The variations in anatomy of the sphenoid sinus and sellar floor to perform transsphenoidal endoscopy in adult age: a literature review

As variações na anatomia do seio esfenoidal e assoalho selar para realização de endoscopia transesfenoidal em adultos: revisão de literatura

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RESUMO
A cirurgia transesfenoidal depende da habilidade de visualizar e identificar referências anatômicas chaves durante cada fase da operação. Um grau notável de variação anatômica existe no seio esfenoidal, sela turcica e estruturas ao redor da base do crânio. Nosso objetivo é revisar as variações anatômicas no seio esfenoidal e assoalho selar que são importantes para realizar uma cirurgia endoscópica transesfenoidal de modo efetivo e seguro em pacientes adultos. Uma detalhada informação em relação a anatomia é o meio mais confiável e efetivo de evitar complicações de todos os tipos na cirurgia transesfenoidal.

Palavras-chave: anatomia, cirurgia transesfenoidal, endoscopia.

ABSTRACT
Transsphenoidal surgery depends on the ability to visualize and identify key anatomical landmarks during each phase of the operation. A remarkable degree of anatomical variation exists in the sphenoid sinus, sella turcica, and surrounding skull base structures. Our purpose is to review the anatomical variations in sphenoid sinus and sellar floor that are important to performing safe and effective transsphenoidal endoscopic surgery in adult patients. Detailed information regarding the anatomy is the most reliable and effective way of avoiding complications of all kinds in transsphenoidal surgery.

Key words: anatomy, endoscopy, transsphenoidal surgery.
**INTRODUCTION**

Transsphenoidal surgery depends on the ability to visualize and identify key anatomical landmarks during each phase of the operation. A remarkable degree of anatomical variation exists in the sphenoid sinus, sella turcica, and surrounding skull base structures. The direct endoscopic endonasal approach because of its minimally invasive characteristics, is progressively gaining popularity. The application of endoscopy to pituitary surgery is based on multiple advantages, including improved visualization, preservation of sinonasal function, reduced length of stay, increased patient comfort, and reduced serious complications. Despite this advance, complications of endoscopic surgery can occur, and can be traced to a number of causes, including the anatomy surrounding the operative approach. Our purpose is to review the anatomical variations in sphenoid sinus and sellar floor that are important to performing safe and effective transsphenoidal endoscopic surgery in adult patients.

The posterior wall of the nasal cavity is formed by the sphenethmoidal recess, which includes the sphenoid ostia. Sethi et al identified the sphenoid ostia subtypes as round (47%), elliptical (40%), and “pinhead” (13%), with the majority measuring less than 2.7 mm in diameter. In elderly patients, the sphenoid ostia may be quite wide.

The sella lies along the posterior and superior walls of the sphenoid sinus, which separates the pituitary gland from the nasal cavity. Hamberger et al in 1961 characterized 3 anatomical variations of the sphenoid sinus: sellar, presellar, and conchal, that are still employed today. The sphenoid sinus is extremely variable with respect to size, shape and relation to the sella. The degree of pneumatization of the sphenoid bone is an important factor in the endoscopic approach.

Several studies have reported findings regarding the various proportions (Table 1):
1. The sellar sinus (73-86%) is well pneumatized with bulging of the sellar floor into the sinus.

2. The presellar sinus (11-27%) is situated in the anterior sphenoid bone and does not penetrate beyond the perpendicular plate of the tuberculum sellae (Fig. 1a).

3. The conchal sinus (0-3%) does not reach into the body of the sphenoid bone, and its anterior wall is separated from the sella turcica by approximately 10 mm of cancellous bone (Fig. 1b).

The conchal type is common in children before the age of 12 years, after which pneumatization begins within the sphenoid sinus.17 As age advances, the sphenoid sinus frequently undergoes further enlargement associated with bone resorption.7

There is typically only one sphenoid sinus septation in the majority of cases (Table 1). According to Cappabianca et al, in 20% of cases the posterior attachment of a lateral sphenoid septum extends to the carotid protuberance (Fig. 2a, 2b).6 Sethi et al found that in 40% of patients the septum deviates laterally and terminates on the internal carotid artery (ICA) protuberance.17 In contrast, Zada et al found that in 79% of healthy patients the vertical septum deviates towards one or the other ICA.21 Oauknine and Hardy described the bony septum as rarely being median in location.22 Sirikci et al affirmed that a deviated nasal septum or a thickened or pneumatized vomer, are the most frequent abnormalities encountered in sphenoid septum variations.18

Figure 1. Sagittal MRIs demonstrating presellar (a) and conchal (b) subtypes, with relationship of the sphenoid sinus to the sella.

Figure 2. Coronal MRI (a) and endoscopic view (b) of sphenoid sinus septations.
Two bulges on the lateral wall of the sphenoid sinus are of considerable clinical significance. They are produced by the optic nerve and the ICA. The optic canal bulges into the anterior superior part of the sphenoid sinus. The ICA bulges into the superolateral wall of the posterior part of the sinus in 71-93%. Depending on the degree of pneumatization, these two bulges may be barely noticeable or quite prominent. Lateral to their junction is the lateral optico-carotid recess. This corresponds to the optic strut connecting to the anterior clinoid process. The medial optico-carotid recess correlates to the partially calcified clinoidal dural ring around the carotid artery. The bone over the ICA and/or optic nerve bones may be dehiscent in approximately 4% of cases. The measurements between the ICAs in different studies range from 4 to 23 mm, as determined in the sphenoid sinus, cavernous sinus or supraclinoid area.

Sphenoethmoidal cells (or large Onodi cells) are anatomical variations that pneumatize lateral and to some degree superior to the sphenoid sinus (Fig. 3a, 3b). They are identified in 3-14% of cases and can be mistakenly identified as part of the sphenoid sinus.

Van Lindert et al reported a series of 185 patients who had endoscopic endonasal transsphenoidal surgery to the pituitary through a binostril approach and found 89 (48.1%) with anatomical variations. The most common were spinae septi and septal deviation. The other anatomical variations were concha bullosa, synchia, extremely narrow pathway, absent chondroid septum, pansinusitis, hypercongestive mucosa and polyps. In 5% of patients, the binostril approach was converted to a mononostril approach because of severe nasal septal deviation; whereas in 18% of patients with an anatomical variation, a correction had to be made in order to allow satisfactory entrance into the sphenoid sinus. Complications related to the endonasal phase occurred in 3.8% and the majority were postoperative epistaxis.

Bolger et al reported paranasal sinus bony anatomic variations and mucosal abnormalities assessed by coronal computerized tomography (CT) in 202 patients and found these problems in 64.9% and 83.2%, respectively. This study excluded patients with previous surgical alterations of the paranasal sinus anatomy. A deviated nasal septum in this report was detected in 18.8%. However, the literature reveals a lack of consensus among investigators with respect to the prevalence of the different anomalies in anatomical structures. This may be due to factors such as inherent differences in study populations and sensitivity of the method of analysis. The definition of mucosal abnormalities ranged from minimal mucosal thickening to total sinus opacification. Abnormality in the sphenoid sinus mucosa was found in 22.3% in this report.
Another anatomical landmark that Hamid et al\textsuperscript{6} considered to be one of the most important to the transsphenoidal approach is the prominent sella (Table 2). Zada et al\textsuperscript{21} found that patients with intrasellar lesions were more likely to have a prominent sella turcica (43\%) than were healthy adults.\textsuperscript{21} Another finding of this study shows that intrasellar lesions were noted to have a wider sphenoid sinus, wider sellar face, and wider separation between the parasellar ICAs (19 mm) when compared to healthy controls.\textsuperscript{21} Many authors emphasize that the most reliable intraoperative midline markers are the vomer, superior sphenoid rostrum, and bilateral parasellar and clival carotid protuberances.\textsuperscript{13,21} Its midline location makes vomer an essential landmark in the transsphenoidal approach to the sella.\textsuperscript{13} In case of large tumors that destroy the sellar floor, invade the cavernous sinus, and occlude the sphenoid sinus the usual anatomical landmarks are absent or poorly demarcated.

**Table 2.** Findings of sellar configuration anatomy in different studies.

<table>
<thead>
<tr>
<th>Study</th>
<th>Type of study</th>
<th>Sellar configuration</th>
</tr>
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<tbody>
<tr>
<td>Ouaknine and Hardy\textsuperscript{13} 1987</td>
<td>Surgery report</td>
<td>94.7 regular/symmetrical 5.3 asymmetrical/oblique</td>
</tr>
<tr>
<td>Hamid et al\textsuperscript{6} 2007</td>
<td>MRI/CT pituitary adenomas</td>
<td>75 prominent</td>
</tr>
<tr>
<td>Zada et al\textsuperscript{21} 2011</td>
<td>MRI healthy</td>
<td>25 prominent 63 curved 11 flat 1 no floor</td>
</tr>
<tr>
<td>Zada et al\textsuperscript{21} 2011</td>
<td>MRI sellar lesions</td>
<td>43 prominent 47 curved 10 flat</td>
</tr>
</tbody>
</table>

MRI: Magnetic Resonance Imaging.
CT: Computerized Tomography.

In acromegaly, specific anatomical variations are seen (Fig. 4a, 4b & 5a, 5b). They include soft-tissue edema, nasal polyps, and bony remodeling. These often contribute to the complexity of the operation, as natural working corridors are typically more constricted and deeper than in other patients.\textsuperscript{10,15} Zada et al\textsuperscript{22} reported 169 endoscopically operated acromegalic patients and found ICA injury in 1 patient (0.6\%), postoperative delayed epistaxis (arterial bleeding) in 5 patients (3\%), and transient diabetes insipidus in 5 patients (3\%). Four patients had delayed hyponatremia secondary to the syndrome of inappropriate antidiuretic hormone hypersecretion (2\%), 2 (1\%) developed postoperative cerebrospinal fluid leaks, and 2 patients (1\%) underwent conversion to a microscopic approach. Intraoperatively they divided transsphenoidal surgery into nasal, sphenoid and sellar phases. In the nasal phase, the primary challenges are typically related to edematous and/or redundant soft tissue of the nasal cavity, and enlarged, hypertrophic bony nasal turbinates, both of which can compromise the endoscopic view and working space. When nasal polyps were encountered, they were coagulated and removed to improve visualization. Due to the size and rigidity of the nasal turbinates, they often require more lateral displacement than in other patients; this can result in increased bleeding if the mucosa is injured.

**Figure 4.** Sagittal MRIs comparing normal sphenoid sinus (a) to changes produced by a GH secreting pituitary macroadenoma (b).
In the sphenoid phase the challenges are: atypical bony anatomy (chronic bony remodeling) accomplishing adequate exposure within the sinus, and maintenance of hemostasis. Thickened sphenoid sinus mucosa is often found and once stripped can cause venous bleeding from the sinus walls.

In the sellar phase, patients with acromegaly have been reported to develop anatomical changes in the caliber, location and tortuosity of the ICA (narrow intercarotid distance) that comes into play during the sphenoid and sellar phases of the surgery. Saeki et al emphasize that acromegalic patients may have marked carotid prominences. In the sellar phase, a complex bony sellar floor may also be present. In addition to the macroscopic anatomical changes, microvascular changes related to chronic Growth Hormone elevation can be seen. These include alterations in the structural integrity of surrounding structures like the cavernous sinus dura and the ICA with deterioration of vessel endothelium causing parasellar and intrasellar ICA aneurysm formation. The risk of ICA injury is more common in acromegalic patients as a result of the anatomical and microvascular changes mentioned.

What are the most challenging anatomic variations for transphenoidal endoscopy? Zada et al concluded that the flat sellar type and complex sphenoid sinus configuration may make intraoperative correlation substantially more challenging, and are a prime argument for the use of image guidance during surgery. Renn and Rhoton studied 50 adult brain specimens and considered the following anatomical variations in the sphenoid and sellar floor disadvantageous for transsphenoidal approach: carotid arteries exposed in the sphenoid sinus with little or no bone over them; optic canals with bone defects in the sphenoid sinus; thick sellar floor; sphenoid sinus with no major septum or a septum that is off midline; and the presellar type with no obvious bulge of the sellar floor.

In summary, anatomic abnormalities may be frequently encountered during routine surgery. Detailed information regarding the anatomy is the most reliable and effective way of avoiding all kinds of complications in transsphenoidal surgery.

**References**


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