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Original Investigation

The Anatomical Variations in the Neurovascular Relations of the Sphenoid Sinus: An Evaluation by Coronal Computed Tomography

Sfenoid Sinüsün Nörovasküler İlişkilerinin Anatomik Varyasyonları: Koronal Bilgisayarlı Tomografiyle Değerlendirme

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ABSTRACT

AIM: The sphenoid sinus is deeply situated in the skull and is the least accessible paranasal sinus. The sphenoid sinus is surrounded by vital structures such as the optic nerve and internal carotid artery, and therefore additional radiological assessment of the sphenoid sinus and the related neurovascular structures is inevitable before surgery. The aim of this study was to note the anatomic variations in the relationship of these structures with the sphenoid sinus by analyzing the coronal computed tomography (CT) scans.

MATERIAL and METHODS: The consecutive coronal CT scans of 100 patients that included 43 males and 57 females were evaluated.

RESULTS: Variations in the neurovascular boundaries of the sphenoid sinus were a common finding in the present study and were seen in as many as 66% of the cases. Variations involving the Vidian canal were the commonest in our study and were seen in around 42%, followed by those involving the bony canal for internal carotid artery, 33%; maxillary nerve, 21 % and optic nerve, 9%.

CONCLUSION: These variations do not represent disease as such, but may increase the risk of endoscopic mishaps. CT of the paranasal sinus region is therefore an essential prerequisite prior to sinonasal and trans-sphenoidal surgeries.

KEYWORDS: Sphenoid sinus, Coronal CT, Paranasal sinus, Neurovascular, Variations, Trans-sphenoidal surgeries

ÖZ

AMAÇ: Sfenoid sinüs, kafatasının derinliklerinde yer alır ve en zor erişilebilen paranazal sinüstür. Sfenoid sinüsün çevresinde optik sinir ve internal karotid arter gibi yaşamsal yapılar vardır ve bu nedenle sfenoid sinüs ve ilgili nörovasküler yapıların cerrahi öncesinde ileri radyolojik değerlendirilmesi kaçınılmazdır. Çalışmanın amacı koronal bilgisayarlı tomografi (BT) taramalarını analiz ederek bu yapıların sfenoid sinüsle ilişkilerinin anatomik varyasyonlarını incelemekti.

YÖNTEM ve GEREÇLER: 43 erkek ve 57 kadından oluşacak şekilde arka arkaya 100 hastanın koronal BT taramaları değerlendirildi.

BULGULAR: Sfenoid sinüsün nörovasküler sınırlarında varyasyonlar çalışmada sık görülen bir bulguydu ve olguların %66'sına kadarında görüldü. Vidian kanal ile ilgili varyasyonlar çalışmamızda en sık görülenlerdi ve hastaların yaklaşık %42'sinde saptandı; bunu %33 ile internal karotid arter kemik kanalı, %21 ile maksiller sinir ve %9 ile optik sinir takip ediyordu.

SONUÇ: Bu varyasyonlar tek başına hastalık anlamına gelmez ancak endoskopik komplikasyon riskini artırabilir. Bu nedenle, sinonazal ve transsfenoidal cerrahiler öncesinde paranazal sinüs bölgesinin BT'si şarttır.

ANAHTAR SÖZCÜKLER: Sfenoid sinüs, Koronal BT, Paranazal sinüs, Nörovasküler, Varyasyonlar, Transsfenoidal cerrahiler

INTRODUCTION

Understanding of pathological processes in radiology is based on good foundation of anatomy (9). The information provided by radiology is also complementary to clinical findings (5). The sphenoid sinus is deeply situated in the skull and is the least accessible paranasal sinus. The pneumatization of the sphenoid sinus is variable and ranges from minimal to extensive. The sphenoid sinus is surrounded by vital neurovascular structures, such as the internal carotid artery, optic nerve, maxillary nerve and vidian nerve. Depending upon the pneumatization, the thickness of the bone covering the carotid arteries, optic nerves, maxillary nerves, and vidian nerves can vary. Sometimes the bone can be thin or even absent. This might make the structures susceptible to iatrogenic injury (8). The importance of anatomic variations as a predisposing cause for sinus disease, particularly in relation to the osteomeatal complex, has been stressed by several authors (4). The initial development of paranasal sinuses takes place early in the fetal life with the exception of the sphenoid sinus. The sphenoid sinus develops during the third fetal month as a constriction of the existing part of the sphenoethmoidal recess. Until the age of 6 -7 years the sphenoid sinus is still a recess and starts expanding by 7 years. The definitive form of the sinus is attained at puberty (12). The degree of pneumatization of the sphenoid sinus varies considerably and a highly pneumatized sphenoid sinus may distort the anatomic configuration and may attenuate the bone over the lateral wall, placing the optic nerve and carotid artery at greater risk (13).

The variability in the anatomy of the sphenoid sinus and its surrounding neurovascular structures are well documented (3) in various populations. The purpose of this study was to assess the frequency of dehiscence of the bony wall of the surrounding structures and also the protrusion of the structures into the sphenoid sinus in Indian patients older than 18 years.

MATERIAL and METHODS

This is a cross-sectional retrospective study of sinonasal computerized tomography of the sphenoid sinus. The consecutive coronal computerized tomography (CT) scans of 100 patients that included 43 males and 57 females were evaluated. The age ranged between 18 to 80 years with a mean age of 49 years. The study included CT scans of the nasal sinus region of patients with or without symptoms suggestive of sinus disease. CT was performed on a High Speed General Electric (GE) CT scanner and coronal scans were obtained by using a bone algorithm with a 2-mm contiguous scan. Gantry position was perpendicular to the hard palate. The scanning parameters were 120 kilovolts peak (kVp), 150 millicoulombs (mAs), Matrix 512 x 512, Scan time 2 sec, Data reconstruction STD+, Scout view lateral. The images were analyzed and the presence of the following variants was noted.

Dehiscence of bony wall surrounding:

a. Internal carotid artery
b. Optic canal
c. Vidian canal
d. Maxillary nerve

Dehiscence is defined as the absence of visible bone density separating the sinus from the course of the concerned structure. Whenever a clear decision between a very thin bony wall and total dehiscence was not feasible, the results were accepted as dehiscence (3).

Protrusion of:

a. Internal carotid artery
b. Optic nerve
c. Vidian nerve
d. Maxillary nerve

Protrusion is determined as the localization of a neurovascular structure with more than 50% of its diameter in the sphenoid sinus (7).

RESULTS

Among the 100 scans evaluated, morphological variations in the sinus region were observed in 99 scans, of which most of them presented with more than one type of variations. The frequency of the variations of the sphenoid sinus was also noted (Table I).

Variations in the neurovascular boundaries of the sphenoid sinus were a common finding in the present study and were seen in as many as 66% of the cases. Few cases showed more than one variation in the sphenoid sinus.

Variations involving the Vidian canal were the commonest in our study and were seen in around 42%. Dehiscence of the bony wall surrounding the Vidian nerve combined with protrusion of the nerve was seen in 18 cases of which 10 were bilateral (Figure 1).

Table I: Incidence of Variations in the Surrounding Anatomic Relations of the Sphenoid Sinus

Anatomic variations of the Sphenoid sinus No. (%)		Unilateral No. (%)	Bilateral No. (%)	Total
Dehiscence	Vidian nerve	4 (4%)	2 (2%)	6 (6%)
	Internal carotid artery	11 (11%)	22 (22%)	33 (33%)
	Optic nerve	5 (5%)	3 (3%)	8 (8%)
	Maxillary nerve	11 (11%)	9 (9%)	20 (20%)
Protrusion	Vidian nerve	4 (4%)	14 (14%)	18 (18%)
	Internal carotid artery	-	-	-
	Optic nerve	-	-	-
	Maxillary nerve	-	1 (1%)	1 (1%)
Dehiscence and Protrusion	Vidian nerve	8 (8%)	10 (10%)	18 (18%)
	Internal carotid artery	-	-	-
	Optic nerve	-	1 (1%)	1 (1%)
	Maxillary nerve	-	-	-

Among the variations involving the internal carotid artery, we observed dehiscence of the surrounding wall in 33 cases (Figure 2). This was more common bilaterally and was seen in 22 cases. Unilateral dehiscence was observed on the right side in 7 cases and left side in 4 cases. We did not encounter any case of protrusion of the internal carotid artery.

Dehiscence of the bony wall surrounding the maxillary sinus was observed in 20 cases of which 9 cases were bilateral. Among the 11 unilateral cases, 6 were present on the right side and 5 on the left. We observed protrusion of the maxillary nerve into the sinus in only 1 case, which was seen bilaterally. However we did not encounter any case that had both dehiscence and protrusion of the bony wall around the maxillary artery.

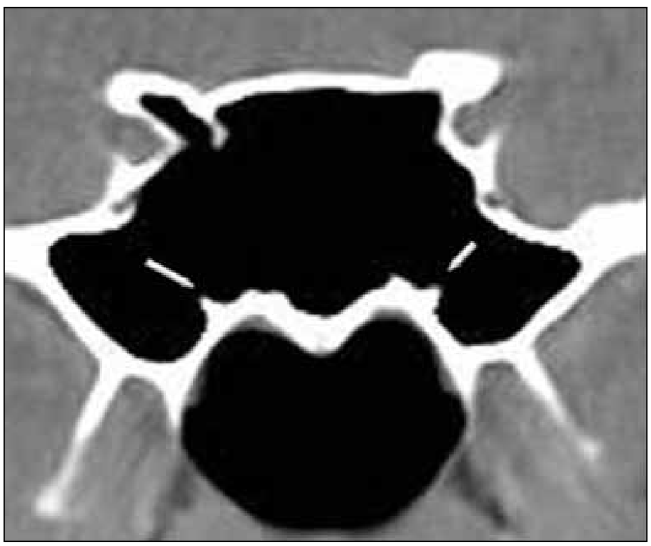

Figure 1: CT image showing bilateral protrusion of the vidian nerve (arrows).

Variations involving the optic nerve were less in our study. A combination of dehiscence and protrusion was observed only in one case and was present bilaterally. Plain dehiscence of optic canal however, was observed in 8 cases (Figure 3), 3 of which were bilateral. Of the unilateral cases right-sided dehiscence was more common (4 cases) than the left.

DISCUSSION

The sphenoid sinus is surrounded by vital structures such as the optic nerve and internal carotid artery, and therefore additional radiological assessment of the sphenoid sinus and the related neurovascular structures is inevitable before surgery, since one of the serious complications of trans-sphenoidal surgery is injury to the internal carotid artery or optic nerve (2). The trans-sphenoid access to approach pituitary adenomas is becoming the most common and different anatomical configurations of the sphenoid sinus can seriously affect the access to the sella via the nose (6). Even though the variations of the sphenoid sinus do not represent disease per se, they may impair normal drainage pathways, hinder endoscopic access to distal areas, serve as a focus for occult disease and increase the risk of endoscopic mishaps (4).

According to Bademci and Unal, 2005 (1), assessment of sphenoid sinus using both coronal and axial scans is accepted as the gold standard of the study. However, Davoodi et al. (2) state that coronal scans are useful in detecting protrusion of optic nerve and Vidian nerve and dehiscence of maxillary nerve and Vidian nerve, whereas axial scans are superior in assessing Onodi cells. Moreover, they opine that choosing one of the planes exposes the patient to less radiation and also saves the patient's time and money. In our study, we have included only coronal sections of CT scans for the study of sphenoid sinus and therefore the focus of the present study is on the dehiscence of the surrounding bony wall and the protrusion, of the structures that relate to the sphenoid sinus.

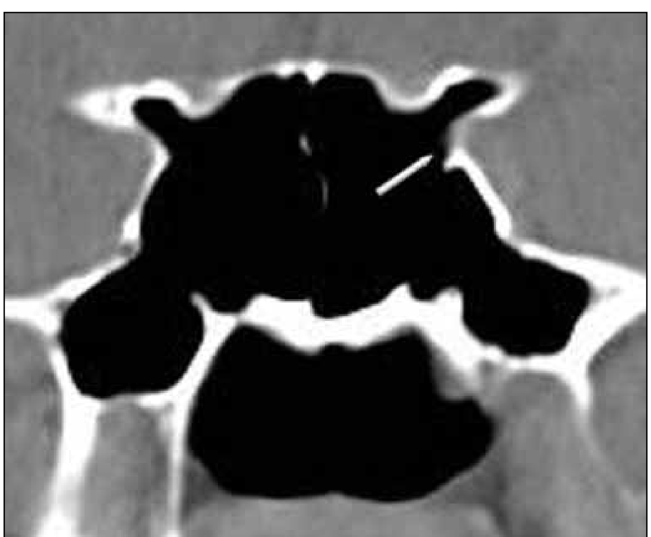

Figure 2: CT image showing (arrow) dehiscence of the bony wall around the internal carotid artery.

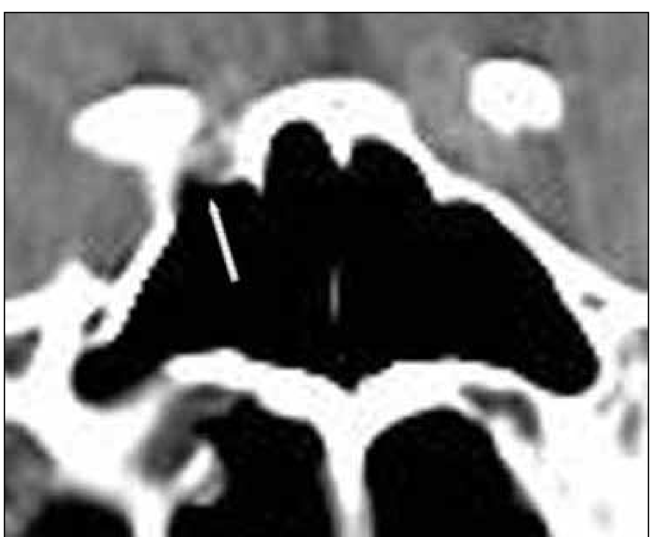

Figure 3: CT image showing (arrow) dehiscence and protrusion of the optic nerve.

Variations involving the Vidian nerve were most commonly encountered in our study and were seen in 42% of the cases. Among these variations we observed dehiscence of the bony wall surrounding the Vidian nerve in 6% of the cases of which unilateral cases were more common. Mere protrusion of the Vidian nerve was seen in 18% of the cases, again more commonly seen unilaterally (77%). Dehiscence combined with protrusion was seen in 18% that was only slightly more common unilaterally (55%).

In a similar study conducted in Iran (2), dehiscence of the bony wall surrounding the Vidian canal was seen in 34.4% in males and 37.5% in females. Protrusion of Vidian nerve was reported in 28.5% of male patients and 22.7% of female patients. They did not report cases that included both dehiscence and protrusion. Another study conducted in Libyan population (8) included 300 coronal scans only and they observed dehiscence of the bony wall surrounding the Vidian nerve in 37%, more commonly unilaterally, and Vidian nerve protrusion in 27% of the cases, both high when compared to our study. However, in their study, protrusion was commonly found bilaterally.

Variation in the relationship between the Vidian canal and sphenoid sinus may lead to involvement of Vidian nerve in sinus disease. This may result in a clinical syndrome of vidian neuralgia characterized by pain referred deeply in the nasal cavity (8) and hence analysis of radiographic anatomy of the Vidian canal is necessary to decrease the complications following endoscopic trans-sphenoidal and vidian neurectomy surgery.

Internal carotid artery is another structure that is at a high risk of injury due to variations in the sphenoid sinus. Variations involving the internal carotid artery have also been commonly reported by several investigators. We found such variations in 33% of the cases, all of which were dehiscence of bony wall surrounding the artery. We did not encounter any case of dehiscence combined with protrusion of the artery or even plain protrusion. Bilateral bony dehiscence was more common in our study and was seen in more than 66%.

Bony dehiscence of the wall around the internal carotid artery is reported by Nitinavakarn et al., 2005 (10) in 10.2% and Pata et al., 2005 (11) in 1.8%, both incidences meager compared to our study. Davoodi et al (2) found bony dehiscence in 39%, slightly higher than in our study. They however found more unilateral cases compared to bilateral at about 62%. They also reported a high prevalence rate of protrusion of the artery in 48.5% that was also more common unilaterally. Another study conducted in Libya (8) reported equally high prevalence rates of protrusion of the artery in 41% and dehiscence in 30%. Bony dehiscence was more common unilaterally in their study unlike ours whereas protrusion of the artery was more common bilaterally. Such a high rate of protrusion reported in both the above studies is probably due to the inclusion criteria adopted by them. In their study, protrusion of internal carotid artery was determined by any degree of protrusion into the sinus cavity whereas we have noted only those cases that had protrusion of more than 50% of the diameter into the cavity.

A close association of internal carotid artery with the sphenoid sinus makes it vulnerable for injury when the sinus is infected or during surgeries. If the surgeon is unaware of dehiscence or protrusion of the artery, even fatal hemorrhage may happen, because it is hardly possible to control bleeding from an injured internal carotid artery within the sphenoid sinus (8).

Variations involving the optic nerve are also clinically significant. We came across a total of 9% in our study, of which bony dehiscence itself was seen in 8% cases. Dehiscence was slightly more common unilaterally. Dehiscence combined with protrusion was seen only in one case where it was present bilaterally. We did not encounter any case of protrusion without dehiscence.

Bademci and Unal, 2005 (1) in their study conducted in Turkey reported bulging of the optic nerve in 34.4% of the cases and dehiscence in 7.7%. Unlike us, they included combined axial and coronal scans. Davoodi et al., 2009 (2) reported protruding optic nerve in 38% of the cases in males and bilateral cases were slightly more and 34.9% in females where unilateral cases were slightly more. Bony dehiscence was seen in 28.5% of males and in 46% of females. Dehiscence was also reported by Nitinavakarn et al., 2005 (10) in 18.2% and dehiscence with protrusion by Hewaidi and Omani, 2008 (8) in 30.6%.

Heskova et al., 2009 (7) studied the sphenoid sinus in both coronal and axial sections. In axial sections they classified the optic nerve into 4 types depending upon its relation with the sphenoid sinus. Of the 4 types, type 3 and 4 indicated an intimate relationship of the nerve to sphenoid sinus and the posterior ethmoidal air cells and were regarded as the most critical for the potential risk of injury to the optic nerve. They reported type 3 and 4 optic nerve in 35.3% of the cases in which unilateral and bilateral cases had almost equal prevalence. The rate of bony dehiscence reported by them was closer to our study at about 11.7% which was seen only unilaterally by them. They concluded that variations in the sphenoid sinus are frequent. Another investigation that studied only axial scans of sphenoid sinus was by DeLano et al., 1996 (3). They studied 150 CT scans of sphenoid sinus and found all 300 optic nerves closely related to the sinus. They also classified the optic nerve into 4 types and found type 3 and 4 in a total of 9% of the cases.

Damage to the optic nerve is serious complication of intranasal sinus surgery (7). A protruding optic nerve can be injured not only during surgery, where damage to the nerve has a high risk of blindness but also as a complication of sinus disease. Defects in vision can result from sphenoid sinusitis or the optic nerve may be compressed by a mucocele in the sphenoid sinus (2). Presence of bony dehiscence when not kept in mind during surgeries can also lead to inadvertent injury to the optic nerve leading to blindness, especially when punch biting forceps are used (1).

Although less commonly described, the maxillary nerve in the foramen rotundum is also closely related to the sphenoid sinus. Variations involving the maxillary nerve were seen in 21% of the cases in our study. These involved bony dehiscence in 20% of the cases and protrusion of the nerve into the sinus in 1%. We did not encounter any cases of combined dehiscence and protrusion.

Hewaidi and Omami, conducted on the Libyan population reported bony dehiscence at a rate of 13% (8). They found protrusion of the nerve in 24.3% of the cases, which is much higher than in our study. They reported that both of the above were more common unilaterally. They also found significant association between protrusion of maxillary nerve and pneumatization of greater wing of sphenoid. Davoodi et al., 2009 (2) reported an equally high prevalence rate of bony dehiscence of the maxillary nerve. They found dehiscence in 28.5% of the male patients and in 36.5% of the female patients. A protruding maxillary nerve was found in 35.2% of male patients and in 32.8% in female patients. In all of the above, unilateral cases were more commonly reported.

Like the other structures related to the sphenoid sinus, the maxillary nerve is susceptible to iatrogenic injuries when protruding or in the presence of bony dehiscence around the maxillary nerve. Also, bony dehiscence makes the nerve vulnerable to neuritis in the presence of sphenoid sinus infection. The maxillary neuritis that develops might present as trigeminal neuralgia (8).

CONCLUSION

Variations in the sphenoid sinus were very common and were present singly or in combination in 69% of the cases of which dehiscence and protrusion of Vidian canal was the commonest. Anatomical variations that can lead to compromise of mucociliary drainage are frequently seen and CT is a valuable tool to evaluate the paranasal sinus anatomy and these variations. Routine preoperative CT in trans-sphenoid surgeries can also direct the surgical decision since the findings hels to map the procedure safely and effectively to reach the sella, avoiding complications. CT of the paranasal sinus region is therefore an essential prerequisite prior to sinonasal and trans-sphenoidal surgeries.

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