Surgical Measurement of the Sphenoid Sinus on Sagittal Reformatted CT in the Turkish Population

Türk Toplumunda Sfenoid Sinüsün Sagittal Reformat Bilgisayarlı Tomografide Cerrahi Ölçümleri

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Abstract

Objective: The objectives of this study were to determine sinus measurements specific for the Turkish population using CT sagittal thin-slice reconstruction images and to clarify the three-dimensional anatomical features of the sphenoid sinus, along with its surrounding structures, that are relevant to performing an endoscopic sphenoidotomy.

Materials and Methods: Images of 300 patients (165 female, 135 male) were studied. The research was conducted on the axial plane with a 1 mm slice thickness and a 0.6 mm slice interval, and sagittal reconstruction was performed with a 0.4 mm slice interval. Measurements of the sinus were obtained, and the presence of Onodi cells was researched.

Results: Line 1 was found to be significantly shorter in the Turkish patients of this study compared to studies of other populations. Lines 4 and 6 were found to be longer on the left side (Line 4 right: 18.8±3.6 mm, left: 19.3±3.4 mm, p=0.027; Line 6 right: 24.1±6.8 mm, left: 24.3±6.8 mm, p=0.008). Lines 2, 3, 4 and 6 were longer in men than in women (p<0.05).

Conclusion: In the Turkish population, Line 1 is shorter, so the risk of skull base perforation is greater. Lines 4 and 6 are longer on the left side; thus, choosing the left ostium in sinus dilation is safer. Because of sex differences regarding Lines 2, 3, 4 and 6, sex should be considered in sphenoid sinus procedures.

Key Words: CT measurements, Sagittal reformatted images, Sphenoid sinus

Özet

Amaç: Endokoskopik sfenoid sinüs cerrahisi yapılacak olgularda ope-

rasyon sırasında bilinmesi önemli ve yarıları sinus ölçümlerinin ve si-

nüs detaylarının Türk toplumuna spesifik olarak ortaya konulmasıdır.

Gereç ve Yöntem: Üç yüz olgu (165 kadın, 135 erkek)'nun görün-

tüleri üzerinde çalışıldı. Aksiyal plan 1 mm kesit kalınlığı ve 0.6 mm 

kesit aralığı tarama yapıldı; 0.4 mm kesit kalınlığı ile görüntüler sagit-

tal rekonstrüktöre edildi. Sinüste ölçümler yapıldı ve Onodi hücrenin 

varlığı araştırıldı.

Bulgular: Line 1 diğer çalısmalarındaki toplumlardan belirgin kısa 

bulunmuştur. Line 4 ve 6 solda daha uzun (Line 4 sağ: 18.8±3.6 mm, sol: 

19.3±3.4 mm, p=0.027; Line 6 sağ: 24.1±6.8 mm, sol: 24.3±6.8 mm, p=0.008). Line 2, 3, 4 ve 6 erkeklerde kadınlardan daha uzundur 

(p<0.05).

Sonuç: Toplumumuzda Line 1 daha kısa olduğundan kafa tabanı 

perforasyon riski daha yüksektir. Line 4 ve line 6 solda uzun olduğun-

dan sinus dilatasyonu için sol ostiumun seçilmesi daha güvenilirdir.

Line 2, 3, 4 ve 6'daki cinsiyet farkı nedeni ile sfenoid sinus girişiminde 

cinsiyet farklı göz önüne alınmalıdır.

Anahtar Kelimeler: BT ölçümleri, Sagittal reformat görseller, Sfe-

noid sinüs

Introduction

Endoscopic sinus operations (ESOs) are widely performed today. Because of its low morbidity and short operation duration and the possibility of an approach toward the wide part of the sinus with an angled telescope, the endonasal endo-

scopic approach was the most commonly used in past years to enter the sphenoid sinus [1, 2]. This approach has been used in treatment of diseases of the sphenoid sinus, such as chronic rhinosinusitis resistant to medical treatment, nasal polyps, mucoceles, cerebrospinal fistulas, fungal infections, foreign objects and tumors, and in many other diseases, such
as sellar or parasellar tumors and optic nerve decompression [3, 4]. Furthermore, the sphenoid sinus represents a passage involved in the surgical treatment of many diseases of the anterior and middle parts of the skull base [4]. The sphenoid sinus is surrounded by many crucial structures, such as the skull base, optic channel, carotid artery and hypophysectomy gland [5]. Some conditions can considerably complicate sphenoid sinus surgery. If sphenoid sinus anatomy were well known, it would be easier to avoid possible complications during surgery. The distance from the sphenoid sinus ostium to the anatomical structures adjacent to the sinus plays a key role in avoiding complications. In recent years, studies concerning the sphenoid sinus and its surrounding anatomical structures have been published, but they have not addressed these anatomical structures from a surgeon’s viewpoint. The progress of multi detector computed tomography (MDCT) and the possibility of obtaining multiplanar images have allowed for images of the sphenoid sinus to be obtained and for measurements to be obtained that meet the needs of surgeons.

The objectives of this study were to determine sinus measurements specific for the Turkish population using CT sagittal thin-slice reconstruction images and to clarify the three-dimensional anatomical features of the sphenoid sinus, along with its surrounding structures, that are relevant to performing endoscopic sphenoidotomy.

**Materials and Methods**

Temporal CT images of 300 patients, obtained at our hospital between April 2011 and March 2012 for various reasons, were retrospectively evaluated. All patients sign informed consent forms before any CT examination in our institution. Name of the patients were anonymized. Patients with skull base fractures, hypophysis adenomas, craniomaxillofacial anomalies, nasal polyps, skull base or sinus surgery in the past or serious rhinosinusitis and who were younger than 20 years old were excluded from the study.

This research was performed with a Philips Marconi MX8000 tomography device with four detectors. The computed tomography images were analyzed using MX View software, version 3.52. The imaging parameters were as follows: 120 kV, 150 mA, 200 mm FOV and 0.625 pitch. All of the images were obtained on the axial plane, in parallel projection to the orbitomeatal line, with a 1 mm slice thickness and a 0.6 mm reconstruction interval. Three-dimensional images were obtained by reconstruction of the axial images with a slice thickness of 0.4 mm. The measurements were performed on sagittal images in the osteal window (window width 3000; window level 300) on a digital monitor. The presence of Onodi cells was researched in all cases. The patients included in the study were evaluated by the same radiologist (HA). The measurements were obtained with left and right side comparisons, and sex distribution was also analyzed.

Measurements concerning the sinus and its surrounding anatomical structures are presented as follows (all of the measurements from the sphenoid ostium were obtained from the middle point of the ostium) [6].

**Line 1:** The vertical distance from the sphenoid sinus ostium to the sinus roof, analyzed and grouped according to the presence/absence of Onodi cells (Figures 1 and 2).

**Line 2:** The vertical distance from the sphenoid sinus ostium to the lowest point of the sinus base (Figure 3).

**Line 3:** The horizontal distance from the center of the sphenoid sinus ostium to the lowest point of the sinus base (Figure 3).

**Figure 1.** The vertical distance from the sphenoid sinus ostium to the sinus roof in the Onodi cell-negative group.
Line 4: The horizontal distance from the anterior wall of the sphenoid sinus to the lowest point of the sella (Figure 6).

Line 5: The distance from the anterior wall of the sphenoid sinus to the sella, equivalent to the skull base length (Figure 7), examined and classified into two groups according to the presence/absence of Onodi cells.

Line 6: The longest horizontal distance from the anterior wall of sphenoid sinus to the posterior wall (Figure 8).

**Statistical analysis**

SPSS software, version 17.0, was used for the statistical analysis. Descriptive statistical methods (mean, standard deviation, median, frequency) were used in the evaluation of the study data. A two-way analysis of variance was used to determine the groups responsible for the differences and to evaluate the groups. Spearman’s correlation analysis was conducted to evaluate the correlations among parameters. The result reliability range was 95%, and significance was set at the level of p<0.05.

**Results**

One hundred sixty-five (55%) of the patients were female, and 135 (45%) were male. The mean age was 43.42±14 years.
old, with a median value of 42 (21–83). The mean length of the vertical line drawn from the center of the sinus ostium to the sinus roof (Line 1) was 7.3±2.4 mm (Table 1). Onodi cells at the lateral ethmoid sinus were present on the right side in 67 (22%) patients and on the left side in 66 (22%) patients [6]. Onodi cells were present bilaterally in 31 (17 female, 14 male) patients. Onodi cells were absent in 198 (85%) of the patients. In the Onodi cell-positive group, the average length of Line 1 was 3.8±1.8 mm. The length of Line 1 in this group, compared to the Onodi cell-negative group, was found to be shorter, and this difference was statistically significant (p=0.001). There was no statistically significant difference in the length of Line 1 between sexes (p>0.05).

The average length of the vertical line from the center of the sphenoid sinus ostium to the lowest point of the sinus base (Line 2) was 12.9±3.8 mm (Table 1). There was no statis-
tically significant difference between the right- and left-side lengths of Line 2 (p>0.05). The average length was 12.4±0.2 mm in women and 13.5±0.2 mm in men, which represents a large, statistically significant difference (p=0.001).

When the sphenoid ostium was located superior to the lowest point of the sella, the horizontal line from the center of the sphenoid sinus ostium to the posterior wall of the sinus (Line 3) was 14.4±3.8 mm on average. When the sphenoid ostium was located inferior to the lowest point of the sella, the horizontal line described was 24.2±5.4 mm on average (Table 2). On both sides, the suprasellar-located line 3 was found to be significantly shorter compared to those with infrasellar measurement. Bilaterally, both suprasellar and infrasellar Line 3 were longer in men than in women (p=0.001).

The average length of the horizontal line from the anterior wall of the sphenoid sinus to the lowest point of the sella (Line 4) was 19.09±3.5 mm (Table 3). Line 4 on the left side, compared to the right side, was found to be significantly longer (p=0.027). Regarding sexes, the length of Line 4 was found to be longer in men than in women (p=0.001). While in the men, there was no significant difference between the right and left sides, in the women, the left side was found to be longer (p=0.047).

The superior horizontal line between the anterior and posterior walls of the sphenoid sinus, drawn from the skull.

Figure 6. The horizontal distance from the anterior wall of the sphenoid sinus to the lowest point of the sella.

Figure 7. The horizontal distance between the anterior and posterior walls of the sphenoid sinus.
The average length of the longest horizontal line between the anterior and posterior walls of the sphenoid sinus (Line 6) was 24.2±6.8 mm (Table 4). When evaluated in terms of sex, Line 6 was longer in men than in women (p=0.018). While in men, there was no significant difference between the left and right sides, in women, the left side was found to be longer than the right side (p=0.008). In cases with a suprasellar
location of Line 3, the average length of Line 6 was 22.4±0.4 mm, and with infrasellar localization, the average length was 26.8±0.5 mm. Line 6 was found to be significantly shorter in patients with suprasellar localization of Line 3 compared to those with infrasellar localization (p=0.004).

**Discussion**

The anatomy of the sinuses plays a key role in surgery. Sphenoid sinus surgeries are quite complicated due to the location and structural variations of this sinus. In this study, the sphenoid sinus was evaluated with multiplanar CT, and different lines were designed to obtain surgical data for the Turkish population [6].

The natural ostium of the sphenoid sinus can be visualized easily with CT and endoscopy. In addition, endoscopic sphenoid sinus surgery can be performed more safely through the natural ostium [6]. Therefore, the distance from the ostium to the vital anatomic structures surrounding the sphenoid sinus is important. Consequently, to measure the distances from the center of the sphenoid sinus ostium to the sphenoid sinus roof, base and posterior wall, lines 1, 2,
and 3 were designated. Lines 4 and 5 were used to evaluate the relationships and show the distances at different levels between the sella and the anterior wall of the sphenoid sinus. Line 6 was used to show the horizontal range of the sphenoid sinus. Obtaining noninvasive measurements of the sphenoid sinus was possible using the thin slice multplanar reconstruction technique. With this technique, the systemic errors that occur in cadaver research due to the shrinking of tissues in formaldehyde can be prevented. The horizontal and coronal planes were very helpful in the visualization of the sphenoid sinus ostium and Onodi cells. To obtain more surgical anatomic information, sagittal plane measurements of the surgical path should be performed.

According to our results, the average length of the vertical line drawn from the center of the sphenoid sinus ostium to the sinus roof (Line 1) was 7.3±2.4 mm. When the surgeon inserts the instrument to dilate the sphenoid ostium, the distance from the skull base is only the size of an aspiration tip of 2.5x3 mm. If the surgeon proceeds to more than the defined height, the skull base might be perforated. In a similar study performed by Wu et al. [6] on a Chinese population, the average length of Line 1 was found to be 10.6±1.5 mm, demonstrating that in different populations, Line 1 can vary; thus, the surgeon should be aware of these distances when performing endoscopic procedures.

The average length of the vertical line from the center of the sphenoid sinus ostium to the lowest point of the sinus base (Line 2) was 12.9±3.8 mm. In the study by Wu et al. [6], the average length of Line 2 was 12±3.7 mm. This value was similar to that obtained in our study, indicating that there is more space when the sphenoid ostium is dilated downward. This information could be used in estimating the vertical width of the sphenoid ostium when dilating it. The average length of the horizontal line from the anterior wall of the sphenoid sinus to the lowest point of the sella (Line 4) was 19.09±3.5 mm. In the study by Wu et al. [6], the average length of Line 4 was found to be 17.5±1.3 mm.

The horizontal distance from the center of the sphenoid sinus ostium to the posterior wall of the sphenoid sinus (Line 3), according to the localization of the ostium, was 14.4±3.8 mm or 24.2±5.4 mm. According to the distances defined, to avoid the injuries to the sella, sphenoid sinus procedures should not exceed a depth of 14 mm. In the study by Wu et al. [6], the average length of Line 3, according to the localization of the ostium, was 18±1.5 mm or 28±2.5 mm. The risk of injury to the sella was found to be greater in the Turkish population than in the general population. If the sphenoid ostium is localized superior to the lowest point of the sella, the surgeon should be very cautious during the procedure [5, 7]. When entering the sphenoid sinus, the unique borderline for guiding the surgeon into the depths of the sinus and finding the targeted point is the posterior wall of the sphenoid sinus, although the risk of injury to the pituitary gland is quite high [8]. If the sinus ostium is localized inferior to the lowest point of the sella, then when entering the sphenoid sinus, the surgeon will immediately come across the posterior wall of the sinus.

The average length of the horizontal line drawn from the anterior wall to the posterior wall of the sphenoid sinus (Line 5), which was the shorter distance, was 10.8±5.03 mm. In the study by Wu et al. [6], the average length of Line 5 was 10.1±1 mm, which is not much different than the length obtained in the present study. During surgery, we get closer to the pituitary fossa as we proceed.

The average horizontal distance from the anterior wall of the sphenoid sinus to the posterior wall, which was the longest horizontal line (Line 6), was 24.2±6.8 mm. This information demonstrates that Line 6 is 2.5 times longer than Line 5. In the study by Wu et al. [6], the average length of Line 6 was 22±7.7 mm. As a result, in the Turkish population, entering the sphenoid sinus is safer from below. In the drainage of inflammatory processes involving the sphenoid sinus (mucocoeles, mucopyoceles, fungal sinusitis, etc.) and in procedures of the pituitary gland, it is important to know how far the sinus extends in the posterior direction [9]. Therefore, Line 6 is important to the effort of the surgeon in fully removing the lower part of the lesion. In the study by Wu et al. [6], no differences between the left and the right side were found concerning the defined distances. However, in the present study, lines 4 and 6 were longer on the left side than on the right side. Therefore, for sinus dilation, it would be safer to choose the left ostium instead of the right. Additionally, Lines 2, 3, 4 and 6 were found to be longer in men than in women, demonstrating that sex differences should be considered in sphenoid sinus procedures.

In the studies performed, it was shown that the presence of Onodi cells was greater in Asian cadavers than in Western cadavers [10]. Therefore, during surgery, surgeons should be aware of the significantly greater presence of Onodi cells in Asian populations because the most common complication during transsphenoidal surgery is cerebrospinal fluid leak (CSF) leakage. Sagittal CT images should definitely be analyzed prior to surgery [11, 12]. In the current study, 204 (34%) sides out of 600 were Onodi cell positive. In Onodi cell-positive patients, the sphenoid sinus roof did not form the skull base; rather, it formed the base of the Onodi cells. Line 1 was found to be shorter in Onodi cell-positive patients compared to the Onodi cell-negative patients. Despite being shorter, the distance in Onodi cell-positive patients is much safer because during sphenoid surgery, the skull base is not directly adjacent to the sphenoid sinus [6]. In Onodi cell-positive patients, the anterior wall of the sphenoid sinus (Line 5) was
located more posteriorly. In such cases, the risk of injury to the sella is not greater compared to the other group because the sphenoid ostium is located more superior to this level [6].

The development of endoscopic endonasal surgical techniques has shown that the sphenoid sinus can allow for anatomic directions in endoscopic otolaryngologic surgical procedures [13]. To perform safe endoscopic surgery, surgeons should have detailed knowledge of the sphenoid sinus and its surrounding anatomical structures, due to the wide variations in sphenoid sinus localization. Especially in endoscopic sphenoidotomy, to approach the sphenoid sinus from all directions and completely remove lesions, it is important to know the spatial conditions of the sphenoid sinus [6].

In the present study and in studies similar to this one, it has been shown that the vertical distance from the sphenoid sinus ostium to the sinus base can vary greatly. Therefore, extreme care should be taken during endoscopic sinus surgeries, and this distance should definitely be analyzed prior to surgery, using reformatted sagittal images. If this distance is ignored, the risk of injury to adjacent structures, such as the brain and hypophysis, is great [6].

Horizontal and vertical distances relative to the sphenoid sinus show great variation due to the high variability of the sinus shape. Therefore, when we open the anterior wall of the sphenoid sinus vertically, much more space is observed than on the horizontal plane. At the same time, it is safer to open and dilate the sphenoid sinus horizontally and in the superior direction because branches of the sphenopalatine artery appear immediately beneath the sphenoid ostium [6].

Endoscopic surgery of the sphenoid sinus can be very critical. The sphenoid sinus wall is very thin and vulnerable. Blindly curetting and tearing of the sphenoidal mucosa can easily damage the wall of the sphenoid sinus, the optical nerve, the carotid artery, the pituitary gland and the anterior cranial fossa, leading to serious complications [11]. In the literature, there have been many studies concerning the sphenoid sinus and its surrounding anatomical structures (optic nerve, carotid artery, skull base, sella, etc.) in Turkish populations [14-17]. Additionally, Hıdır et al. [18] measured the distance between the sinus ostium and the choanal roof. However, in none of these studies was detailed information presented of the spatial distances among the ostium, skull base and sella.

Thin slice multiplanar reconstruction has been developed recently. Thanks to this evolution in imaging, doctors can change angles and obtain various reconstruction plans. In the present study, the fine three-dimensional anatomical relationships of the anterior wall of the sphenoid sinus, the sphenoid ostium and the surrounding structures (sella, skull base) were defined using a multiplanar reconstruction technique. Therefore, we hope that this information will be of great assistance to surgeons.

**Conflict of interest statement:** The authors declare that they have no conflict of interest to the publication of this article.

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