

Sphenoid Sinus: Anatomic Variations and Their Importance in Trans-sphenoid Surgery

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ABSTRACT

Background: Over the past decades, instruments and techniques of the transsphenoidal approach have improved greatly. All of these procedures, whether microscopic or endoscopic, must pass through the sphenoid sinus to reach the lesions. The sphenoid sinus is surrounded by several vital anatomical structures. Knowing the details of the anatomy of the sphenoid sinus and the extent of pneumatization can guide the surgeon through difficult corners of this approach.

Purpose: This work aimed to determine the incidence of the different anatomical variations of the sphenoid sinus in Iranian patients with pituitary adenomas as detected by preoperative MRI and CT scans.

Methods: Preoperative CT scan and MRI of 64 adult patients with pituitary adenomas were retrospectively reviewed regarding degree of pneumatization and septation of the sphenoid sinus.

Results: Regarding the degree of pneumatization, there were 34 cases with sellar type (59.4%), 10 patients with presellar type (15.6%), and 16 cases with conchal type (25%). Regarding degree of septation, no absence of septum observed in any of our cases. A single intersphenoid septum observed in 18 of cases (28.1%), and 46 of cases had more than one intersphenoid septum (71.9%). Also, one onodi cell was identified.

Conclusion: Enrichment of the knowledge of the sphenoid sinus anatomic variation would aid in reducing complications. Surgeons must meticulously study the preoperative imaging to become familiar with the nuances and variations unique to each case and proceed accordingly to decrease the risk of complications.

Keywords: Sphenoid sinus; Pneumatization; Trans-sphenoid surgery; Anatomy

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INTRODUCTION

Over the past decades, instruments and techniques of the transsphenoidal approach have greatly improved^{1,2}. More than 35 years ago, Hardy et al, established the transsphenoidal approach as the gold standard for sellar lesions³⁻⁵.

Nowadays, by use of the endoscope and bilateral nostril corridors⁶, the extended transsphenoidal approach

is being used more widely to treat parasellar, suprasellar, clival, and even petrous lesions⁷⁻¹¹.

All of these procedures, whether microscopic or endoscopic, have to pass through the sphenoid sinus to reach lesions. The sphenoid sinus is surrounded by several vital anatomical structures: the internal carotid arteries, optic nerve, cranial nerves III and IV inside the cavernous sinus, basilar sinus, and brain stem behind the clivus

bone⁷. Vascular or neurological complications, though rare, can lead to permanent disability or even death^{12,13}. Knowing the details of the anatomy of the sphenoid sinus and the extent of pneumatization can guide the surgeon through difficult corners of this approach.

The aims of this study are to evaluate the different anatomical variations of the sphenoid sinus in Iranian patients with pituitary adenomas as detected by preoperative MRI and CT scans.

MATERIALS AND METHODS

CT scans and MRIs of adult patients operated for pituitary adenomas at Shohada Tajrish Hospital, Shahid Beheshti University of Medical Sciences, Tehran, Iran, in the period between January 2010 and September 2013 were reviewed. Patients who had trauma or prior surgery of the ethmoid or sphenoid sinuses were excluded from this study.

Preoperative MRIs were obtained using a standard head coil of a 3T scanner, contiguous 3 mm thick in T1-weighted pre- and postcontrast sequences and fast spin-echo T2-weighted sequences of in axial, coronal, and sagittal planes. Preoperative contrast-enhanced CT scans were obtained in both axial and coronal planes. MRIs and CT scans reviewed for the degree of sphenoid sinus pneumatization and number of septa.

According to degree of pneumatization, sphenoid sinuses were categorized in one of three types, depending the position of the sinus in relation to the sella turcica: Conchal (completely missing or minimal sphenoid sinus), presellar (posterior wall of sphenoid sinus is in front of the anterior wall of the sella) and sellar (posterior wall of sphenoid sinus is behind anterior wall of sella). This was best seen in the sagittal MRI. Absence, single, or multiple intersphenoid septa was best evaluated on both axial and coronal CT scans.

RESULTS

CT scans and MRIs of 64 adult patients were reviewed including 27 males and 33 females. The age ranged between 19 to 62 years (mean=46). 38 cases had nonfunctioning pituitary adenomas and 26 cases had functioning adenomas. The size of the tumor ranged from 8 mm to 7 cm.

Among 64 sphenoid sinuses reviewed, regarding the degree of pneumatization, there were 34 cases with sellar type (59.4%), 14 patients with presellar type (15.6%), and 16 cases with conchal type (25%).

The evaluation of CT scans of these patients, revealed absence of septum in no one of our cases. A single

intersphenoid septum observed in 18 of cases (28.1%), and 46 of cases had more than one intersphenoid septum (71.9%). In this study, also, 1 Onodi cell was identified.

DISCUSSION

The sphenoid sinus is located in the center of the cranial base. The sinus is bordered by the cavernous sinuses laterally, the ethmoidal air cells anteriorly, the clivus posteriorly, the pituitary fossa and planum sphenoidale superiorly, and the choana inferiorly¹⁴.

Pneumatization, which can be seen as early as 6 months of age, begins at the ostia and progresses in posterior, inferior, and lateral directions^{15,16}. Sinus expansion does not reach its full extent until adolescence and continues after puberty¹⁴.

The sphenoid sinus may show varying degrees and directions of pneumatization in each individual, with its various extensions bringing it in close relationship to the cavernous sinus, internal carotid artery, optic nerve, frontal lobe, ventral surface of the brainstem, cranial nerves III to VI, and pituitary gland¹⁴. Some of these structures may underlie and produce bony prominences and related recesses inside the sinus¹⁷⁻¹⁹. Pneumatization of the sphenoid sinus provides a dilating natural cavity through which wide areas of the cranial base may be accessed¹⁴.

Congdon ED, originally classified the sphenoid sinus into three types based on the level of pneumatization²⁰. The conchal type is described as pneumatization in which the posterior wall of the sinus lies anterior to the sella. In the presellar type, the posterior limit of the sinus extends into the anterior portion of the sella.

The conchal Type sphenoid is usually found to be the least common type, with average of 2.3% in 11 studies performed on Caucasians and average of 7.2% in 6 studies performed on Chinese¹¹. However, Tan and Ong's study of adult Asian cadavers exhibited a much higher proportion of conchal type of sphenoid sinuses pneumatization, with 28% of their specimens²¹. Our study found an overall prevalence of 25%, which is more in accordance with Tan and Ong's reported data.

The conchal type of sphenoid sinus pneumatization, due to the amount of bone present between the sphenoid face and the sellar/parasellar region, increases the difficulty of the transsphenoidal approach²¹. However, with the surgeon informed in advance, different tools can make such an approach feasible. Intraoperative navigational devices, can be used to confirm surgical landmarks. Anyhow, in these cases, the surgeon should consider the size of the tumor: small and intrasellar

tumors can be completely removed, but with larger tumors, transcranial approaches should be considered to allow safe and adequate removal²².

The presellar type of pneumatization is usually intermediate in frequency in studies conducted thus far, with average of 16.8% in 11 studies performed on Caucasians and average of 28% in 6 studies performed on Chinese¹¹. In our study, we found an overall percentage of presellar sphenoid pneumatization in 15.6% of our cases. This type presents less of a challenge than the conchal type during transsphenoidal approach, because there is less bone between the anterior wall of the sella and the sphenoid sinus²³. However, there is a lack of sellar bulge since the sinus only extends up to a plane perpendicular to the anterior face of the sella turcica.

The sellar pneumatization type has been the most prevalent of the pneumatization types in previous studies, with average of 80.9% in 11 studies performed on Caucasians and average of 64.8% in 6 studies performed on Chinese¹¹. Our study found an overall prevalence of 59.4%, which is more in accordance with Tan and Ong's reported percentage of 55% in Asian cadavers¹⁶.

The sellar type has pneumatization past the anterior border of the sella such that the sella bulges into the sinus. This is considered one of the most important surgical landmarks to the sellar floor²². The sellar pneumatization type is most amenable to transsphenoidal approach²³. The access to the sella was further facilitated when the pathology caused thinning or breaching of the sellar floor²².

However, if the degree of pneumatization is extremely extensive, the anatomy can be distorted, attenuate the bone over the lateral wall, with protrusion or dehiscence of the optic nerves, internal carotid arteries, V2s, and the vidian nerves²³. These situations are not uncommon²⁴ and lead to increased risk of inadvertent perforation and damage to those adjacent structures. Additionally, increased pneumatization may lead minimal if any sellar bulge. This can cause the floor of the middle cranial fossa to be mistaken for the sella and lead to unwarranted intracranial entry²².

The septa of the sphenoid sinus were found to be variable. Single intersphenoid septum observed in 28% and multiple septa were found in 71.9% of cases; which is in accordance with previously reported data²⁵⁻²⁷. The main septum (highest and the broadest septum), usually deviates to one side, dividing the sinus into two unequal cavities resulting in an asymmetrical appearance of the sella turcica floor²². According to Sethi, Stanley et al report, in 32 to 40 percent of patients the septum deviates

quite laterally and terminates on the carotid artery²⁸. Thus, when removing the main septum to expose the floor of the sella, it is wise to use extreme caution while removing the terminal septum, in order to prevent accidental and disastrous injury to the carotid artery²⁹. The terminal septa are usually inserted lateral to the sellar floor and may not require complete removal for adequate exposure³⁰.

The sphenothmoidal cell, also called the Onodi cell, is an ethmoidal air cell located at the most posterior end of the ethmoid bone which pneumatizes far laterally and to some degree superiorly into the sphenoid sinus³¹. The prevalence of onodi cell is reported 8-14 %. However, in our study, we found only one case with onodi cell (1.6%).

The optic nerve and carotid artery may be exposed in an Onodi cell. There are significant correlations between the presence of the onodi cell and optic nerve protrusion (80.1 %), optic nerve dehiscence (36.3 %), internal carotid artery protrusion (59 %), and internal carotid artery dehiscence (20.8 %) ($p < 0.01$)³². The other surgically significant point is that the sphenoid sinus is located medially and inferiorly to the onodi cell. Consequently, attempts to use instrumentation to locate the sphenoid sinus directly behind the onodi cell may result in serious damage to the optic nerve or carotid artery³¹.

CONCLUSION

The anatomy of the sphenoid sinus can be quite complex. The great amount of anatomic variation is attributed to the extent of sphenoid sinus pneumatization, varying number and position of septae, and the relationship with surrounding structures.

Enrichment of the knowledge of the sphenoid sinus anatomic variation will aid in reducing complications. Surgeons must meticulously study the preoperative imaging to become familiar with the nuances and variations unique to each case and proceed accordingly to decrease the risk of complications.

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