Radiologic anatomy of the sphenoid sinus for intranasal surgery*

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SUMMARY *Endoscopic surgery of the sphenoid sinus can present the operator with a considerable challenge. The relationship of the sphenoid sinuses, in particular on the lateral wall, to the carotid artery, optic nerve, as well as the other anatomic structures, is of utmost importance. Surgical complications can occur because of a lack of orientation during dissection. To avoid the complications or lessen, somehow, the rate of complications, some described the technique consisting of the opening of the sphenoid sinus ostium medially. We studied 69 axial high resolution computed tomography (HRCT) of temporal bones to reveal the relationship of sphenoid sinus to the vital structures and to get some measurements in the sphenoid sinus. The lateral distance from the sphenoid ostium revealed that the lateral distance was about the distance between both ostea. We consider that in selected cases the dissection might be carried out laterally from the sphenoid ostium for safe enlargement of the ostium and approaching the sinus.*

Key words: endoscopic sinus surgery, paranasal sinus, radiologic anatomy, sinus surgery sphenoid sinus

INTRODUCTION

The sphenoid sinus is the most posteriorly located of the paranasal sinuses. Since the sphenoid sinus occupies the most central portion of the head, it has been termed the "silent sinus". Vague symptoms are common, as this sinus is the most common site of overlooked disease in the head and neck. However, sophisticated radiographic techniques such as computed tomography (CT) and magnetic resonance imaging (MRI) have opened a window on this region and allowed earlier diagnosis and competent preoperative evaluation. With the expanding role of endoscopic sinus surgery and introducing the new advanced microsurgical instruments, a thorough understanding of the anatomy of the sphenoid sinus has become increasingly important.

The surgical approaches to the sphenoid sinus used are due to the disease process such as pituitary neoplasms, sphenoid inflammatory disease, and optic nerve compression and the experience of the surgeon.

The aim of the present study is to describe the radiologic anatomy of the sphenoid sinus as it relates to the approaches, in particular the endoscopic approach.

MATERIALS AND METHODS

Axial high resolution computed tomography (HRCT) images of the temporal bone of 69 patients collected in the archives of the Department of Radiology, Celal Bayar University Medical School, Manisa, Turkey, were used to study the anatomy of the sphenoid sinus. CT scans were obtained in the axial plane, 1.5 mm slice thickness and intervals continously using Hitachi 1000 equipment. Scans were evaluated in the bone window levels. The CTs of the patients who had paranasal sinus opacifications, in particular sphenoid sinus opacification, and/or findings of previous sinus surgeries were excluded for this study. For the purpose of improving preoperative assessment of the sphenoid sinus and decreasing the risk of unpleasant problems during the sphenoid sinus surgery, some morphometric measurements were done, which were as follows:

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Table 1. The outcomes of the morphometric measurements (Number=69).

	Mean (mm)	Std Dev (±)	Minimum (mm)	Maximum (mm)
The distance between the right and left sphenoid sinus ostium (RO-LO)	7.95	3.26	1.32	15.00
The distance between the lateral end-point of anterior wall of the right and left sphenoid sinus (REP-LEP)	27.36	3.82	15.00	37.50
The distance between the right sphenoid sinus ostium and right lateral end-point (RO-REP)	8.07	2.33	2.38	13.16
The distance between the left sphenoid sinus ostium and left lateral end-point (LO-LEP)	8.00	2.47	2.08	13.16
The largest distance between the anterior and posterior wall of the sphenoid sinus (AS-PS)	27.61	6.22	10.71	41.67
The largest width of the sphenoid sinus (SW)	31.77	6.54	21.25	55.36
The distance between the sphenoid sinus ostium and base of the sphenoid sinus (SO-SB)	28.24	8.51	10.71	45.71

1. The distance between the right and left sphenoid sinus ostium (RO-LO)
2. The distance between the lateral end-point of the anterior wall of the right and left sphenoid sinus (REP-LEP)
3. The distance between the right sphenoid sinus ostium and the right lateral end-point (RO-REP)
4. The distance between the left sphenoid sinus ostium and the left lateral end-point (LO-LEP)
   For the above mentioned measurements, we selected the CT slices which had clear sphenoid sinus ostea and did the measurements. In most cases, the lateral end-point of the anterior wall represented the junction of the anterior wall of the sphenoid sinus and the medial orbital wall. However, when an Onodi cell was present, we considered the lateral end point as a junction of the anterior wall of the sphenoid sinus and the medial wall of the Onodi cell.
5. The largest distance between the anterior and posterior wall of the sphenoid sinus (AS-PS)
6. The largest width of the sphenoid sinus (SW)
7. The distance between the sphenoid sinus ostium and the base of the sphenoid sinus (SO-SB).

The outcomes of measurements in both sexes were compared by using the Student's t-test.

Furthermore, the presence and the prevalence of some structures having vital importance were recorded:

1. The prevalence of the Onodi cells, a posterior ethmoid cell into which the optic canal made an identifiable impression on CT or endoscopic examination (Kainz and Stammberger, 1991)
2. The localization of the septum of the sphenoid sinus according to the bony covering of the carotid artery (anteriorly or posteriorly attached septum)
3. The asymmetry of the carotid artery
4. The prevalence of the accessory septa and crests and their relations with the carotid artery.

RESULTS

Our material consisted of 69 axial HRCTs of temporal bone delineating the sphenoid sinus clearly. There were 46 females (67%) and 23 males (33%). The patients' ages ranged from 20 to 73 years with a mean of 41 years.

The results of the morphometric measurements are summarized in Table 1.

The comparative outcomes of females and males were shown in Table 2.

Onodi cells (Figure 1) were noted in 5 cases (7.2%). Four cases (5.8%) had unilateral Onodi cells and the remaining case (1.4%) had bilateral cells.

Table 2. Comparative measurements of females and males (mean= mm) and statistical results.

	Female (No=46)	Male (No=23)	Statistic (p≤0.05)
The distance between the right and left sphenoid sinus ostium (RO-LO)	7.96	7.91	P=0.6
The distance between the lateral end-point of anterior wall of the right and left sphenoid sinus (REP-LEP)	26.69	28.69	P=0.1
The distance between the right sphenoid sinus ostium and right lateral end-point (RO-REP)	7.78	8.64	P=0.4
The distance between the left sphenoid sinus ostium and left lateral end-point (LO-LEP)	7.73	8.55	P=0.8
The largest distance between the anterior and posterior wall of the sphenoid sinus (AS-PS)	27.60	27.65	P=0.1
The largest width of the sphenoid sinus (SW)	31.03	33.26	P=0.6
The distance between the sphenoid sinus ostium and base of the sphenoid sinus (SO-SB)	26.38	31.97	P=0.6

Figure 1. The Onodi cell has an optic nerve bulging on the right side.

Posteriorly attached septums (Figure 2) of the sphenoid sinus were found in 44 cases (63.80%) and anteriorly attached septums (Figure 3) were present in 15 cases (21.70%). Septums in 10 cases (14.50%) were inserted into the bony covering of the carotid arteries (Figure 4).

Carotid artery asymmetry was observed in 5 cases (7.2%).

Accessory bony septa or crests (Figure 5) were seen in 48 cases (69.56%). In 27 cases (39.13%) they were unilateral and in the remaining 21 cases (30.43%) they were bilateral. The septa or crests were inserted into the bony covering of the carotid arteries in 9 cases (13.04%) including 4 unilateral (0.6%) and 5 bilateral (0.7%) cases. There were no septa or crests inserted into the bony covering of the optic nerve.

DISCUSSION

The sphenoid sinus, which is the most inaccessible paranasal sinus, is surrounded by more vital structures than any other sinus. With the widespread acceptance and expanding role of

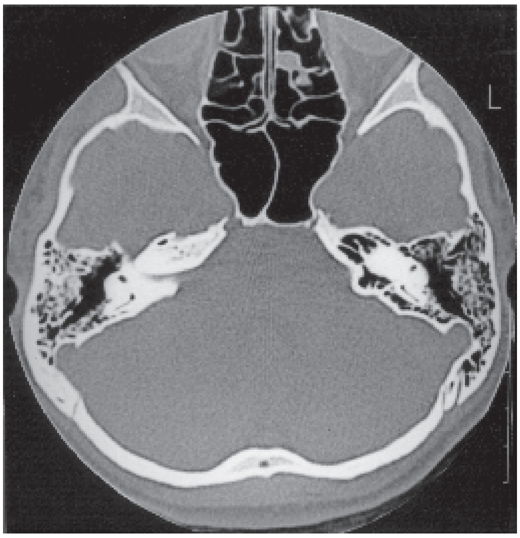

Figure 2. Posteriorly attached intersinus-septum in the midline.

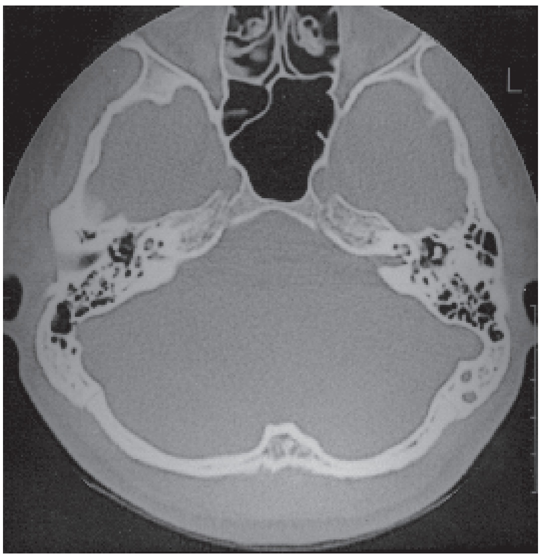

Figure 3. Anteriorly attached intersinus-septum mimicking an Onodi cell.

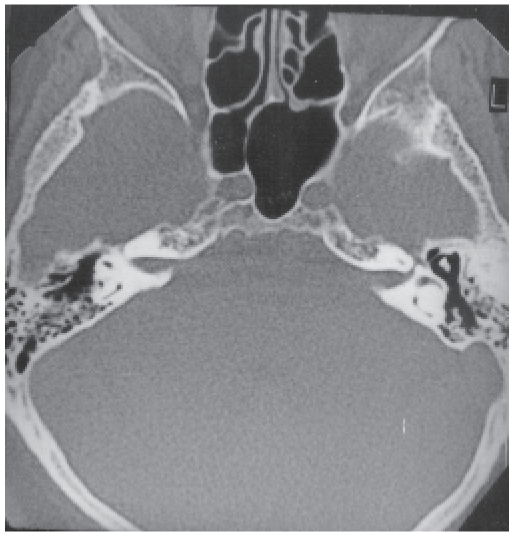

Figure 4. Intersinus-septum inserted into the bony covering of the right carotid artery.

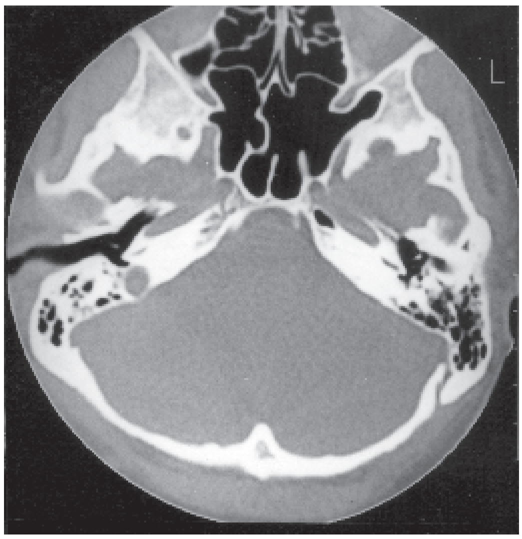

Figure 5. Pterigoid extension to the the left sphenoid sinus and multiple crests are seen.

endoscopic sinus surgery, a proper understanding of the anatomy of the sphenoid sinuses has become increasingly important. The sphenoid sinus ostium is the first landmark to identify for the surgeons preferring transnasal approaches to the sphenoid sinuses. The common accepted procedure is widening the sphenoid sinus ostium inferiorly and medially toward the rostrum after the localization of the ostium and then, completing the rest of the surgical procedures. Thus, with staying inferior and medial, the complications to adjacent vital structures could be avoided (Fuji et al., 1979; Kennedy et al., 1990; Bolger et al., 1999; Elwany et al., 1999). However, recently, Aust et al. (1998) have described a new method to have a wide opening of the sphenoid sinus. After enlarging the sphenoid ostium inferiorly, they removed the vomer and sphenoid rostrum bilaterally to encompass both natural ostea.

In previous reports, the distance between the medial border of the sphenoid ostium and the midline was generally implied and measured. Elwany et al. (1999) measured this distance as 5.2 mm (1.4-8.8 mm) and Lang (1989) found it to be 4.8 mm (0.6-9 mm). In our study, however, we measured the distance between the both natural ostea (RO-LO) and the distance from each ostium to the lateral wall of the sphenoid sinus (RO-REP and LO-LEP). The mean RO-LO was 7.95 mm. The mean RO-REP and LO-LEP were 8.07 mm and 8.00 mm, respectively. As shown, the distance from the sphenoid ostium to the lateral wall is a little greater than the distance between the right and left sphenoid ostium.

The mean width of the sphenoid sinus in adult cadavers was found as 13.5 mm in its superior segment, 16.9 mm in the center and 18.7 mm in its lower segment. The anterior-posterior length of the sphenoid sinus was 19.4 mm in the superior segment, 4.8 mm in the center and 18.5 mm in the inferior segment (Lang, 1989). We studied only the widest and longest diameter of the sphenoid sinus. We measured the width (SW) and the anterior-posterior length (AS-PS) of the sphenoid sinus as 31.77 mm and 27.61 mm, respectively.

The height between the inferior border of the ostium and the floor of sphenoid sinus (SO-SB) was recorded as 28.24 mm. Elwany et al. (1999) have reported this distance to be 14.8 mm.

Generally coronal computed tomography is the choice of study for sinus imaging. Coronal sections provide excellent demonstration of bony anatomy and mucosal disease. Axial scans are generally added when sinus disease is found. If the disease process occupied the posterior ethmoid cells and/or sphenoid sinus, axial scans should be an integral part of the preoperative imaging. Not only provides it safe approaches to the sphenoid sinus but it also helps to avoid the untoward complications since it visualizes the presence of Onodi cells and details of the lateral wall of the sphenoid sinus (Driben et al., 1998).

Cells derived from the ethmoid lying within the sphenoid bone were referred to as Onodi cells (named after the Hungarian surgeon) by Lang (1989). This definition, however, differs from that adopted by Kainz and Stammberger (1991) who defined the Onodi cell as a posterior ethmoid cell into which the optic canal made an impression (a tuberculum nervi optici) on CT examination or a posterior ethmoid cell into which optic canal made an endoscopically identifiable impression. This definition was also accepted by Yeoh and Tan (1994) and Driben et al. (1998). The prevalence of the Onodi cell was 7.2% in our cases. Four cases (5.8%) had unilateral Onodi cells and the remaining case (1.4%) had bilateral cells. Elwany et al. (1999) found Onodi cells in seven cadavers (7.5%) including 5.3% bilateral. These cells were detected in 9-12% of the material of Van Alyea (1939) and Lang (1989). However, Yeoh and Tan (1994) reported them in 50.98% and Kainz and Stammberger (1991) found them in 42%. Driben et al. (1998) reported the prevalence of Onodi cell at 39% by using endoscopic dissection, while they noted a lower prevalence of 7% by using coronal and axial CTs of same materials. They concluded that this variation could be due to the orientation of the anterior wall of the sphenoid sinus.

Septal deviations of the sphenoid sinus from the midline were observed frequently in Lang‘s study (1989). The septum lied in the midline in 27%. In 43% of cases only the anterior part lied in the midline, whereas in the rest the septum was S-shaped, C-shaped or other shapes (Lang, 1989). We noted that the septum of the sphenoid sinus was in the midline and attached posteriorly in 63.80% of cases and anteriorly attached septum was 21.70%. In 14.50% of cases septums were inserted into the bony covering of the carotid artery.

Intersinus accessory septa or crests are usually present in the area of the former synchondroses of the sphenoid bone. Of paramount importance is the potential of a septum or crest for insertion into the bony covering of the carotid artery or the optic nerve. Inadvertently fracturing or trials to fracture the crests in these cases could lead to injury of these two major structures with serious consequences. Elwany et al. (1983) reported the prevalence of the accessory septa as 76% (48% unilateral and 28% bilateral) in their previous study and as 68.8% (47.8% unilateral and 21% bilateral) in their recent study (Elwany et al., 1999). In their study (Elwany et al., 1999), crests were inserted into the bony covering of the carotid artery in 12.9% and into the bony covering of the optic nerve in 5.9% of cases. The accessory septa or crest was detected in 69.56% of our cases. In 39.13% of cases they were unilateral and in 30.43% bilateral. The prevalence of the crests inserted into the bony covering of the carotid artery was 13.04%.

CONCLUSIONS

1. The distance from the lateral border of the sphenoid ostium to the lateral wall of the sphenoid sinus was measured to be about 8 mm on both sides. This can encourage us to widen the sphenoid ostium laterally during the sphenoid sinus procedures. To get precise knowledge of the surgical anatomical relationships of the sphenoid sinus, preoperative axial CTs would be complementary to the coronal CTs.
2. The mean height from the sphenoid ostium to the floor of the sphenoid sinus was found to be about 28 mm and this distance allows us to enlarge safely the ostium inferiorly.
3. The prevalence of Onodi cell was 7%.
4. Anteriorly attached intersinus septa or crest was seen in 22% of cases. Since these septae or crests could be assumed as Onodi cells and lead to serious untoward complications

during the surgeries, their presence should be evaluated on preoperatively taken coronal and axial CTs.

5. The intersinus-septum inserted into the bony covering of the carotid artery was found in 15% of cases and accessory septae or crests were in 14% of cases. Special care should be taken and kind manuplations should be done.

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