Anatomical and Radiological Parameters of the Sphenoid Sinus among Egyptians and its Impact on Sellar Region Surgery

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ABSTRACT
Background: Pneumatization of the sphenoid sinus provides a dilating natural cavity through which wide areas of the cranial base may be accessed. Careful examination of various pneumatized extensions of the sphenoid sinus may facilitate extended approaches directed through the sinus to the perisellar pathologies. Objectives: to provide anatomical information among Egyptians about the location of the sphenoid sinus inside and outside the sphenoid bone and how to use extended pneumatization as natural trajectories to various targets at the skull base. Material and Methods: This study was conducted on twenty five adult dried hemi skulls. Different sagittal, coronal and axial cuts were carried out to evaluate the pattern and extent of pneumatization through the sphenoid bone in various directions, bulges and dehiscence of relevant neurovascular structures. The morphometry of the vidian canal and foramen rotundum was analyzed. The results were correlated with the outcomes from CT and MRI images of three hundred sixty four patients who were retrospectively evaluated at a period between 2010 and 2013. Results: In the anatomical twenty five specimens, no conchal pattern, three (12%) were presellar type and twenty two (88%) were sellar type. The pneumatization within twenty two sellar sinuses (88%) showed nine specimens (36%) of sphenoid body type, seven specimens (28%) of lateral type, three specimens (12%) had clival recesses, three specimens (12%) with lesser wing type (Anterior clinoid process type). On the other hand, among the radiologically-examined three hundred sixty four cases, there were six cases (1.6%) showing conchal pneumatization, forty six cases (12.6%) with presellar pneumatization and three hundred twelve cases (86%) showing sellar pneumatization. The sellar pattern was reclassified into six types; sphenoid body type was found in seventy three cases (20%). the lateral type of extension was found in forty six cases (12.6%). Twenty seven patients (7.4%) presented with clival type sinuses. Superior wall, optico-carotid and tuberculum recess (Lesser wing type), was found in seven cases (2%). The sphenoid sinus with anterior recess (anterior type), was found in fifty six cases (15%). Combined type of pneumatization existed in the same case, were found in one hundred eighty two cases (50%). Conclusion: The full preoperative anatomical information of each patient going to extended transsphenoidal surgery is important to assess different types of extension of sphenoid sinus pneumatization, areas of bony dehiscence and areas of critical septal terminations and subsequently avoid injury of the nearby neurovascular structures and reduce the possibility of CSF leakage.

INTRODUCTION

The sphenoid sinus is located in the center of the cranial base and attains its mature size by the age of 14 years. The sphenoid sinus may show varying degrees and directions of pneumatization, with its various extensions bringing it in close relationship to the optic nerve, cavernous sinus, internal carotid artery, frontal lobe, ventral surface of the brain stem, cranial nerves III to VI and pituitary gland. Several important surgical landmarks, such as recesses, prominences, and impressions caused by neurovascular structures coursing underneath the bone, could be clues to locate these vital structures, which help avoid injury during the operation. Pneumatization of the sphenoid progresses from presphenoidal (front) to the postsphenoidal (back) centers, forming the main sphenoid sinus cavity. Aeration of the more peripheral ossification centers
result in pneumatization of the greater and lesser wings, and the anterior clinoid and pterygoid processes. The lines of fusion between the various ossification centers are thought to be zones of relative resistance to pneumatization. Persistence of bony ridges and crests as residuals of the fusion lines accounts for complex internal septation of the sphenoid sinus\(^6\).

The recent advent of the endoscope, with its improved illumination, wider field of view, together with current sophisticated neuronavigation systems, has enabled the neurosurgeon to extend approach tumors beyond the sellar region under a better direct visual control\(^9\).

Cerebrospinal fluid (CSF) leakage represents one of the most common post intervention complications. Other complications including hormonal dysfunction, permanent and transient neurological deficit and visual affection were reported as well in different publications\(^3,10,16\).

**Objectives:**

To provide anatomical information among Egyptians about the location of the sphenoid sinus inside and outside the sphenoid bone and how to use extended pneumatization as natural trajectories to various targets at the skull base.

**MATERIAL AND METHODS**

Two groups of material were studied and analyzed, group A; included 25 adult dried hemi skulls were examined to evaluate the pattern and extent of pneumatization through the sphenoid bone in various directions as well as bulges and dehiscence of relevant neurovascular structures. The specimens were obtained as part of dry bone collection stored at the department of anatomy (Zagazig University). (Fig. 1,2,3,4,5,6) We adopted the detailed Wanj and his colleagues’ classification \(^9\) as shown in (Table 1) to describe the position of sphenoid sinus in and out the sphenoid bone and the direction of external sinus extension.

None of the dried specimens presented fractures, malformations, damage due to conservation or pathologies that could influence the development of the studied region. The sphenoid sinus length at the upper and lower margins was measured. The height of the sinus at the anterior and posterior limits was taken. The distance between the median plane to the vidian canal and foramen rotundum was measured. The distance between the vidian canal and the foramen rotundum was also measured. All the distances were measured by Diamond Master Vernier Caliper to the nearest millimeters (Fig. 1).

The other group (group B); included 364 patients who were radiologically evaluated for the same purposes utilizing the available CT and/or MRI images at Department of Diagnostic Radiology, Suez Canal University hospital-Egypt between June 2010 to June 2013.

This group included 196 females and 168 males. Their ages ranged from 17 to 67 years. The Inclusion criteria were every patient had 2mm thickness slice CT for the paranasal sinuses and skull base for different clinical presentations. Axial, coronal and sagittal images for the sphenoid sinus were evaluated mainly in CT images and at the appropriate MRI studies. The Exclusion criteria were any patient who had previous sinus surgery, brain tumors distorting sinus areas, craniofacial trauma, congenital facial abnormality or any patient who was not having adequate CT/ MRI images appropriate for interpretation.

The CT and MRI of these patients were reviewed retrospectively for the following anatomic variations:

**I- Degree of pneumatization:** The sellar pattern (The pneumatization extended beyond the anterior sellar wall) were reclassified into 6 divisions depends upon extent of sphenoid sinus pneumatization into the surrounding bony structures\(^8\), sphenoid body type whereas the pneumatization does not extend beyond the sphenoid bone, Lateral type whereas the sinus extends lateral to a line connecting the medial edge of the anterior opening of Vidian canal, which located in the line of fusion between the pterygoid process and the body of the sphenoid bone transmitting the vidian nerve and vessels, and the extra cranial end of foramen rotundum (VR line) (Fig. 4,6). Superior type referred to lesser wing type (optico carotid or tuberculum recesses) whereas the pneumatization extended into the lesser wing and possibly into the anterior clinoid process. Anterior type; the anterior wall of the sinus extended anterolaterally beyond the vertical coronal plane of the sinus side of the sphenoid crest. A clival type sinus was identified as being present when a clival recess extended beyond the vertical coronal plane of the posterior wall of the pituitary fossa\(^14\). Three types of clival recesses were found, the dorsum type, which extends above the horizontal plane of the floor of the pituitary and into the dorsum sella, the subdorsum type, which lies between the horizontal plane of the floor of the pituitary fossa and the horizontal plane passing through the anterior opening of the vidian canals, and the occipital type which extends inferiorly below the horizontal plane crossing the anterior opening of the paired vidian canals and combined type, more than one type of extension appears in the same sinus (Fig: 2).

**II-Septation:** The presence or absence of single or multiple inter sphenoid septa and their termination at the optic canals or carotid canals in both axial, coronal CT and MRI images.

**III- Inter carotid distance at anterior clinoid process (ACP).**

**Statistical analysis:**

Analysis of the data was done using statistical program for social science as follow: Description of the
quantitative variables as no and %, Chi-square test was used to compare qualitative variables, Fisher exact probability test was used when the study group was <5. Unpaired t-test was used to compare 2 independent groups as regard quantitative variable. Correlation coefficient test (r-test) was used to rank different variables against each other either positively or inversely. P value >0.05 was considered insignificant, p value <0.05 was considered significant while p value <0.01 was considered highly significant.

RESULTS

Among the examined 364 cases (group B), there were 6 cases (1.6%) showing conchal pneumatization, 46 cases (12.6%) showing presellar pneumatization and 312 cases (86%) showing sellar pneumatization (Table 2).

<table>
<thead>
<tr>
<th>Table 1: Radiological classification of sellar type of sphenoid sinus pneumatization into 6 types:</th>
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<tr>
<td>Type</td>
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</tr>
<tr>
<td>Sphenoid body type</td>
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<tr>
<td>Lateral type</td>
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<tr>
<td>Greater wing type</td>
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<tr>
<td>Pterygoid type</td>
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<tr>
<td>Both</td>
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<tr>
<td>Posterior type (clival recess)</td>
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<tr>
<td>Dorsum type</td>
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<tr>
<td>Subdorsum type</td>
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<tr>
<td>Occipital type</td>
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<tr>
<td>Combined dorsum occipital type</td>
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<tr>
<td>Lesser wing type (ACP)</td>
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<tr>
<td>Anterior type</td>
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<td>Combined type</td>
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</table>

In the anatomical 25 specimens, no conchal pattern, 3 (12%) were presellar type (The pneumatization was limited to the area anterior to the vertical plane of the anterior sellar wall) and 22 (88%) were sellar type. The pneumatization within 22 sphenoid sinuses(88%) showed 9 cases(36%) of sphenoid body type, 7 cases (28%) showed lateral type, three specimens of greater wing (12%), four specimens of pterygoid type (16%) and no cases with both (full lateral), three specimens (12%) had clival recesses, two of them were (8%) dorsum and one specimen (4%) of subdorsum type, three cases (12%) with lesser wing type (ACP). (Table 2)

<table>
<thead>
<tr>
<th>Table 2: Anatomical and radiological classification of sphenoid sinus pneumatization:</th>
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<tr>
<td>Anatomical group</td>
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<tr>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td>Conchal</td>
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<tr>
<td>Presellar</td>
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<tr>
<td>Sellar</td>
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The length and height of the sphenoid sinus

The average distance of the sphenoid sinus length in the upper part was 13.9±4.5 mm while in the lower part was 25.9±4.8 mm. Whereas, the mean values of the sphenoid sinus height was 18.9±3.9 mm anteriorly while in the posterior was 12.1±1.8 mm (Table 3).

<table>
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<tr>
<th>Table 3: The length and height of the sphenoid sinus:</th>
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<tr>
<td>Measurements</td>
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<tr>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td>1- Length (upper)</td>
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<tr>
<td>2- Length (lower)</td>
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<tr>
<td>3- Height (anterior)</td>
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<tr>
<td>4- Height (posterior)</td>
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</tbody>
</table>

The mean distance from the midline to foramen rotundum on the right side was 20.6±2.38mm; however, it was 19.8±1.4 mm on the left. The average distance between the midline and the vidian canal was 20.86±1.9 mm on the right side; however, it was 20.4±1.2 mm on the left. Moreover, the mean value for the distance between the vidian canal and the foramen rotundum on the right side was 16.1±0.8 mm; however, it was 15.4±0.3 mm on the left (Table 4).

<table>
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<th>Table 4: Statistical analysis of the anatomical linear measurements related to the midline:</th>
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<tr>
<td>Measurements</td>
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<td>-----------------------------------------------</td>
</tr>
<tr>
<td>1- M-FR</td>
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<tr>
<td>2- M-VC</td>
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<tr>
<td>3- VC-FR</td>
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Among the anatomical group, there was no intersphenoid septum in 4 specimens (16%). A single middle inter sphenoid septum was seen in 8 patients (32%). The insertion of the septum was at the lowest point in the sellar floor in 16 patients (64%). The septum pointed toward the carotid canal in 5 patients (20%), 3 patients, (12%) to the Rt. Carotid canal and 2 patients (8%), to the left one. Accessory septum was found in 3 patients (12%). The accessory septum pointed toward the carotid canal in 4 cases (16%), 2 cases, (8%) to the Rt. Carotid canal and 2 cases (8%), to the left one. 7 cases (28%) have multiple intersphenoid septa with different orientations. Inter carotid distance at ACP ranged from 10.2 to 27.8mm with mean 20.0±3 mm (Fig. 3,5).

Among the radiological group, there was no intersphenoid septum in 48 patients (13%). A single middle inter sphenoid septum was seen in 127 patients (35%). The insertion of the septum was at the lowest point in the sellar floor in 192 patients (53%). The septum pointed toward the carotid canal in 38 patients (10%), 14 patients, (3.8%) to the Rt. Carotid canal and 24 patients (6.5%), to the left one. Accessory septum
was found in 26 patients (7%). The insertion of the accessory septum in the sellar floor was visualized in 12 cases (3%). The accessory septum pointed toward the carotid canal in 14 cases (3.8%), 4 cases, (1.26%) to the Rt. Carotid canal and 10 cases (2.7%), to the left one. 20 cases (5.4%) have multiple inter sphenoid septa with different orientations (Fig. 7,8). Inter carotid distance at ACP ranged from 11.2 to 28.8mm with mean 21.0±2.1 mm.

Sphenoid body type whereas pneumatization does not extend beyond the sphenoid bone was seen in 73 cases (20%). Lateral type of extension was found in 46 cases (12.6%). The greater wing type which extends only into the greater wings, was found in 18(5%), pterygoid type, which extends into the pterygoid process only in 15(4%) (Fig. 10) and full lateral type, which extends into both the greater wing and the pterygoid process, in 13(3.6%) from all the cases (Fig. 11,12).

The range of lateral sinus extension on the left was (9.1-15.3mm) and (10-17) on the right side. The difference was highly significant (P< 0.01). The maximum lateral extension was 17 mm lateral to foramen rotundum. Posterior wall and clival recesses, Out of 27(7.4%) patients with clival type of sinuses; 8(2.2%) were of dorsum type, 3(0.8% cases of subdorsum type, and 7(2%) cases were occipital type (Fig. 13,14).

Combined dorsum-occipital type was found in 9 (2.4%) cases. Superior wall, opticocarotid and tuberculum recesses(lesser wing type) was found in 7 cases (2%) from all cases (Fig. 9).

The average distance between the medial edges of the optic nerves at their entry into the optic canals was 16 mm in cases with anterior clinoid process pneumatization (ACP) compared to 15.7 mm in cases without ACP pneumatization. The difference was not significant (p>.05). Anterior wall and anterior recess (anterior type) was found in 56 (15%) from the examined cases. The average extension of the anterior recess in the anterior type of sinus was 9.7mm (range from 4 to 15.9mm) beyond the sinus side of the crest (Fig. 15, 16).

The average width of the anterior recess at the level of the sphenopalatine foramen, as measured on CT, was 7.4mm (ranges 5.3-10mm). Combined type, whereas more than one type of pneumatization was existing in the same case were found in 182 cases (50%) from all the cases. The racial difference has enlisted in (Table 5).

<table>
<thead>
<tr>
<th>Variant</th>
<th>Current study</th>
<th>Egypt (Emad et al, 2014)</th>
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<tbody>
<tr>
<td>ACP</td>
<td>13%</td>
<td>25%</td>
</tr>
<tr>
<td></td>
<td>20%</td>
<td>15%</td>
</tr>
<tr>
<td></td>
<td>5%</td>
<td>15%</td>
</tr>
<tr>
<td>GWS</td>
<td>26%</td>
<td>35%</td>
</tr>
<tr>
<td></td>
<td>20%</td>
<td>11%</td>
</tr>
<tr>
<td></td>
<td>13%</td>
<td>22%</td>
</tr>
<tr>
<td>PP</td>
<td>31%</td>
<td>40%</td>
</tr>
<tr>
<td></td>
<td>29%</td>
<td>22%</td>
</tr>
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<td></td>
<td>31%</td>
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</table>

The mean distance between right and left carotid grooves at pneumatized ACP was 21.0±2.1 mm and 20±2.2 mm at non-pneumatized ACP. The difference was not significant (p>.05).
Fig. 3: Precutting interior view of sellaturcica and its anatomical relations.

Fig. 4: Axial cut of dried skull specimen inside the body of sphenoid showing partially pneumatized dorsum sellae and the imaginary V-R line.

Fig. 5: Coronal cut of dried skull specimen inside the body of sphenoid showing Foramen Rotundum and Vidian canal.

Fig. 6: Oblique view of dried skull specimen showing the imaginary V-R line.

Fig. 7: Coronal CT shows multiple intersphenoidseptae. Note: extension pneumatization into the left lesser wing and partially into the pterygoid processes.

Fig. 8: Axial CT shows deviation of the septum towards the left carotid canal.
Fig. 9: Coronal CT shows left lesser wing pneumatization (Lesser wing type).

Fig. 10: Coronal CT shows right lateral type (pterygoid variety).

Fig. 11: Coronal CT shows full lateral extension type on the left Side and partially extended into the Rt. pterygoid processes. Moreover, extension of the pneumatization into the Rt. lesser wing.

Fig. 12: Coronal CT shows bilateral full lateral extension type (more in the left).

Fig. 13: Coronal CT of occipital type of clival recess extends inferiorly below the horizontal plane, crossing the upper edge of the anterior opening of the paired vidian canals. Extension of pneumatization into the Rt. lesser wings is noted as well.

Fig. 14: MRI, Sagittal T1WI of the sphenoid & sellar region shows presellar pneumatization
DISCUSSION

The sphenoid sinus has attracted attention over the past decade due to diagnostic techniques, selective endoscopic approaches to the sellar region and advancement of surgery. The extension of the sphenoid sinus is important not only for providing alternative surgical approach, but also for the evaluation of the structures surrounding the sphenoid sinus. The superiorit of the transsphenoidal approach over the transcranial is based on the fact that the former is the least traumatic route to the skull base; it avoids brain retraction and provides excellent visualization of the region, only thin shelves of bone separate the sinus from the nasal cavity below and the pituitary fossa above.

Egypt showed evidence of brain surgery as early as 3,000 B.C. in papyrus writings. Trans-sphenoidal approach to sella and nearby skull base structures is not a new approach. The pharos were first to approach the skull base through the nose to get the brain out prior to mummification without disfigurement. In the last 100 years it has gone numerous changing refinements from using headlight to microscope and more recently the sensitive endoscope.

The division of sphenoid sinus by Hammer and Radberg into three types: conchal, presellar and sellar based on the extension of pneumatization around the sella turcica was widely adopted because transsphenoidal surgery focused mainly on the sellar region during that era. In recent years, the transsphenoidal approach has been expanded from the sellar region to all areas bordering the sphenoidal sinus including the planum sphenoidale, suprasellar region, cavernous sinus, middle cranial fossa and the clivus. In our study we adopted the new detailed Wang and his coworkers’ classification of sphenoid sinus pneumatization. This expanded classification helps understanding the current needs to different extended approaches to the peri-sellar region.

Locatellie and his coworkers showed that percentage of CSF leak after endonasal approach was higher than transcranial surgical approach. Leng and his colleagues found also that Critics of the endonasal approach cite high rates of CSF leak as a major disadvantage. Increased CSF leak rates can be explained by the larger bony and dural opening of extended transsphenoidal approaches compared with standard transsphenoidal approaches. Moreover, the extended posterior pneumatization into the dorsum sella may result in penetrating the posterior wall of the sphenoid, with resultant CSF leak. The extended anterior pneumatization through the tuberculum sellae and planum sphenoidale may result in CSF leak when the speculum is overstretched antero-superiiorly.

The conchal non-pneumatized sphenoid was always considered to be a contraindication for trans-sphenoidal approach to the sella, however, if the surgeon is informed in advance and has intra-operative fluoroscopic imaging and navigation devices, the conchal non-pneumatized sphenoid approach can be feasible and it should be confined only to small and intra sellar tumors though it is time consuming. However, conchal type sinuses represent a relative contraindication to the extended approach. In our study, the conchal type was nil in the anatomical group and presented 1.6% of the radiological cases. This is most probably because of the limited number of the examined anatomical specimens and the rarity of this variation itself.

On the other hand, a highly pneumatized sphenoid sinus is not an advantage at all times. It may distort the anatomic configuration and may attenuate the bone over the lateral wall with subsequent bony dehiscence, placing the optic nerve and carotid artery at great risk. The sella turcica is seen as a prominence in the roof in a well pneumatized sphenoid sinus (sellar bulge) and this is considered the most important landmark to the sellar...
floor. In the absence of sellar bulge, especially with hyperpneumatized sinus it is extremely important to determine the midline when opening the sella.

In our study, we found a single midline intersphenoid septum in almost one third of the cases. Emad and his colleagues confirmed that the septum acquired the midline position in 30.5%. Lee and his coworkers reported a midline location of septum in 32%. One can follow the floor of the nasal septum as an indication of the midline or the remaining sphenoid sinus septum attachment superiorly. However, Kapur and his coworkers warned that the sphenoid sinus septum should not be taken as a midline landmark in endoscopic procedures.

We had carotid terminating septa in 14%. Emad and his coworkers detected septa terminating at the ICA in 16% of the Egyptian too. Moreover, Cappabianca and his coworkers stated 20%. Poirier and colleagues encountered 17%. Preoperative CT scan detection of such midline deviation is extremely useful for intraoperative neuronavigation. In our study, the anterosuperolateral septa terminating at the optic protuberance was seen in 16%, 6% to the right and 10% to the left that not far away from Emad and coworkers study 20%. Unal and his coworkers reported 18%. In our study, the paramedian, accessory and deviated septations represent more than 50% from all examined cases. This can be explained by the flowing pneumatization may take many different pathways from one ossification nucleus to the adjacent center. It is essential to use extreme caution while removing the terminal septa as a brisk avulsion may result in blindness or massive bleeding.

Unal and his coworkers noticed that the more extension of pneumatization to ACP, the more thinning of the sinus wall at this region, the more incidence of carotid bulge, the more areas of dehiscence, the more vulnerability of the neurovascular structures to surgical trauma. Moreover, the smallest (low pneumatization) sphenoid sinus volume presented without ICA protrusion but the largest volume (high pneumatization) presented with bilateral ICA protrusions. Furthermore, the ICA and optic nerve do not bulge to the sinus cavity in the low pneumatization sphenoid sinus so; an endoscopic trans-sphenoidal operation might not be the first choice. However, ICA and optic nerve do bulge into the cavity in the high pneumatization sphenoid sinus. Therefore, this may facilitate some surgeries such as carotid aneurysm and optic nerve decompression.

In our study the average distance between the medial edges of the optic nerves at their entry into the optic canals was 16 mm in cases with ACP pneumatization compared to 15.7 mm in cases without ACP pneumatization. The mean distance between right and left carotid grooves at pneumatized ACP was 21.0±2.1 mm and 20±2.2 mm at non-pneumatized ACP. These differences were not significant (p>.05). Bulging and dehiscence of the structures surrounding the sphenoid sinus are likely to be positively correlated to the extent of the sinus pneumatization. ACP pneumatization affects positively on optic nerve and ICA prominence within sinus. However, it does not affect the position of the optic canals or ICA distance. Lewin and his colleagues explained that because of the indentation resulting from the ICA as it passed under ACP rather than the pneumatization process itself. Moreover, the relationship between protrusion of the optic nerve and ICA showed that optic nerve protrusions accompanied absolutely with ICA protrusion, however, ICA protrusion didn’t always accompany with optic nerve protrusion. It is implied that injury could be avoided during optic nerve decompression if an ICA protrusion in the sphenoid sinus should be thought.

In cases of extensive pneumatization, the maxillary nerve and Vidian nerves may bulge into the sinus and thus become liable to iatrogenic injury. A dehiscent ICA can also be vulnerable to damage from sphenoid sinus infection. Moreover, a dehiscent optic nerve can get optic neuritis from sphenoid sinus infection.

Li and his coworkers have evaluated the risky factors of anatomic variations of sphenoid sinus during operation. They came up with the classification to predict whether to carry operative procedure or not using 3D reconstruction the MIMICS software by studying the relationship between sphenoid sinus volume and protrusions of ICA and optic nerve in the sphenoid sinus.

The anterior wall of the sphenoid sinuses is positioned behind the nasal turbinates, ethmoidal air cells and sphenoid crest which is the most anterior part of the sinus. An anterior recess, which originates from the lateral portion of anterior wall of the sphenoid sinus, was identified as being present when the recess extended anteriorly beyond a line directed from side to side along the sinus side of the sphenoid crest on the axial CT. The optic nerve leaves the orbital cavity via the optic canal and passes through the lateral wall of the posterior ethmoid sinus and sphenoid sinus, and then, it passes posterior-medially form the optic chiasm. Spreading of the transsphenoidal retractor at the anterior wall of the sphenoid sinus especially if it was extensively pneumatized can carry some risks of optic nerve injury. Li and his colleagues found that almost 50% of ACP pneumatized cavities were fused with the posterior ethmoid sinus, and optic nerve was in the posterior ethmoid sinus freely or located at the lateral wall of the posterior ethmoid sinus. Therefore, it is difficult to find the optic nerve if transsphenoidal approach is selected because the optic nerve ran in the ethmoid sinus rather than located in the sphenoid sinus.

Arsalan and his colleagues clarified the importance of the pre intervention diagnosis of the anterior recess as the sphenopalatine foramen and artery are positioned...
below the anterior recess. During transnasal ethmoidectomy, the identification of the sphenomaxillary plate is important because the sphenoid sinus is easily mistaken for posterior ethmoidal cells. In Raymond and coworkers large series, they reported 19% of their cases had injuries of the sphenopalatine artery.

We found pneumatization of pterygoid process and greater wing almost in half of the Egyptian. Earwaker stated that Pneumatization of the pterygoid process and the greater wing of sphenoid is not uncommon (35-40%)\(^1\). The size of the lateral recesses of the sphenoid sinus which extends outward from the main sinus cavities into the greater wing of the sphenoid bone is highly variable. The air cells pass between the vidian’s canal and the foramen rotundum, resulting in variation in the distance between these two structures.

Wang and his coworkers appreciated the value of pre-operative diagnosis of the lateral type of sinus because the middle cranial fossa lateral to the cavernous sinus may be exposed after removal of the lateral wall of the sphenoid sinus if the pneumatization extends lateral to the foramen rotundum and foramen ovale. The pneumatized greater wing type will facilitate the approach to middle cranial fossa, avoiding manipulation of the pterygopalatine fossa contents and easier identification of the mandibular nerve.

Pneumatization of the sphenoid sinus into greater sphenoid wing in the presence of arachnoid granulations forms (Pit holes). The enlargement of these pits has been implicated in the development of spontaneous CSF leaks. Pneumatization of the pterygoid plate represents an important pathway for the central skull base and may provide route for endoscopic repair of CSF leaks and endoscopic biopsies of the skull base lesions. Rivierez and Valsaint reported a patient with a temporosphenoidal meningoencephalocele that presented with CSF rhinorrhea and a radiologically confirmed defect in the superior wall of the right lateral recess of the sphenoid. They used a frontotemporal approach with orbitozygomatic osteotomies for accessing this lesion.

Landreneau and his coworkers after reporting four cases recommended the transcranial approach for dealing with CSF fistulas involving the lateral extension of the sphenoid sinus because this approach, despite its higher morbidity, would provide direct visualization for obliteration of the defect. They addressed the importance of developing a new endoscopic technology that would allow direct visualization and repair of such lesions. On the other hand, Mehandale and his coworkers reported successful repair of three cases of CSF fistulas involving the lateral recess of the sphenoid sinus using an endoscopic assisted sublabial transseptal approach.

Because a pneumatized pterygoid recess can lie directly posterior to the maxillary sinus, an endoscopic approach through the pterygopalatine fossa seems to provide adequate and direct access to lesions limited to that area. The pterygopalatine fossa approach provides a wide and direct approach to the lateral recess of the sphenoid sinus. It provides better space and visualization for repairing CSF leaks or dealing with space-occupying lesions confined to this region; it also has less morbidity when compared with the transeptal approach.

We found clival type in 15% of Egyptian people as single entity and within the combined form. The clival types of sinuses are the most suitable type for transnasal inlets into the posterior cranial fossa because of the thinner clivus. When pneumatization reaches the basilar portion of the occipital bone, direct contact with the meninges, basilar plexus, basilar artery and pons may be established. Cases of spontaneous CSF fistula and reports of vasculitis of the basilar artery with ischemic infarction of the pons secondary to sphenoid sinusitis support this theory.

Since 2004, De Divitiis and his coworkers have started to use extended transsphenoidal approach for a variety of lesions involving the midline skull base. Moreover, they stated that the portion of cranial base extending from the back wall of the frontal sinus to the craniovertebral junction can be exposed passing through the sphenoid, depending upon its grade of pneumatization. In last report, they did move from clival chordoma to reach the retroclival prepontine region.

Rajappa and his colleagues described this approach for Endoscopic endonasal transclival approach to a ventral pontine pediatric ependymoma. On their cadaveric study, Leon and his coworkers described the ability to even handle basilar artery aneurysm through this approach. Moreover, Stamm and Pignatari stated that the clivus a thin and an eminent weak region in skull base. Therefore, there is high incidence of CSF leak especially if it is pneumatized. Therefore, Iacoangeli and his coworkers described new technique to clival reconstruction including a precise layer by layer reconstruction.

**CONCLUSION**

The preoperative anatomical image reconstruction of each patient going to extended transsphenoidal surgery is important to assess different types of extension of sphenoid sinus pneumatization, areas of bone dehiscence and areas of critical septal terminations and subsequently avoid injury of the nearby neurovascular structures and reduce the possibility of CSF leakage.

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