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Endoscopic anatomy of the sphenoid sinus

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Abstract
The anatomy of the sphenoid sinus, as it relates to endoscopic sinus surgery, was studied in 93 cadaver heads (186 sphenoid sinuses) using endoscopic dissections as well as sagittal sections. The relationship of the sphenoid sinuses to the carotid artery, optic nerve, floor of sella turcica, as well as other important structures, were verified and discussed. The recesses of the sinus as well as its ostium and accessory septa and crests were described and their clinical importance was discussed. Pertinent measurements were included wherever appropriate.

Key words: Paranasal sinuses; Sphenoid sinus; Anatomy

Introduction

The sphenoid sinuses are the most inaccessible paranasal sinuses. They are also bordered by more vital structures than any other sinus. With the expanding role of endoscopic sinus surgery, proper understanding of the anatomy of the sphenoid sinuses has become increasingly important.

Despite the importance and complexity of the anatomy of the sphenoid sinuses, only relatively few recent reports focus on it (Lang, 1989; Kennedy *et al.*, 1990; Fujii *et al.*, 1979). In a previous publication (Elwany *et al.*, 1983) we described the surgical anatomy of the sphenoid sinus. The aim of the present research is to describe the anatomy of the sphenoid sinus as it relates to endoscopic sinus surgery.

Materials and methods

The material used consisted of 93 cadaver heads (186 sinuses). There were 123 male cadavers and 60 female. Endoscopic examination and dissection of the sphenoid sinuses was carried out using 0°, 30° and 70° endoscopes. In all cadavers the ostium of the sinus was at first located and the sinus was then entered transnasally through its anterior wall. All areas of the sphenoid sinus were explored and pertinent findings were recorded and photographed. Sections were then made in the sagittal plane to confirm the anatomical findings and to take the necessary measurements with millimeter strips and special micrometers.

Results

Ostium of the sphenoid sinus (Figure 1)

The ostium of 126 sinuses (67.7 per cent) was located behind the posterior end of the superior turbinate. In the rest of the material the ostium was located at a lower level. The distance between the medial border of the ostium and the midline was 5.2 (1.4–8.8) mm. The distance between the inferior border of the ostium and the floor of the sinus was 14.8 (7.0–19.0) mm. The distance between the superior border of the sinus and the cribriform plate was 7.3 (5.0–12.0) mm. The ostia of both sides were at different levels (more than 2.0 mm difference) in 59 cadavers (63.4 per cent).

The ostium was round in 133 sinuses (72 per cent) with a mean diameter of 2.8 mm. In the remaining sinuses (28 per cent) it was oval with the greater diameter being vertical. The distance between the floor of the ostium and the tip of the anterior nasal spine was 64.4 (59.0–69.0) mm in male cadavers, and 59.2 (53.0–61.0) mm in female cadavers. The distance between the ostium and the floor of the sella was 16.8 (11.0–23.0) mm in male cadavers, and 14.3 (9.0–20.0) mm in female cadavers.

Accessory septa and crests (Figure 2)

Bony septa or crests were seen in 128 sinuses (68.8 per cent). In 89 sinuses (47.8 per cent) they were unilateral, and in the remainder (39 sinuses – 21 per cent) they were bilateral. The crests were inserted into the bony covering of the carotid arteries in 24 sinuses (12.9 per cent), and into the bony covering of the optic nerve in 11 sinuses (5.9 per cent).

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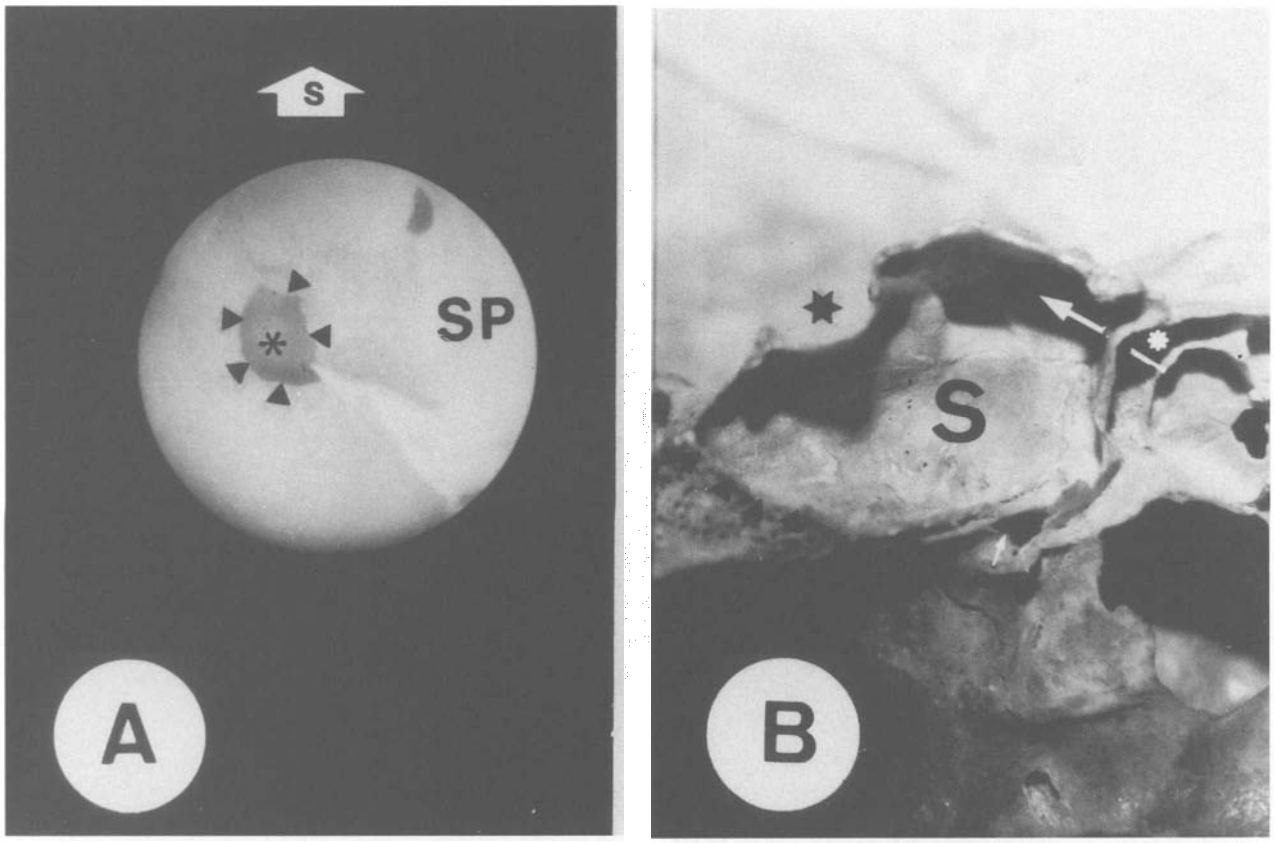

FIG. 1

The ostium of the sphenoid sinus. A – A circular ostium (arrowheads) partially hiding behind the superior turbinate. The sinus cavity (*) is seen through the ostium. SP: nasal septum. B – A fully pneumatized sphenoid sinus (S) extending beneath the full length of the sella (black asterisk). The ostium of the sinus (large white arrow) communicates the sinus cavity with the sphenoethmoidal recess (white asterisk). The small white arrow points to the sphenopalatine foramen. S: Superior.

The carotid canal (Figure 3)

Impressions made by the carotid canal can be divided, according to Fujii *et al.* (1997) into three anatomical segments:

(1) Pre-sellar segment adjacent to the anterior wall of the sella. This was found in 79 sinuses (42.7 per cent).
(2) Infra-sellar segment beneath the sella. This was found in 55 sinuses (29.5 per cent).
(3) Retro-sellar segment in the postero-lateral wall of the sinus. This was found in 33 sinuses (17.7 per cent).

Impressions made by the entire course of the carotid artery were seen in 34 sinuses (18.2 per cent). A definite dehiscence in the bony covering was seen in nine sinuses (4.8 per cent). All dehiscences were located in the pre-sellar segment.

The optic nerve (Figure 4)

The optic nerve produced a definite bulge in the supero-lateral wall of the sinus in 54 sinuses (29.0 per cent). The bony shell over the nerve was intact in all cadavers.

Other prominences in the lateral wall and floor of the sinus

The maxillary nerve (Figure 4B), before its exit from the foramen rotundum, indented the lower lateral wall of 24 sinuses (12.9 per cent). The pterygoid canal, housing the vidian nerve, produced a definite ridge (Figure 4B) in the floor of 14 sinuses (7.5 per cent).

Onodi cells (Figure 5)

Onodi cells (posterior-ethmoid cells within the sphenoid bone) were found in seven cadavers (7.5 per cent). In five cadavers (5.3 per cent) they were bilateral. In two cadavers (2.1 per cent) the optic nerve made a clear impression in the wall of the cell but the bony covering of the nerve was intact.

Recesses of the sphenoid sinus

Several recesses were encountered. These, in order of frequency, included:

(1) The infra-optic or optico-carotid recess (Figure 4A) in 78 sinuses (41.9 per cent).
(2) The inferolateral recess, in the greater wings of the sphenoid (Figure 4B) in 59 sinuses (31.7 per cent).
(3) The pterygoid recess in 29 sinuses (15.5 per cent).

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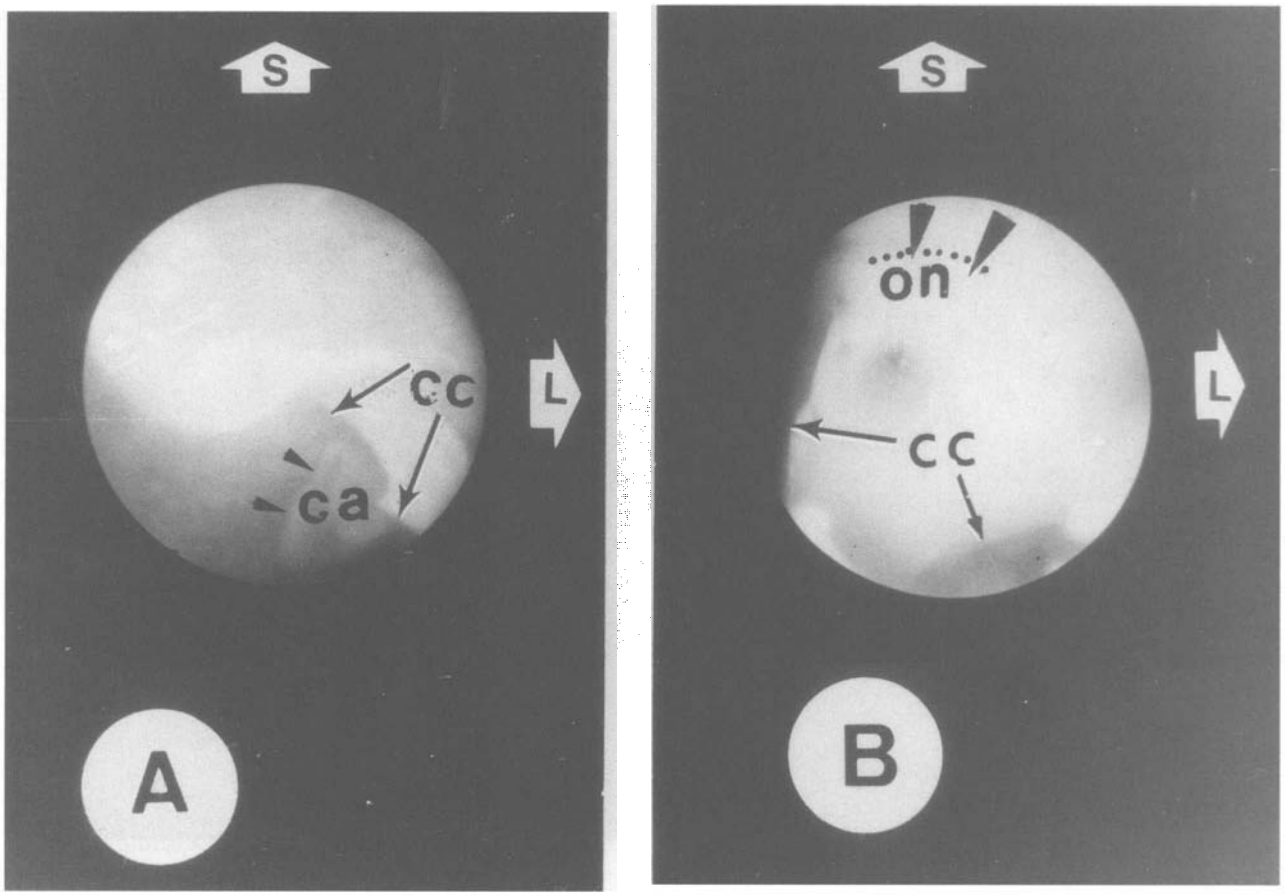

FIG. 2
Accessory crests. A – A coronal crest (cc) inserted across a bulging carotid artery (ca). B – A small coronal crest (cc) inserted into the prominence of the optic nerve (on). S: Superior. L: Lateral.

(4) The posterior clinoid recess in 11 sinuses (5.9 per cent).

Discussion

With the expanding role of endoscopic sinus surgery, a thorough understanding of the anatomy of the sphenoid sinus has become increasingly important. The sphenoid sinus is adjacent to many important structures, and its relationship to them is subject to considerable variations.

For surgeons who prefer the transnasal approach to the sphenoid sinus, to ostium is probably the first landmark to be identified. The ostium communicates the sinus with the spheno-ethmoidal recess and its location may demonstrate wide variations. Also mucosal folds may considerably encroach over it rendering its identification more difficult. In most instances, the ostium is located in the upper one-third of the anterior sphenoidal wall 5.0–7.0 mm from the medial sagittal plane and within 5.0–12.0 mm of the cribriform plate. Tunis (1912) described one ostium opening into a bony canal running between the ethmoid and sphenoid bones, and Peele (1957) described another ostium opening very close to the sinus floor.

Additional intersinus septa and crests are, in fact, the rule rather than the exception as they were found in 68.8 per cent in sinuses. They are usually present at the site of fusion of the several synchondroses of the sphenoid bone. These septa and crests have been previously described by Cope (1917), Congdon (1920) and Elwany *et al.* (1983). Of paramount importance is the potential of a septum or crest for insertion into the bony covering of the carotid artery or the optic nerve. Trials to fracture the crest in these cases could lead to injury of these two major structures with serious consequences.

The sphenoid sinus may pneumatize structures outside the sphenoid body leading to the development of various recesses. Such recesses are named according to the area of pneumatized bone. These recesses may place the sinus in close proximity to important structures. The infra-optic or optico-carotid recess, between the optic nerve and carotid artery, was the most frequently encountered recess in our series, and is apparently the most important. Van Alyea (1941) described the infero-lateral recess, extending laterally into the orbital surface of the greater wing of the sphenoid bone, in 36 per cent of his specimens. The same recess has been described in 25 per cent of the material of Cope (1917), and in 32 per cent of our material. Other recesses have been described by Sluder (1909), Peele (1957), and Lang (1989).

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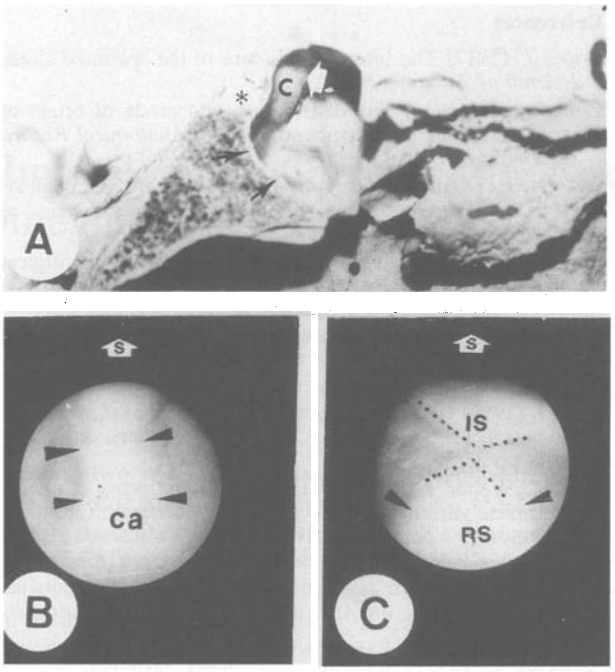

FIG. 3

The carotid artery. A – A sagittal section showing a pre-sellar carotid prominence (c). The sinus extends only beneath the anterior half of the floor of the sella (asterisk). The black arrow indicates the posterior limit of the sinus cavity. B – Endoscopic view of a pre-sellar carotid prominence (ca). C – Endoscopic view of an infra-sellar (IS) and a retro-sellar (RS) carotid prominences. S: Superior.

The lateral wall of the sphenoid sinus is hallmarked by indentations created by important structures, notably the carotid artery and the optic nerve. The surgical significance of these indentations lies in the vulnerability of the underlying structures.

The cavernous segment of the carotid artery is the most medial structure within the cavernous sinus. The impression made by the carotid canal may vary in length from few millimetres to several centimetres, outlining the whole length of the cavernous segment of the artery. Impressions produced by the carotid artery have been reported by Van Alyea (1941), Fujii *et al.* (1979), Elwany *et al.* (1983), Lang (1989) and, Kennedy *et al.* (1990). The bony covering

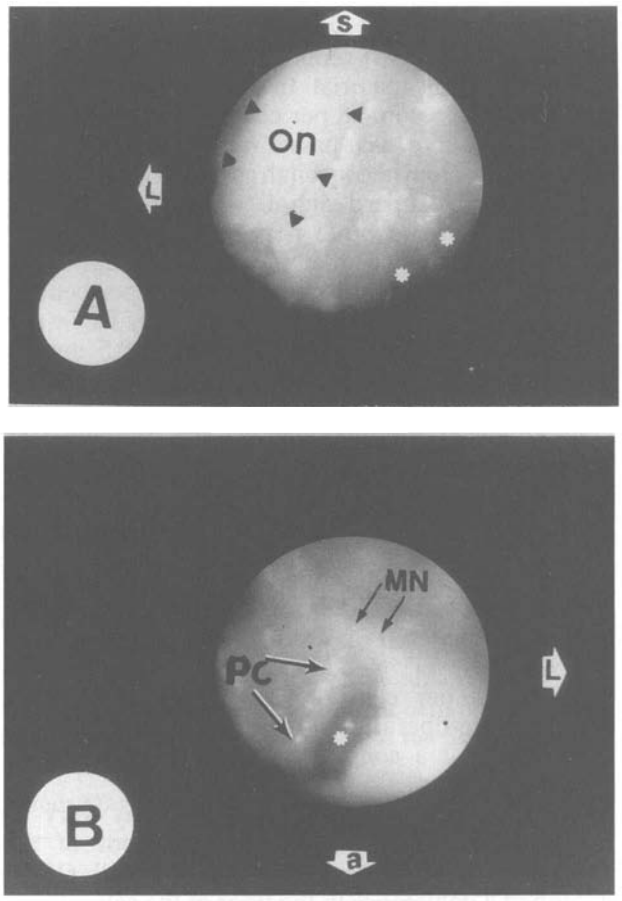

FIG. 4

A – Endoscopic view showing the optic nerve (on) producing a bulge in the supero-lateral wall of the sphenoid sinus. The white asterisk marks the infra-optic or optico-carotid recess separating the optic canal from the carotid prominence. B – Endoscopic view showing the maxillary nerve (MN) producing a definite ridge in the lower lateral wall of the sinus. The pterygoid canal (pc) also produces a ridge in the sinus floor. The white asterisk marks the infero-lateral recess of the sinus. S: Superior L: Lateral a: Anterior

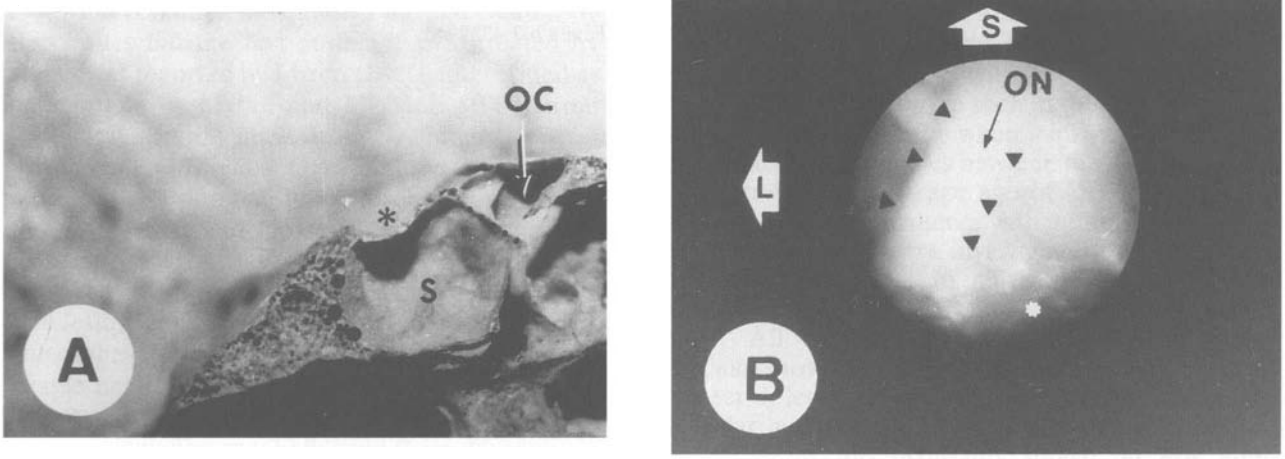

FIG. 5

A – Onodi cell (oc) extending into the sphenoid bone and reaching the sphenoid sinus (S). The sinus extends beneath the whole length of the sella (asterisk). B – Endoscopic view showing the optic nerve (on) projecting into the wall of Onodi cell. The bony covering of the nerve is intact. The white asterisk marks the cavity of the cell. S: Superior L: Lateral

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of the carotid canal varies greatly in thickness. Kennedy *et al.* (1990) reported dehiscences in up to 22 per cent of his material. In our material we found these dehiscences in 4.8 per cent of sinuses.

The optic nerve, as it passes from lateral to medial after its exit from the orbital apex, may produce a bulge in the supero-lateral wall of the sinus. Impressions of the optic nerve were found in 29 per cent of our specimens. However, Fujii *et al.* (1979) reported these impressions in 40 per cent of his material. He also found that as many as 78 per cent of specimens had bones less than 0.5 mm in thickness covering the optic canal, and four per cent had a bony dehiscence. May *et al.* (1995) described a case in which the optic nerve was running free through the sphenoid sinus, only surrounded by a barely visible bony shell.

Onodi cells (Onodi, 1895) are posterior ethmoid cells lying within the sphenoid bone. In the present series they were identified in 7.5 per cent of cadavers. These cells were found in nine to 12 per cent of the material of Van Alyea (1939) and Lang (1989). However, Yeoh and Tan (1995) reported them in 32 per cent of Asian cadavers. Unless identified pre-operatively, Onodi cells may place the optic nerve at a considerable risk during sphenoethmoidectomy.

The roof of the sphenoid sinus may vary in thickness and is hallmarked by the floor of the sella. In an old publication, Zuckerkandl (1893) described a dehiscence in the floor of the sella. These dehiscences, however, appear to be extremely rare.

The floor of the sinus occasionally shows a ridge corresponding to the pterygoid canal. This ridge was present in 7.5 per cent of our material but was reported in 36 per cent of the material of Van Alyea (1941). Van Alyea (1941) also mentioned that the nerve might have only a mucosal covering.

The complex and diverse relations of the sphenoid sinus have a dual significance. Firstly, diseases of the sphenoid sinus tend to give rise to a complexity of symptoms and potentially serious complications. Secondly, inadequate understanding of these relationships undoubtedly increases the possibility of serious and occasionally fatal iatrogenic mishaps.

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