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The relationship between the variations of sphenoid sinus and nasal septum

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SUMMARY

The aim of this article is to discuss the sphenoid sinus variations that could be important for transsphenoidal pituitary surgery planning. 314 computed tomography angiography performed with 64-detector multi-slice scanner of the head and neck region in consecutive patients were studied. Thin slices axial, coronal and sagittal, maximum intensity projection and multiplanar reformatted images were obtained for detailed evaluation. 57 cases had presellar (18.2%), 40 patients had sellar (12.7%), 214 patients (68.2%) had postsellar and 3 patients (1%) had conchal pneumatization. We identified sellar bulging in 249 of 314 cases (79.3%), (43% mild, 36.3% prominent). We detected more than one septum in 107 cases (34.1%). In 4 cases (1.3%) we could not define any septum. Nasal septum was deviated to the right in 129 cases (41.1%), deviated to the left in 140 cases (44.6%) and non-deviated in 45 patients (14.3%). There was statistically significant difference in the mean distances between the deviated main sphenoid septum and the internal carotid arteries on the deviation and opposite sides. Knowing the nasal septal deviation direction does not facilitate to predict the direction of the deviation of the main sphenoid septum. Reporting important anatomical variations routinely in computed tomography and/or magnetic resonance imaging reports in transsphenoidal pituitary surgery candidates may reduce transsphenoidal pituitary surgery complications during surgery.

Keywords: *Sphenoid sinus, Septum, Transsphenoidal pituitary surgery, ICA, CTA*

ÖZET

Nazal septum ve sfenoid sinüs varyasyonları arasındaki ilişki

Bu çalışmanın amacı, Transsfenoidal Hipofiz Cerrahisi planlanması için önemli olabilecek sfenoid sinüs varyasyonlarını tartışmaktır. Ardışık 314 hastada baş-boyun bölgesine yönelik 64-dedektör kesitli tarayıcı ile yapılan bilgisayarlı tomografi anjiyografi tetkikleri incelendi. İnce aksiyel, koronal ve sagital kesitler, maksimum intensite görüntüler ve multiplanar reformat görüntüler ayrıntılı değerlendirme için elde edildi. 57 olguda (% 18.2) presellar, 40 olguda sellar (% 12.7), 214 olguda (% 68.2) postsellar ve 3 olguda (% 1) konkal pnömatizasyon vardı. 314 olgunun 249' unda (% 79.3) sellar taşma (% 43 hafif, % 36.3 belirgin) tanımladık. 107 olguda (% 34.1) birden fazla septum tespit ettik. 4 olguda (% 1.3) herhangi bir septum tanımlayamadık. Nazal septum 129 olguda (% 41.1) sağa, 140 olguda (% 44.6) sola deviye idi ve 45 hastada (% 14.3) deviasyon yoktu. Deviye ana sfenoid septum ve internal carotid arterler arasında, deviasyon tarafındaki ve ters taraftaki ortalama mesafelerde istatistiksel olarak anlamlı fark vardı. Nazal septal deviasyon yönünü bilmek ana sfenoid septum deviasyonu yönünü tahmin etmeyi kolaylaştırmamaktadır. Transsfenoidal hipofiz cerrahisi adaylarının bilgisayarlı tomografi ve/veya manyetik rezonans görüntüleme raporlarında rutin olarak önemli anatomik varyasyonları raporlamak ameliyat sırasında cerrahi komplikasyonlarını azaltabilir.

Anahtar kelimeler: *Sfenoid sinüs, Septum, deviasyon, Transsfenoidal hipofiz cerrahisi, ICA, BTA*

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Introduction

Transsphenoidal route is the standard approach for surgery of the pituitary tumors (1). Therefore, pre-operative anatomic evaluation of the sphenoid sinus and related anatomical variations by computed tomography (CT) or magnetic resonance imaging (MRI) is a routine procedure and can directly effect the surgical decision. The knowledge of the number, direction and deviation of the sphenoid septum, the distance between the sphenoid septum and internal carotid artery (ICA), degree of sphenoid sinus pneumatization, the existence of the sellar bulging and the fragile structures near the sellar region can be beneficial for the surgeon and prevent fatal complications (2).

MRI is the modality of choice in most of the centers that is used for evaluation of the sellar-parasellar region pathologies. Multi-detector CT and CT angiography (CTA) scans may also provide detailed anatomic information about the sellar and parasellar region with the advantage of the Multiplanar Reformatted (MPR) and Maximum Intensity Projection (MIP) imaging features (2, 3).

The main aim of this retrospective study was to assess the relationship between the orientation of the main sphenoid septum and the nasal septum deviation. This relationship would be beneficial for planning transsphenoidal pituitary surgery (TPS), especially the access side. We also evaluated the number of the sphenoid septa, the degree of the sphenoid pneumatization, the existence of the sellar bulging and the distance between the sphenoid septum and bilateral ICAs in our study group.

Materials and Methods

We performed a retrospective study on 314 consecutive patients who admitted to radiology department for head-neck CTA examination for any reason in between January 2010 and November 2011. This study was approved by institutional review-board.

Head-neck CTA scans were performed by a 64-detector multi-slice scanner. None of the patients had previous history of sinus or sellar surgery or sellar-parasellar tumor at the time of imaging. Thin slices (1 mm), axial, coronal and sagittal MIP and MPR images were obtained and the images were processed in manufacturer's workstation for detailed evaluation. CTA scans of these cases were reviewed retrospectively for the following anatomical variations.

Degree of sphenoid pneumatization: This variation was classified as presellar, sellar, postsellar or conchal (4,5). In conchal type pneumatization, sphenoid sinus has no prominent aeration. In presellar type, the posterior border of the aeration of the spheoid sinus is anterior to the border of the sella turcica or further anterior. In sellar type, the posterior border of the aeration of the spheoid sinus is below sella turcica. In postsellar type, the aeration of the spheoid sinus is extending posterior to the sella turcica. Sphenoid pneumatization was best seen on sagittal images. Type of sphenoid sinus pneumatization depends on the position of the sinus in relation to sella turcica (2).

Sellar bulging: We evaluated the degree of sellar protrusion into sphenoid sinus. If there was no bulging into the sphenoid sinus, the case was accepted as negative. Positive cases were also classified as mild (≤3 mm) or prominent (>3 mm). This variation was also best evaluated on sagittal images.

Number of sphenoid septa: We noted the number and the configuration of the septum/septa in sphenoid sinus. We classified the number of the septa as 1, 2 and >2. These features were best evaluated on axial and coronal images.

The distance between the main sphenoid septum and ICAs: We measured the distance between the main sphenoid septum and bilateral ICAs at the level of pituitary gland in the cases with sellar and postsellar pneumatization. In the cases with presellar or conchal pneumatization, we measured the closest distance between the main septum and ICAs on axial MIP images.

Orientation of the main sphenoid and nasal septa: We identified the orientation of the main sphenoid septum on axial images at anterior, posterior parts and at the level of sella turcica respectively, as right, median and left. We also noted the direction of the nasal septal deviation as right, left or none.

Statistical Analysis

Statistical analyses were performed by using SPSS version 15.0 program (SPSS 15.0.1 Inc., Chicago, IL, USA). For data definition; average, mean, standard deviation, number and percentage values were used. Chi-square and Paired Sample T-test were performed for the analyses of the variables. P values < 0.05 were considered statistically significant for all tests.

Results

CTA images of 314 cases [207 males (65.9%) and 107 females (34.1%)] were reviewed. The ages of the cases were ranging between 18 and 89 years, with a mean value of 57.3±18.1.

According to the degree of pneumatization of the sphenoid sinus, 57 cases had presellar (18.2%), 40 cases had sellar (12.7%), 214 cases (68.2%) had postsellar and 3 cases (1%) had conchal pneumatization.

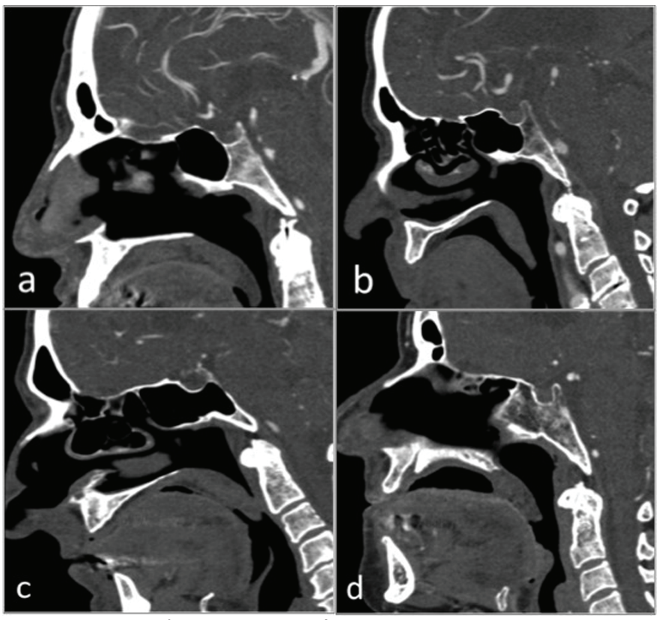

Figure 1. **Degree of pneumatization. Sagittal computed tomography angiography images demonstrate presellar (a), sellar (b), postsellar (c) and conchal (d) pneumatization paterns of the sphenoid sinus.**

We detected sellar bulging in 249 of 314 cases (79.3%), (43% mild, 36.3% prominent). In 65 cases (20.7%), there was no sellar bulging.

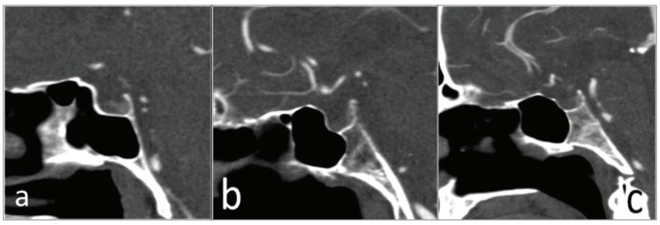

Figure 2. **Degree of sellar bulging. Sagittal computed tomography angiography images show prominent (a) and mild (b) sellar bulging. In (c), no sellar protrusion to sphenoid sinus is seen.**

No statistically significant gender difference was determined according to sellar bulging in our study group (p= 0.737, Chi-square test).

In the evaluation of the number and configuration of sphenoid septa; we detected one septum in 202 of the 314 cases (64.3%). 63 cases (20.1%) had two, 44 cases (14%) had >2 sphenoid septa.

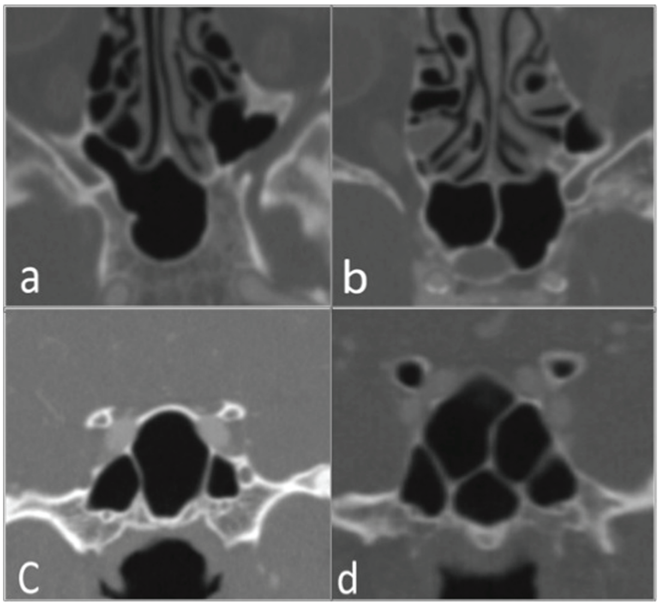

Figure 3. **Number of the sphenoid septa. Axial computed tomography angiography (CTA) images demonstrate the cases who has no septum (a), one septum (b) and two septa (c). Coronal (CTA) image (d) shows the sphenoid sinus with multiple septa.**

There was no complete transvers septum in any of the cases. In 4 cases (1.3%) there was no septum (3 of them had conchal pneumatization patern, 1 case had no septum). There was no statistically significant gender difference between the number of the sphenoid septa in our study group (p= 0.465, Chi-square test).

We detected nasal septal deviation in 268 out of 314 cases (85.4%). There was no deviation in rest of 46 cases (14.6%). There was no statistically significant gender difference according to the existence or absence of the nasal septal deviation (p= 0.054, Chi-square test). Nasal septum was deviated to the right in 129 patients (41.1%), deviated to the left in 140 cases (44.6%) and non-deviated in 45 patients (14.3%).

In cases with more than one sphenoid septum, the median or paramedian oriented complete septum anterior to posterior was accepted as the main septum. According to this, 293 cases out of 314 (93.3%) had one and 21 cases had no main septum.

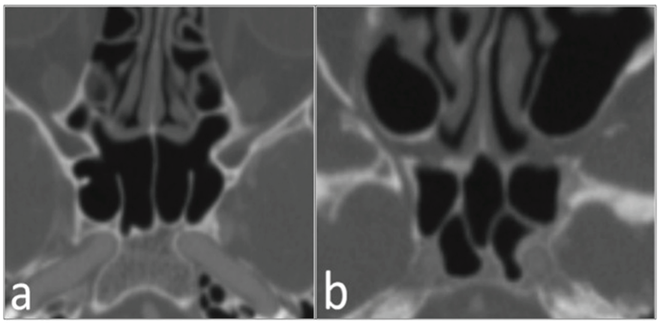

Figure 4. In (a), axial computed tomography angiography image of a case who has a detectable main septum is seen although there are three septa in the sphenoid sinus. In (b), although multiple septa are seen in sphenoid sinus as well, there is no detectable main sphenoid septum.

The orientation of the main sphenoid septum was identified as right, left and median at the anterior and posterior end point and at the level of pituitary gland, respectively. Direction of the deviation was noted according to the posterior end point of the main sphenoid septum at the level of pituitary gland.

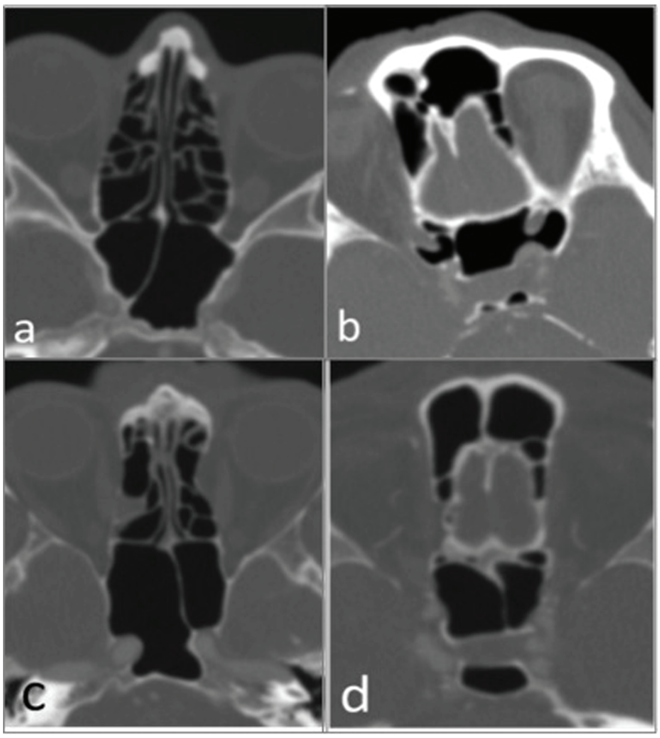

Figure 5. Deviation directions of main sphenoid septum. Axial computed tomography angiography (CTA) images obtained from the level of the ethmoid air cells (a) and pituitary gland (b) demonstrate the right deviation of the main sphenoid septum according to its posterior end point. Similarly, axial CTA images obtained from the same levels (c and d) show the left deviation of the main sphenoid septum according to its posterior end point. In (b and c), prominent protrusion of bilateral internal carotid arteries to sphenoid sinus is seen. Also note the prominent protrusion of bilateral optic nerves to sphenoid sinus in (b).

Right-deviated main sphenoid septum ratio was 43.3% (127 cases), left-deviated septum ratio was 38.9% (114 cases). Non-deviated main sphenoid septum was seen in 52 cases (17.7%).

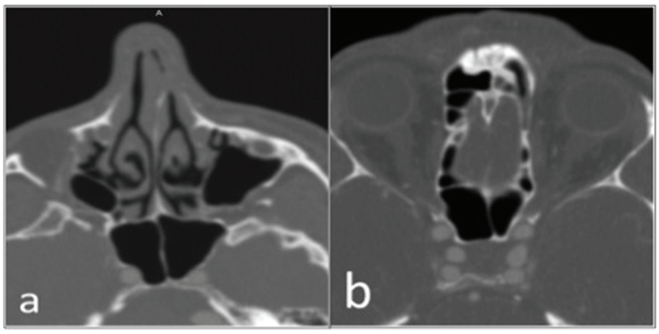

Figure 6. Deviation paterns of the main sphenoidal septum. Axial computed tomography angiography (CTA) image (a) shows no deviation of the main sphenoid septum. In another axial CTA image (b), although there is no lateralization at the main sphenoid septum according to its anterior and posterior end points (not shown), left deviation is seen at pituitary gland level.

In 20 cases (6.8%), the main sphenoid septum was deviated to the right or to the left at the level of pituitary gland only while it was situated medianly at anterior and posterior end points (Fig. 6b). We also noted the deviation direction of the nasal septum in all of the cases. With these informations we evaluated the directional relationship between the main sphenoid and the nasal septa. We have detected 8 cases (2.7%) who have non-deviated sphenoid and/or nasal septa (Fig. 7a). 18 (6.1%) and 26 cases (8.9%) had right and left nasal septal deviation, respectively, without prominent main sphenoidal septal deviation.

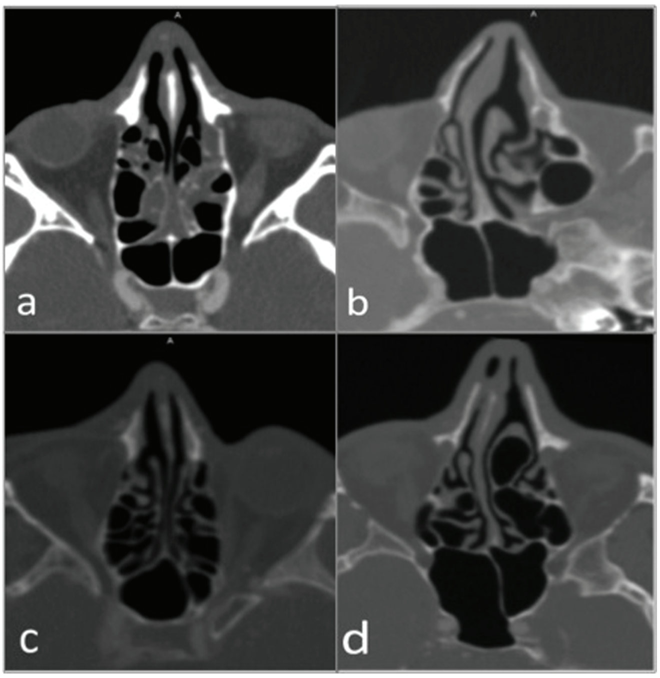

Figure 7. Relationship between main sphenoidal and nasal septal deviation directions on axial computed tomography angiography images. In (a), main sphenoidal and nasal septum locate medianly, and there is no deviation in both. In (b), nasal septum is prominently right deviated while no deviation is seen at the main sphenoidal septum. Main sphenoidal and nasal septum are deviated to the same direction (left) in image (c). In (d), while the nasal septum is deviated to right, main sphenoidal septum is left deviated according to its posterior end point, oppositely. Note that the very narrow distance between the posterior end point of the main sphenoidal septum and the left internal carotid artery in (d).

In 15 cases (5.1%), main sphenoid septum was deviated to the right without nasal septal deviation. And also in 18 cases (6.1%), main sphenoid septum was deviated to the left without nasal septal deviation. In cases with right-deviated main sphenoid septum, right-, left- and non-deviated nasal septum percentages were 21.8% (n= 64), 16.4% (n= 48) and 5.1% (n= 15), respectively. In cases with left-deviated main sphenoid septum, right-, left- and non-deviated nasal septum percentages were 14% (n=41), 18.8% (n= 55) and 6.1% (n= 18), respectively. Totally in 119 (40.6%) cases, the deviation of the main sphenoid and nasal septa were in the same direction and in 89 patients (30%) were in opposite direction (Fig. 7c, d).

We also measured the distances between the main sphenoid septum and the cavernosal segment of bilateral ICAs at the level of the pituitary gland in the cases with sellar and postsellar pneumatization.In the cases with presellar and conchal pneumatization, the closest distance between the main sphenoid septum and ICAs were noted .

Figure 8. Distance between the main sphenoidal septum and bilateral internal carotid arteries (ICA). Axial computed tomography angiography image demonstrates the left deviation of the main sphenoid septum, clearly. While only a thin bone roof is seen between the main sphenoid septum and left ICA, main sphenoid septum is far from the right ICA (14 mm).

Table I. Directional relationship between main sphenoid and nasal septal deviation in our patient group

			Deviation direction of nasal septum			Total
			None	Right	Left	Number (percentage) of patients
Deviation direction of main sphenoidal septum	none	Number (percentage) of patients	8 (2.7%)	18 (6.1%)	26 (8.9%)	52 (17.8%)
	right	Number (percentage) of patients	15 (5.1%)	64 (21.8%)	48 (16.4%)	127 (43.4%)
	left	Number (percentage) of patients	18 (6.1%)	41 (14%)	55 (18.8%)	114 (38.9%)
Total		Number (percentage) of patients	41 (14%)	123 (42%)	129 (44%)	293 (100%)

The cases without main sphenoid septum [21 cases (conchal pneumatization (n=3), no septum (n=1), multiseptated cases who had no main septum (n=17)] were excluded. Among 293 patients, in cases with right-deviated main sphenoid septum; the distance between sphenoid septum and right ICA was 4±2.5 mm and left ICA was 11.8±3.7 mm. In the patients with left-deviated main sphenoid septum; the distance to the left ICA was 3.7±2.6 mm, and to the right ICA was 11.3±3.2 mm. We found statistically significant difference in distances between the deviated main sphenoid septum and the ICA at the same side, compared with ICA which was located in the opposite side ($p < .001$ for both sides, Paired Sample T-test) (Table II). The cases with non-deviated main sphenoid septum, the distances to ICAs were very close to each other and were 7.9±2.6 mm on the right side and 7.7±2.2 mm on the left side. There was no statistically significant difference between these values ($p = 0.506$, Paired Sample T-test).

Discussion

The versatility of the trans-sphenoidal approach is based on solid foundations: it is the least traumatic route to the sella turcica, it avoids brain retraction, and it provides an excellent visualization of the pituitary gland and related anatomical structures. It also provides lower morbidity and mortality rates when compared with transcranial procedure (1). Knowledge of the degree of sphenoidal pneumatization, number and configuration of sphenoid septum/septa, the existence or absence of sellar bulging and the localization or anatomical variations of ICAs may guide the surgeon and effect TPS planning (6).

In this retrospective study with the largest number of cases (n= 314) on this topic in the literature, we examined the parameters that have also reported previously in medical literature such as the degree of sphenoidal pneumatization, number and configuration of the sphenoid septa, the existence and the degree of the sellar bulging (2,5,6,9,10).

Pneumatization degree of the sphenoid sinus varies and significantly effects the safety of the access to the sella (6). We classified the degree of the pneumatization into 4 groups as presellar, sellar, postsellar and conchal (4, 5). Hamid et al (2) reported presellar, sellar, postsellar and conchal pneumatization; 21%, 54.7%, 22.3% and 2%, respectively, in a study with 296 cases based on CT and MRI scans. Idowu et al (6) reported the degrees of pneumatization as 5%, 83%, 6.7% and 0%, respectively. In our study consisted of 314 cases, presellar, sellar, postsellar and conchal pneumatization ratios were 18.2%, 12.7%, 68.2% and 1%, respectively. In contrast to previous studies, our results were a little different especially in the ratios of sellar and postsellar pneumatization. We determined higher postsellar and lower sellar pneumatization ratios in our study group.

If the sphenoid sinus is well-pneumatized, sella turcica is seen as a prominence in the roof of the sinus, called sellar bulge (7). This is considered as one of the most important surgical landmarks in TPS. Hamid et al. (2) reported prominent sellar bulge in 222 out of 296 cases (75%), and in 74 cases they identified ill defined and inappreciable sellar bulge. Zada et al. (8) classified the sellar bulge as prominent, curved and flat type according to their sellar floor angles in their study consisted of 178 cases. They determined the percentages of these types as 25%, 63% and 11%, respectively. In their study, they have detected conchal (no identifiable floor) type pneumatization ratio similar with our study. We evaluated the existance of the sellar bulging as negative and positive (mild or prominent). 249 of 314 cases (79.3%) had sellar bulging (43% mild, 36.3% prominent). There was no sellar bulging in 65 cases (20.7%). Our results were a little different when compared with those two studies mentioned above.

There is usually an intersphenoid septum within the sphenoid sinus. This septum is removed to achieve optimal exposure to the floor of the sella in TPS. The septum usually deviates to either side, separating the sinus into two unequal parts, thereby resulting in an asymmetrical appearance of the sella turcica floor, of which the surgeon must be aware (6). Idowu et al. (6) reported one main sphenoid septum in 95% (n= 57) of the cases, although 29 of them had multiple septa, in their study based CT images of 60 cases. Hamid et al (2) reported no intersphenoid septum in 32 (10.8%), single intersphenoid septa in 212 (71.6) and an accessory septum in 32 cases out of totally 296 (10.8%) patients in their study. Zada et al (8) performed a study on same topic based on MRI scans of 178 cases. And they noted no septum, 1 septum or 2 symmetric septa in 71% of the cases, and complex configuration (2 or more asymmetrical or any kind of septa, or the presence of a horizontal septum) in rest of the cases (29%). In our study group, we determined the ratios of the cases with 1, 2 or >2 septa as 64.3%, 20.1% and 14%, respectively. There was no transvers septum in any of the cases.

We identified the orientation of the main sphenoid septum in 293 cases on axial images at the level of pituitary gland and noted the direction of the nasal septal deviation. At the beginning of this study, we thought that the main sphenoid and nasal septa might be continuing structures from anterior to posterior. Therefore, we aimed to reveal any possible relationship between the directions of the main sphenoidal and nasal septal deviations and to find out if it is beneficial or not for surgical planning especially for deciding the access side. Any possible relationship between these structures could be used to predict the deviation direction of the main sphenoidal septum, by evaluating nasal septal deviation direction during physical examination. In the patients whose main sphenoid and nasal septa were both deviated to the same direction, the opposite nasal cavity would be appropriate for the main access side to approach more easily to the sella and pituitary gland without removing the sphenoid septum. On the other hand, if the access point was chosen as the same with the deviation side of sphenoid and nasal septa, the surgeon could not see the major part of the pituitary gland and need to remove the sphenoid septum for a large view and manipulation (Fig. 7c) that can result in fatal hemorrhagic complications especially in cases with ICAs located too close the sphenoid septum. The main sphenoid and nasal septa were deviated to the same side (Fig. 7c) in 40.6% of the cases, and to opposite sides in 30.3% of the cases (Fig. 7d). In 2.7% of the cases, there was no deviation in either main sphenoid or nasal septa (Fig. 7a). 26.2% of cases had either sphenoidal or nasal septal deviation (Fig.7b). Due to statistical analyses, there was no significant relationship in the presence or absence of main sphenoidal and the nasal septal deviation in our study group ($p = 0.750$, Chi-square test). There was also no statistically significant relationship in the deviation directions of the main sphenoid and nasal septa ($p = 0.161$, Chi-square test). Consequently, these statistical results revealed that deviation direction of the main sphenoid septum cannot be predicted by determining the deviation direction of the nasal septum.

The localization of the cavernosal segment of bilateral ICAs is very important for the TPS surgeon, because of the variations that can lead to fatal hemorrhagic complications. Fernandez-Miranda et al. (9) reported a study which included high-resolution CT angiography scans of 27 patients and 27 fresh-frozen cadaveric heads which analyzed endoscopically and radiologically. In radiologically evaluated 27 cases, they determined at least one septum adjacent to the ICA. They have found out of 27 sphenoid sinuses which radiologically studied from patients, 23 (85%) and 11 (41%) had at least one or two septa, respectively touching one of the ICAs. These ratios were %89 and %48, respectively in cadaveric heads. Abdullah et al. (10) examined 5-mm–slice thickness CT scans of 70 cases, and reported that in 22 of 70 subjects (31%) the septa were related with either ICA. Unal et al. (11) studied the anatomic variations of the sphenoid sinus of 56 cases by using 3-mm–slice thickness CT scans, and by dividing the sphenoid sinuses into right and left parts. They reported that in 34 of 112 parts (30%) a septum was protruding to the ICA. Sethi et al.(12) performed an endoscopic study on 30 cadavers and found that the incidence of sphenoid septa terminating on the edge of the carotid arteries was 40%. In addition to these studies, we measured the distances in mm between the main sphenoid septum and bilateral cavernosal ICAs in the cases with main sphenoid septum on 1 mm-slice thickness CTAs, and determined statistically significant difference in the distances between the deviated main septum and the ICA at the same side compared with the contralateral side ($p < .001$) (Table II). In 83 (28.3%) cases out of 293, there was only a very thin bone roof between the main sphenoid septum and the ICA. In cases with non-deviated main sphenoid septum, the distances to cavernosal ICAs were very close to each other on both sides and were 7.9±2.6 mm on the right and 7.7±2.2 mm on the left ($p = 0.506$).

Table II. Statistical relationship of the distance between deviated and non-deviated main sphenoid septum, and cavernosal segment of ipsilateral and contralateral ICAs

Orientation of Sphenoid Septum	Internal Carotid Artery (ICA)	Mean Distance (mm)	"p" value
Right deviated (n= 127)	Right ICA	4 ± 2.5	**< 0.001**
	Left ICA	11.8 ± 3.7	
Left deviated (n= 114)	Right ICA	11.3 ± 3.2	**< 0.001**
	Left ICA	3.7 ± 2.6	
Non-deviated (n= 52)	Right ICA	7.9 ± 2.6	**0.506**
	Left ICA	7.7 ± 2.2	

Conclusion

We believe that the type of the aeration of the sphenoid sinus and sphenoid septal deviation direction are very important for TPS candidates and cannot be predicted by physical examination. Recently, CT and/or MRI are the routine imaging protocols for pituitary surgery candidates in pre-surgical evaluation. Defining the sphenoid and nasal septal deviation direction, the orientation of the ICAs, their relationships with the sphenoid septum/septa and other important variations at sellar and parasellar regions in the radiologic reports may be beneficial for the TPS surgeons especially for deciding the main access side. The radiologists should be familiar with the anatomy of this region and precisely report the septal and other anatomical variations to facilitate preoperative planning and to reduce minor and major TPS complications.

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