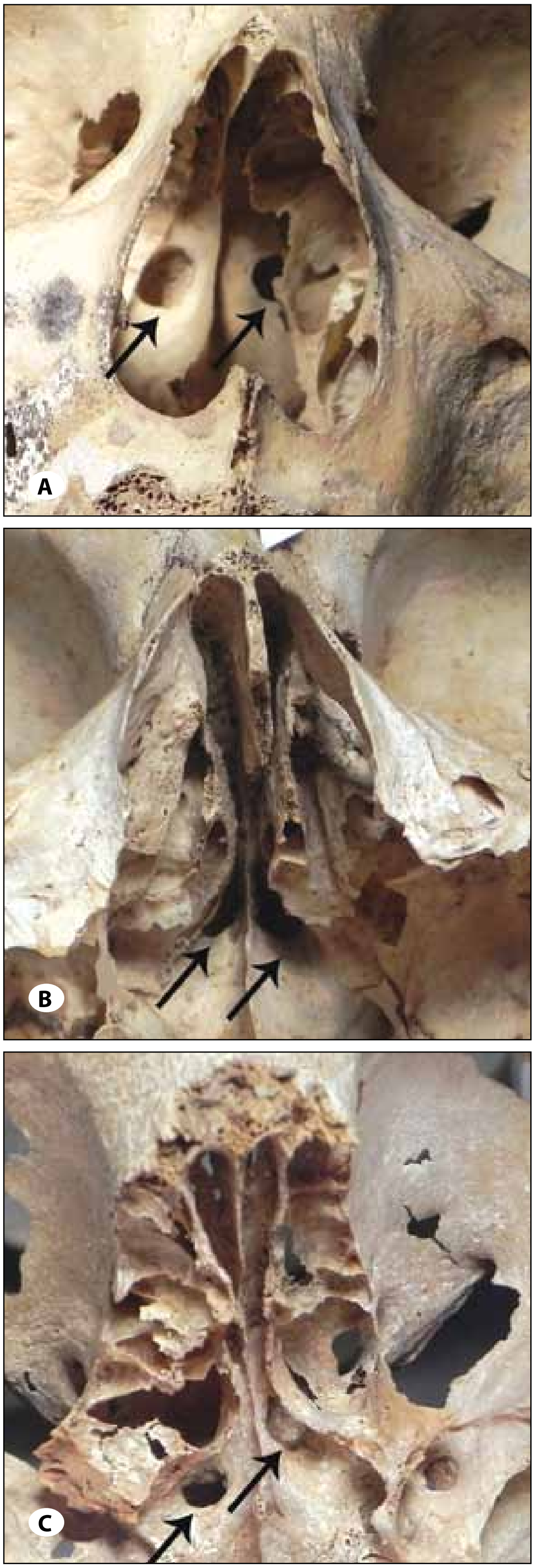

Figure 5: A) Ostiums at equal distances from the midline, **B)** ostiums at zero distance from the midline, **C)** ostiums at differing distances from the floor and the midline.

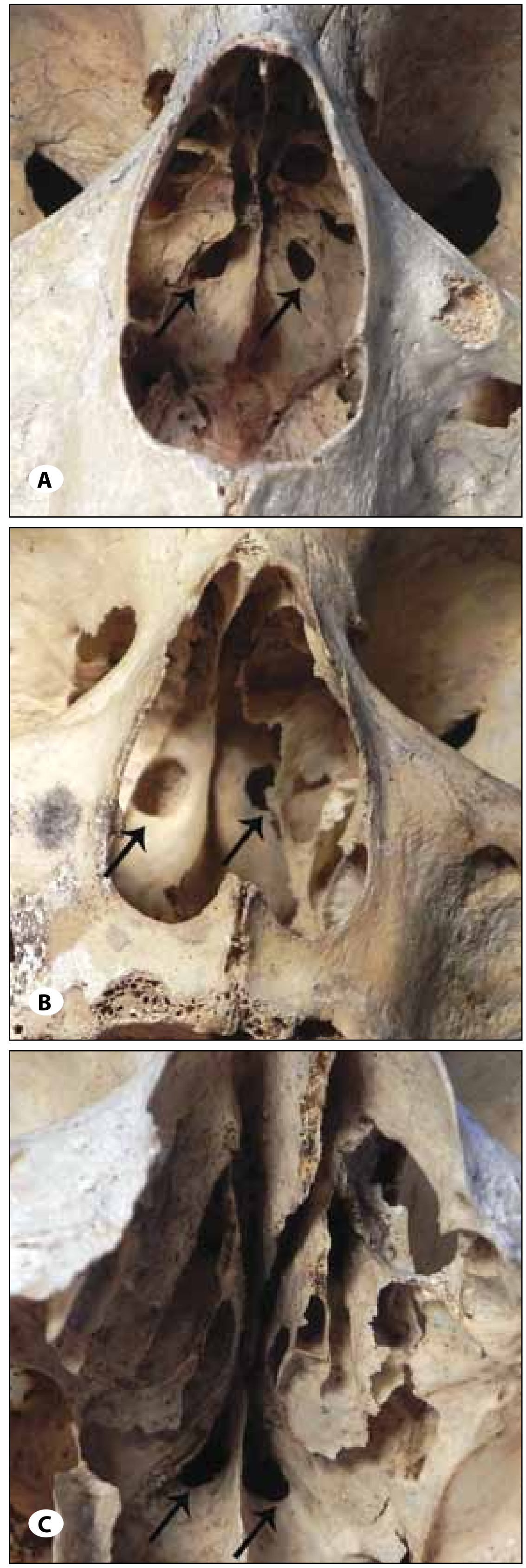

Figure 6: Ostiums with different shapes **A)** oval, **B)** round, **C)** fusiform.

We think that the chances of surgical success will improve in transsphenoidal intersections in cases where the safe corridor may be larger owing openings which were at equal distances from the median, at the same level, on the midline and ovoid (Figure 5A). The distance of the openings from the midline is also an important anatomical factor. In previous study, Campero et al. remarked that the left SO is generally not situated on the same horizontal plane as the right SO; they have also reported that both SO are often close to the midline, sometimes they are several milimeters away from it (4, 5). One of the SOs is generally located at a different level in comparison with the opposite one; in addition, in terms of distance from the inner margin of the SO to the midline there is great variability. The closer the opening is to the midline and the more symmetrical they are, the freer the corridor for transsphenoidal approaches becomes. On average, the distance from the inner margin of the right and left SO to the midline was 2.03 and 1.79 mm (range: 0.2 - 5. 3 mm). This presents the great variability observed in the location of the SO in relation to the midline; in some skulls, where the SO was located far away from the midline (Figure 5A), whereas in others, both SO were practically abutting (Figure 5B). In some, it was determined that the right and left openings were at differing distances (Figure 5C). In SOs which were located very close to the midline (Figure 5B), very high off the floor (Figure 3B), double openings (Figure 4C), absence of SO (Figure 4A, B) or at different distances from the floor or the midline (Figure 5C), SO may, the clinical picture may be blurred.

In transphenoidal routes, the ones with the largest perimeter are ovoid specimens that allow the most surgical success (Figure 6A). The high frequency rate of ovoid shape opening (Figure 6A) (74.4%) and round opening types (Figure 6B) (15.4%) improve the chances of success (85%) in techniques. In the other type that includes a fusiform opening shape (Figure 6C), the opening surface is quite narrow and this might lead to problems in orientation. The quite low incidence of these types (10.2%) is in fact fortunate. SO types with a narrow area and fusiform shape SO are among those that are not suitable for use as a transsphenoidal corridor.

Upon examination of both opening structures, it was noted that they were not symmetrical (Figures 4B,C; 5C). The incidence of these is quite high (21.8%). Ostiums at varying distances from the floor, differently shaped openings and those with absence of opening on one side or with bilateral openings were determined. This situation necessitates separate coordinates for right and left openings, and the calculation of safe transsphenoidal corridor routes.

The anatomical and biomechanical results of transsphenoidal routes to the pituitary gland with an opening at different levels are different from those obtained with symmetrical SO. At the level of the well-pneumatized sphenoidal sinus, there are a series of differences in location, diameter and the shape of SO that must be identified by endoscopic surgeons that use the transsphenoidal corridor.

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