

Evaluation of the surgical anatomy of sphenoid ostium with 3D computed tomography

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Abstract

Purpose To evaluate the anatomy of the sphenoid ostium (SO), which has so far only been investigated with the aid of two-dimensional computed tomography (CT) or using a cadaver, from a new point of view through the use of 3D CT for the first time.

Methods We have evaluated 50 patients who had CT angiography done for different reasons. The sphenoid sinus types and the SO were evaluated three dimensionally. The average diameters of the sphenoid ostia, and their distances to the midline, as well as to each other and the choana have been measured. In addition, the SO were categorized according to their shapes.

Results The average age of the patients was 48.5. No SO was found in seven cases (14 %). The average distance of the SO to the midline was 2.78 mm on the right side and 2.77 on the left. Four different shapes of SO were determined; round, oval, irregular and linear. The average distance of the right and left SO to the choana was 15.22 ± 0.95 and 14.87 ± 1.11 mm, respectively. No statistically significant difference was found between the male and female sexes with regard to the calculated diameters and shapes of the SO ($p > 0.05$).

Conclusion The anatomy of the sphenoid sinus and the SO varies widely from individual to individual. We have demonstrated in our study that these anatomic variations could be evaluated pre-operatively. Using this imaging

technique, surgeons can make a pre-operative 3D evaluation of the sphenoid ostium, encountered in the surgery and thus achieve better orientation.

Keywords Sphenoid ostium · Sphenoid sinus · Transsphenoidal surgery · 3D computed tomography · Choana

Introduction

The sphenoid sinus is an important pathway to reach skull base pathologies, especially in the sellar region. Both neurosurgeons and otolaryngologists primarily aim to reach the sphenoid ostium (SO) using this path. Some writers have claimed that the SO is the most important landmark for endoscopic transsphenoidal surgery [7, 8]. Kim et al. [8] have pointed out that the posteroinferior end of the superior turbinate is the best landmark for determining the locations of the SO. However, due to conditions such as paradoxical middle turbinate, bifid middle turbinate, paradoxical uncinate process, and pneumatized uncinate process, it might be difficult to correctly locate the superior and middle turbinates in some patients [13]. In addition, the anatomical features of the sphenoid sinus and the SO might show a great variety depending on the person. There might be considerable anatomical differences between the right and the left sides even in the same person [2, 5]. Considering all this, the importance of meticulous evaluation of the anatomical structures in the pre-operative period for each patient appears evident.

The purpose of this study is to evaluate the anatomy of the sphenoid ostium, which has so far only been investigated with the aid of two-dimensional computed tomography (CT) or using a cadaver, from a new point of view

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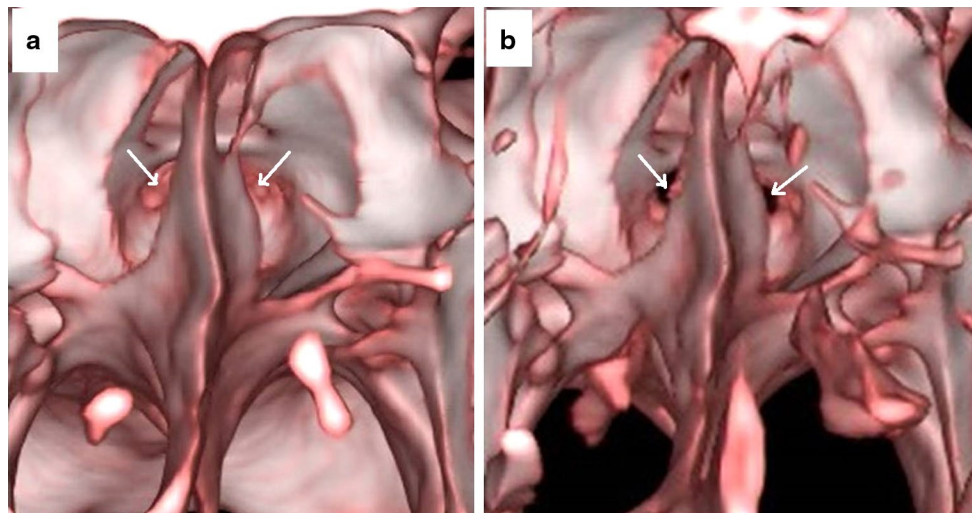


Fig. 1 **a** Sphenoid ostium cannot assess clearly due to the superposition of the structures behind the front wall of the sphenoid sinus in a 58-year-old woman. **b** After removal of these structures in the same 3D CT, sphenoid ostium is seen more clearly. (arrows sphenoid ostium)

through the use of 3D CT for the first time. It is also to emphasize the contributions it might be able to provide to the surgeon in the pre-operative period, since this method yields images that are similar to what the surgeon will be encountering during the surgery.

Materials and methods

Between the dates of 01.06.2012 and 04.04.2013, we have evaluated 59 patients who had CT angiography done for different reasons at our centre. The scans of nine patients in which the anatomical details were affected by the artefacts resulting from the patient and the scan technique could not be evaluated. As a result, results of 50 cases (23 men and 27 women), whose SO could be evaluated three dimensionally have been demonstrated in the study. On the other hand the exclusion criteria were as follows: have a history of sinus surgery or craniofacial trauma, have routine contraindications for contrast-enhanced CT, and pediatric patients.

The images were evaluated with a 64-detector-row CT (Philips Brilliance CT scanner; Philips Medical Systems, Cleveland, Ohio) with the following scan parameters: 300 mAs, dose 120 kV, detector collimation 0.625 mm, pitch 0.9, gantry rotation time 0.75 s, and slice thickness 0.90 mm. A volume of 75 ml of non-ionic contrast agent was injected through an antecubital vein at a rate of 4.0 ml/s with an automatic power injector. The images were sent to our archive system.

The same radiologist reconstructed the images. Anatomical structures were evaluated through 3D rendering. We used bony window and only bony ostium was analyzed in the study. Sphenoid sinus has three types which

were described well in the literature [3]. Classification of sphenoid sinus types is based on according to its degree of pneumatization; (1) conchal type sinus with minimal extension; (2) presellar type sinus, expanding posteriorly to the anterior sellar wall; and (3) sellar type, extending below the sella or farther. First the sphenoid sinus types were defined as mentioned above, and then the sphenoid ostia (SO) were evaluated. To examine the SO better, the structures behind the sphenoid front wall have been removed (Figs. 1, 2). The average diameters of the sphenoid ostia, and their distances to the midline, as well as to each other and the choana have been measured (Fig. 3). In these calculations, we considered the closest point of the SO to the target measured. In addition, the SO were categorized according to their shapes. Overall, four types ended up prominent: round, oval, irregular, and the linear type whose transfer diameter is quite small compared to its vertical diameter (Fig. 4).

Statistical analysis was performed using the Statistics Package for Social Sciences software (SPSS 18.0 for Windows). All values were given as mean \pm SD. The normalization of the data was analyzed with Kolmogorov–Smirnov test. The Mann–Whitney *U* test was used in comparing the nonparametric continuous values, and Chi-square tests were used for categorical series. A *p* value of <0.05 was considered statistically significant.

Results

SO of 50 patients (84.75 %) could be evaluated in all 59 by the 3D CT imaging. The average age of the patients evaluated in the study was 48.5, (the range was 17–86). In 47 cases (94 %) a sellar type, and in 3 cases (6 %) a

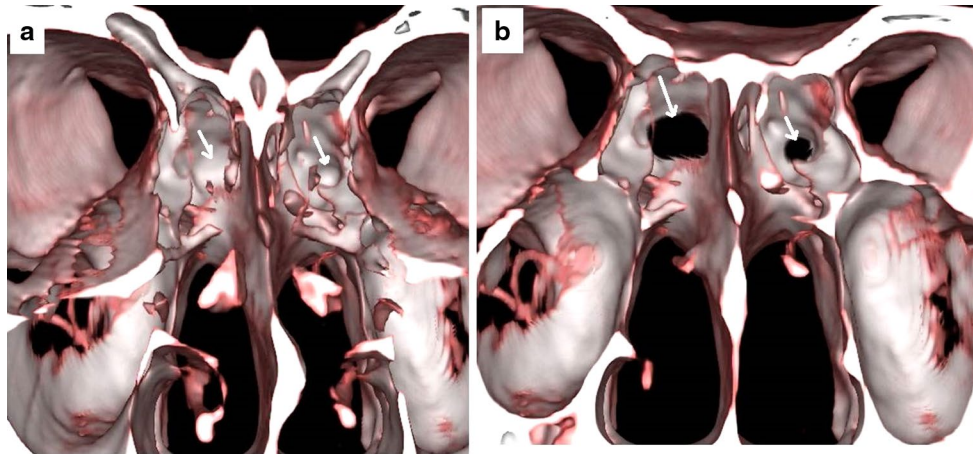


Fig. 2 3D CT images of a 38-year-old woman. Sphenoid ostium is shown before (a), and after (b) removal of the structures behind the front wall of the sphenoid sinus (arrows sphenoid ostium)

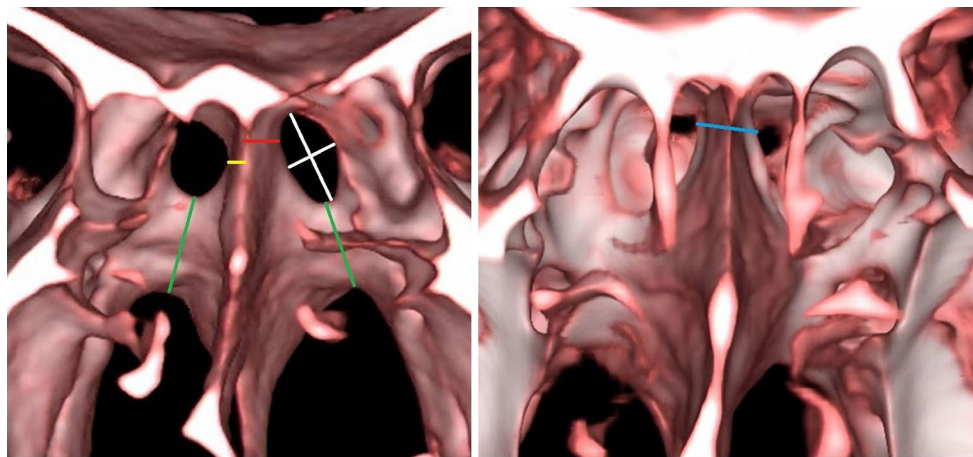


Fig. 3 Measurements of the sphenoid ostium obtained from 3D CT; red and yellow lines distance from left and right ostium to the midline, green line distance from right and left ostium to the roof of the

choana, blue line distance between medial margins of two sphenoid ostia, white lines inner diameters of sphenoid ostium (vertical/transverse)

presellar type sphenoid sinus were observed. There was no conchal type. No SO was found on the right side in four cases (8 %), and the left side in three cases (6 %). In a total of seven cases (14 %) the SO was only on one side (Fig. 5). The average distance of the right SO to the midline was 2.78 mm, (range 0.96–5.78 mm); and the average distance of the left SO to the midline was 2.77 mm (range 1.08–6.80 mm). There was no statistically significant difference between right and left SO in terms of distance from SO to the midline ($p > 0.05$). The average distance of the SO to each other was observed to be 5.52 mm (range 2.38–11.66 mm) (Table 1).

Four different shapes of SO stood out in general. As their right SO, 14 of the patients (28 %) had round, 4 (8 %) had irregular, 10 (20 %) had linear, 18 (36 %) had oval shapes, and SO were not found in 4 patients (8 %). As the

left SO, 12 (24 %) had round, 10 (20 %) had irregular, 8 (16 %) had linear, 17 (34 %) had oval shapes, and SO were not found in 3 (6 %). In 16 patients (32 %), the shape of the SO was symmetrical on the right and the left side, and in 34 patients (68 %) it was asymmetrical.

The average distance of the right SO to the choana was 15.22 ± 0.95 mm (range 13.50–16.90 mm), and for the left SO it was 14.87 ± 1.11 mm (range 12.10–17.10 mm). The average transverse diameter of the SO was 1.98 ± 0.99 mm (range 0.80–4.80 mm) on the right, and 2.24 ± 1.03 mm (range 0.53–5.3 mm) on the left. The average vertical diameter was observed as 2.60 ± 1.19 mm (range 0.94–6.91 mm) on the right, and as 2.97 ± 1.52 mm (range 0.72–8.67 mm) on the left (Tables 1, 2).

No statistically significant difference was found between the male and female sexes with regard to the diameters of

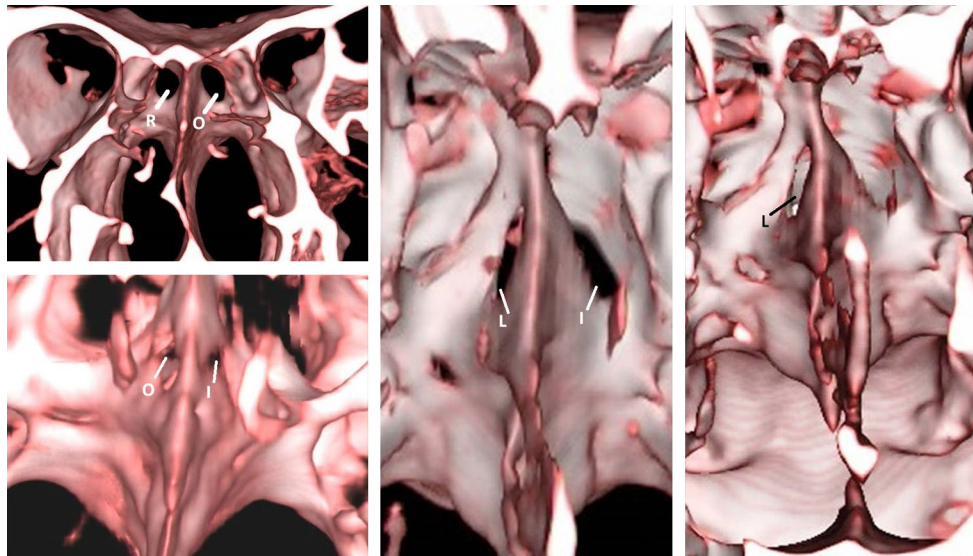


Fig. 4 3D CT scan shows different types of sphenoid ostia; *R* round type, *L* linear type, *O* oval type, *I* irregular type

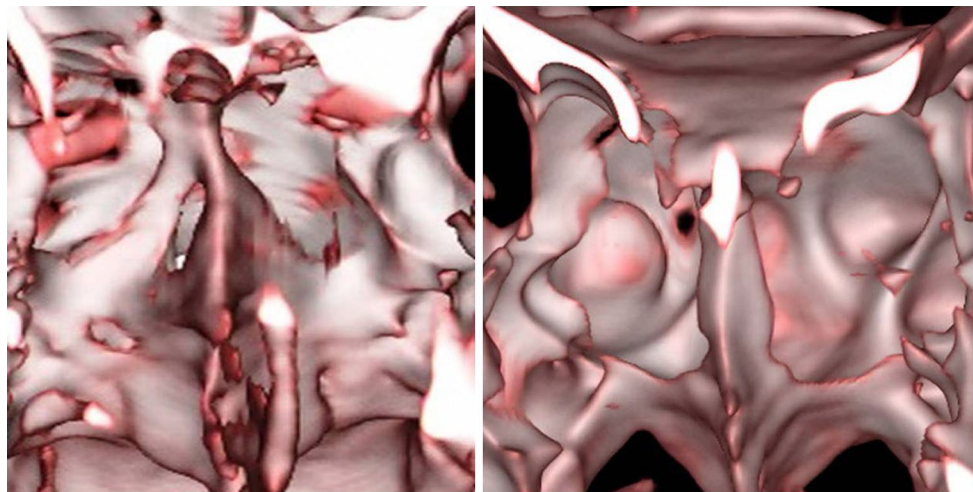


Fig. 5 3D CT scan shows that there is only one sphenoid ostium in different two patients

Table 1 Anatomical measurements related to the sphenoid ostium (SO) that are obtained during the studies

Authors (material) (population)	Distance from right SO to the midline (mm)	Distance from left SO to the midline (mm)	SO's the distance between each other (mm)	Vertical diameter, right/left SO (mm)		Transverse diameter, right/ left SO (mm)	
Present study (3D CT-alive) (eastern anatolia)	2.78	2.77	5.52	2.60	2.97	1.98	2.24
Campero et al. [2] (dry skulls) (Argentina)	2.04	2.18	–	5.61	5.63	3.10	3.15

Table 2 Distance of the sphenoid ostium (SO) to the choana that is obtained during the studies

Authors (material) (population)	Distance from right SO to roof of the choana (mm)	Distance from left SO to roof of the choana (mm)
Present study (3D CT-alive) (eastern anatolia)	15.22	14.87
Hidir et al. [6] (2D CT-alive) (middle anatolia)	10.9	
Abuzayed et al. [1] (cadaver) (western anatolia)	14.9	
Wu et al. [14] (2D CT-alive) (China)	12.0	

the SO, their shapes, distances to the choana, to each other, and to the midline ($p > 0.05$).

Discussion

Transsphenoidal surgery is a generally accepted method for the sellar region pathologies, due to its efficiency, reliability, and the short operating time [10]. No matter whether it is performed endoscopically or microscopically, transsphenoidal surgery is an important surgical step in finding the SO [4, 7, 8, 11].

Many anatomical studies have been conducted on the sphenoid sinus and the ostium using two-dimensional CT and cadavers [1, 2, 5, 6, 8, 13]. However, the difficulties in obtaining cadavers, and in studies that utilizes skulls, the deterioration and the constriction of bones over time are certain disadvantages. In this study, we, for the first time, have evaluated the sphenoid ostia with 3D CT. Even though it is a little time-consuming, this process ultimately gives us an image that is very close to the image that we will encounter in surgery. Anatomical evaluations and calculations can comfortably be made on these images, as it would be on a skull. We believe that this anatomical information, and the pre-operative evaluation of the patient with 3D CT could be useful in transsphenoidal surgeries.

For the surgeons, bone shape of SO is as important as the mucosal shape. In the study they have done with 32 dry skulls, Campero et al. [2] have reported that only one skull (3 %) did not have the left ostium. Abuzayed et al. [1] could not find the sphenoid ostium in seven cadavers (23.3 %), in the endoscopic anatomical study they have done with 30 fresh cadavers. In our study, the SO unilaterally could not be found in a total of seven cases, four of them on the right, and three on the left. The reason of this may be its small diameter, insufficient spatial resolution of the CT, or difficult orientation of it. Also, as the results of the studies on dry skulls and fresh cadavers, SO may be absent due to insufficient development. In such patients whose sphenoid ostium cannot be found, C-arm fluoroscopy can be useful in determining the entry point to the sphenoid. The average distance of the SO to the choana as well can be an important clue in determining the entry point to the sphenoid.

Hidir et al. [6] have found this distance to be 10.9 mm, Abuzayed et al. [1] as 14.9 mm, Wu et al. [14] as 12 mm. In our study, we have found this distance to be 15.22 mm on the right, and 14.87 mm on the left. We all know that, during the transsphenoidal surgery, after entering the nasal cavity surgeon should find the mucosal SO. If the SO cannot be found, mucosa should be cauterized to reach the anterior wall of the sphenoid bone. An additional advantage of this study was that, surgeon can calculate the diameter between choana and SO in each individual patient before the surgery. Based on this calculation he can cauterize the exact point of the mucosa to find the SO.

In their study conducted on 20 cadavers, Sareen et al. [12] have found by 75 % sellar (postsellar), and by 25 % presellar type sphenoid pneumatization varieties. Abuzayed et al. [1] have observed the sellar type of sphenoid sinus in 80 % (n:24), and the presellar type in 20 % (n:6) of the cases, in their study conducted on 30 cadavers. In our study, we have encountered the sellar type by 94 %, and the presellar type by 6 %. A variation is seen in the results of the studies. This variation might be caused by racial differences among the subjects evaluated, as well as the difference in the average age. That is because while the sphenoid sinus exhibits a tiny cavity at birth, it principally develops after puberty.

Lang [9] has observed the SO as round by 70 %, ovoid by 28 %, and has stated that the larger diameter settled on a vertical plan. In the endoscopic anatomical studies that Abuzayed et al. have conducted on fresh cadavers, they have found 13 % to be round, 22 % oval, 30 % fusiform, and 35 % linear [1]. However, they have evaluated the SO from a shape-focused modal point of view, without removing its mucosa. In our study, the findings regarding the right SO were that 28 % of the patients had round, 8 % had irregular, 20 % had linear, 36 % had oval shapes, and SO were not found in 8 % of the patients. As the left SO, 24 % had round, 20 % had irregular, 16 % had linear, 34 % had oval shapes, and SO were not found in 6 % of the patients. The right–left asymmetry in shape was seen to be 68 %. As these findings show as well, the sphenoid anatomy exhibits a great diversity, even in the same person.

In addition to the earlier studies, in this study the effect of sex on the distance of the SO to the choana, their

distance to each other and on the diameters of the SO, as well as on their shapes was investigated. However, no statistically significant discrepancy was found.

The fact that in some patients the SO were visible on the sagittal and axial plane, but they could not be visualized three dimensionally, as well as the examination time being long, has defined the limitations of our study. However, we believe that the examining duration will get shorter with the development of computer-aided programs.

In conclusion, many cadaver and tomography studies on the anatomy of the sphenoid sinus have been conducted, and their results differ considerably. That is because the anatomy of the sphenoid sinus and the SO varies widely from individual to individual. To standardize these anatomical structures is quite difficult. This condition makes it necessary for the surgeons to know the patient's individual anatomy in detail. Our study emphasized that 3D imaging can provide to the surgeon in the pre-operative evaluation of the SO.

Using this imaging technique, surgeons can make a pre-operative 3D evaluation of the sphenoid ostium they are to encounter in surgery, thus achieve better orientation. This, at the same time, might decrease the use of intraoperative C-arm fluoroscopy. We believe that this anatomical information, as well as the pre-operative evaluation of the patient with 3D CT could prove to be beneficial in trans-sphenoidal surgeries.

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