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Sphenoid Sinus Anatomical Relations and their Implications in Endoscopic Sinus Surgery

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ABSTRACT

With advances in endoscopic sinus surgery (ESS), radiologist and otolaryngologists should have thorough knowledge of anatomy of paranasal sinus (PNS). Regarding this, sphenoid sinuses are the most variable among paranasal sinuses. the anatomical relationship of crucial neurovascular structures for example internal carotid artery (ICA) and optic nerve (ON) is extremely variable and these structures are at a risk during ESS. This article will help readers understand the relationship of neurovascular structures with sphenoid sinus (SS) more precisely.

Keywords: Endoscopic sinus surgery, Sphenoid sinus, Internal carotid artery, Optic nerve, Computed tomography

INTRODUCTION

Interest of surgeons in both the anatomy and pathophysiology of the PNS has been stimulated due to advances in ESS. The ultimate aim of surgeon is aerating the sinuses and restoring mucociliary clearance in order to restore the function of paranasal sinuses [1].

ESS is consistently gaining momentum in the diagnosis and treatment of sinus disease [2]. Visualization and treatment of all sinus drainage passages is now possible on outpatient basis. Excellent mapping of the sinuses has been made possible by high resolution CT. It is also found to be helpful in informing about the extent of mucosal disease [3].

The normal anatomy and variations of sinus structure, as well as pathologic appearances and complications of sinus disease, needs to be well understood by the radiologist to provide optimal patient care.

Anatomy of sphenoid bone

The sphenoid bone shows high structural complexity. It is an unpaired bone of the neurocranium. It forms a component of the floor of middle cranial fossa, the orbital apex and also a part of the lateral wall of skull. It resembles the shape of a butterfly with extended wings. It is composed of the body, the greater and lesser wings and the pterygoid plates. The development of SS takes place in the body of sphenoid bone [4]. The floor of the middle cranial fossa is formed by the body of the sphenoid bone flanked by the greater wings on each side.

Understanding of the sphenoidal sinus anatomy is of particular importance because of the critical position of the sinus relative to vital neurovascular structures. Both right and left SSs are divided by an inter sinus septum in the sagittal plane. This septum is present in the mid- line, producing paired symmetrical sinuses in only 27% of specimens. The inter sinus septum is situated in the midline anteriorly in the majority of the sinuses and then deviation to either side occurs as the septum extends posteriorly (43%). In some cases, there may be multiple septa while some sinuses show no septa.

Development of SS

Presphenoid and postsphenoid centers are responsible for the development of the sphenoidal body. Some contribution is also from the orbitosphenoid [5,6]. The lesser wings develop from the orbitosphenoid and the larger alisphenoid gives rise to greater wings.

The development of pterygoid plates occurs through both intramembranous and endochondral ossification. The lateral pterygoid plate develops by intramembranous ossification and the medial pterygoid plates develop by means of the endochondral ossification [7]. Bones of Bertin are two paired ossification centers adjacent to the vomer. The unossified rostral part of the basisphenoid is enclosed in between these ossification centers. This part will form the first site of sphenoid pneumatization in future [8].

The ossification centers of the sphenoid body are in close relationship with neurovascular structures for instance, the maxillary nerve, the ON, the ICA and the vidian nerve. This explains their close relations to the SS.

As compared to other paranasal sinuses, SS follows a different developmental pattern. A recess appears at birth which is present between the presphenoid body and the sphenoid concha. The development then begins posteriorly and inferiorly.

Throughout the second or third year of life, fusion of a part of sphenoid concha takes place with the presphenoid, thus forming the cavity for SS. As a result, the presphenoid recess becomes the sphenoethmoidal recess. Pneumatization occurs after this stage in the presphenoid and the basisphenoid of the sphenoid bone [9].

Although the definitive cavity forms at puberty, the actual sinus cavity starts becoming visible by the age of 8 to 10 years [10]. On the posterior nasal wall, the origin of the sphenoid sinus can be clearly identified by the location of its ostium.

Variants of SSs

There are three main types of sphenoid pneumatization [11] as shown in Figure 1. The conchal type or the fetal-type represents a small sinus that is parted from the sella turcica by a very thin layer of trabecular bone. The presellar type or juvenile type is pneumatized upto the level of sella turcica. The sellar type or adult type is pneumatized below the sella or further posteriorly [12].

Sellar type is found to be the most frequent. It appears in 75% to 86% of cases, followed by the presellar type which is found to be present in 10% to 25%. Only 2% of cases show conchal or fetal type [13]. Pneumatization also extends into the greater and lesser wings, the pterygoid plates, and the basiocciput. These extensions of the air cells of sinus brings it nearer to nerves and vessels of the skull base.

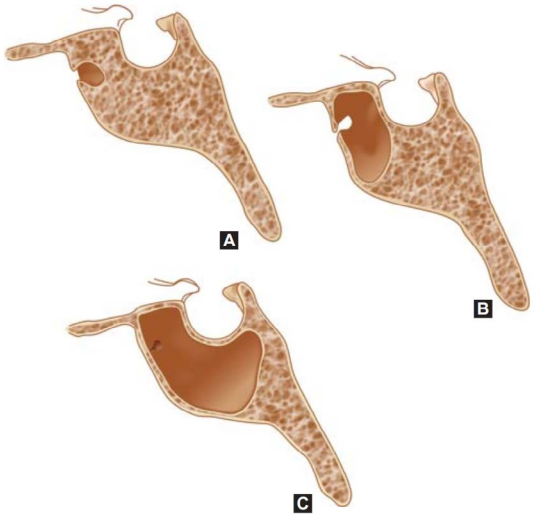

Figure 1 Three types of sphenoid sinus [14]

Relations of sphenoid sinus

The sphenoidal sinus is a roughly octagonal structure, out of which two of its sides face the nasal cavity and the rest are facing the endocranium [14].

The sinus's superior wall is in continuity with the ethmoidal sinus roof and it comes in direct contact with the optic

chiasma, hypophysis cerebri (Figure 2) and olfactory nerves at the floor of the anterior and middle cranial fossa. In the midline, the anterior wall is connected to the perpendicular plate of the ethmoid and vomer, it is also connected to the lateral masses of the ethmoid on each side [15]. Sinus ostium is often found on the anterior wall of the SS. This wall can be displaced by Onodi cells [16]. They are highly-developed posterior ethmoid cells that begin pneumatizing far laterally and to some degree superiorly to the sphenoid sinus. They are found to be intimately associated with the optic nerve. Adolf Onodi in 1903 first described the importance of the most posterior localized ethmoidal cell and its close relation to the ON.

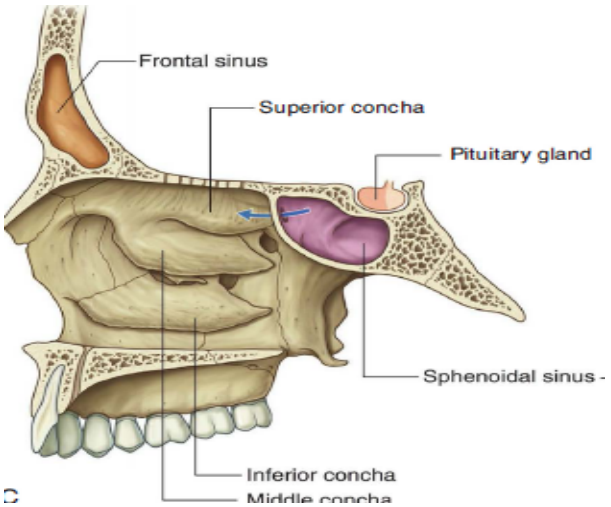

Figure 2 Relationship of sphenoid sinus with hypophysis cerebri [17]

The sinus floor forms the dome of nasopharynx and choanae. The thin lateral walls are divided into two areas: anteriorly is the orbital zone and posteriorly is the cranial zone. Extremely important structures such as ICA, ON and the cavernous sinus are located adjacent to this wall as shown in Figure 3.

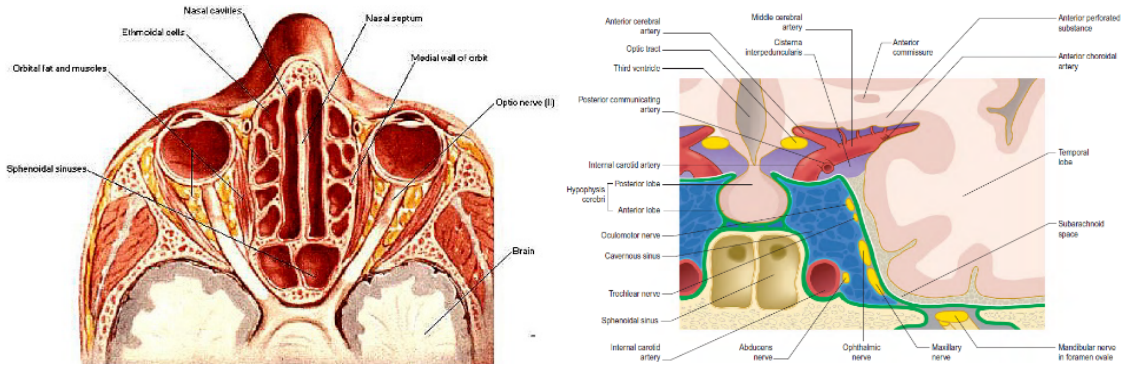

Figure 3 Location of optic nerve and internal carotid artery in relation to sphenoid sinus [4,17]

DISCUSSION

A well pneumatized sinus has visible irregularities or ridges. These are formed due to close proximity of surrounding vessels and nerves. If the sphenoid sinus pneumatizes anterior clinoid processes, it can encroach on the optic nerve [18]. Literature reports anterior clinoid process pneumatization to be in between 11% and 29.3% [19]. If pneumatization extends to the pterygoid processes, the sinus is observed to extend between two nerves, maxillary nerve and the nerve of the pterygoid canal (Vidian nerve) [20]. This type of extension may reach up to the posterior aspect of the maxillary sinus, and this has been reported to be present in 37.5-43.6% of cases [21].

On the most medial aspect of cavernous sinus is situated the internal carotid artery which lies on the lateral aspect of sphenoid sinus. The impression of the internal carotid artery may be barely noticeable or highly noticeable depending on the pneumatization of the sphenoid sinus [22]. Internal carotid artery is seen to be bulging into the sphenoid sinus

in 34% to 93% of cases. Obvious differences between races do occur [12,23]. Sometimes, a thin bone usually covering the internal carotid artery is found to be dehiscent and this has been reported in approximately 4% of the cases [12]. This condition leaves the artery exposed into the sinus cavity. Therefore, it is vital that the surgeon is informed about these variations by the radiologist in order to avoid complications during surgery [24].

The bony septum that divides the sphenoid sinus is rarely situated in the median plane. It is very often deviated laterally to one side or the other commonly inserting itself on the carotid canal or the optic canal. The sphenoid cavity is very often divided by multiple septae. Sareen, et al. [13] reported multiple inter sinus septae in 80% of cases. At least one of these septa is reportedly inserted on the carotid canal in 87% of cases according to Fernandez Miranda, et al. [25]. Thus, intraoperatively extreme caution should be practiced avoiding fracture or removal of such septa [26].

CONCLUSION

In-depth knowledge of the anatomical relationships of sphenoid sinus is fundamental for the success of endoscopic sinus surgeries and to avoid the possible intraoperative surgical complications. The communication between the clinician and radiologist is central to interpretation of CT scans to optimize their patient's treatment.

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