SPECULUM OPENING IN TRANSSPHENOIDAL SURGERY

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OBJECTIVE: To assess the extent to which the transsphenoidal speculum can be safely opened at the face of and within the sphenoid sinus without risking damage to the optic nerves in the optic canals and at the orbital apex and the nerves coursing adjacent the walls of the sphenoid sinus.

METHODS: The distance was measured between the optic nerves at the level of the anterior wall of the sphenoid sinus and 0.5 and 1.0 cm within the sinus. In addition, the distance between the middle turbinates and the contralateral optic canals was assessed because this turbinate is the largest structure blocking access to the sphenoid sinus in the transsphenoidal approach and tends to force the speculum away from the midline and toward the optic nerve in the contralateral side of the approach.

RESULTS: Opening the transsphenoidal speculum at the anterior wall of the sphenoid sinus beyond 2.5 centimeters carries some risk of damaging the optic nerves and this distance narrows when the speculum opening is positioned inside the sphenoid sinus. Displacement of the speculum to one side by the middle turbinate places the speculum near the contralateral optic nerve and may be associated with optic nerve injury with lesser degrees of speculum opening.

CONCLUSIONS: Careful attention should be directed to avoiding excessive opening of the transsphenoidal speculum at the anterior face of the sphenoid or within the sphenoid sinus.

KEY WORDS: Optic nerve, Sphenoid sinus, Transsphenoidal surgery

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Loss of vision after transsphenoidal surgery has been reported in 0.5 to 2.5% of cases (2). A number of mechanisms have been reported, including direct injury to the optic nerves, removing tumor adherent to the optic pathways, postoperative hematoma, overpacking the sella, downward traction on the nerves created by leaving a large open sella below the nerves, vascular occlusion, or spasm and fracture of the optic canals or orbital walls with nerve compression caused by vigorous spreading of the blades of the transsphenoidal speculum (1, 2, 7). This study addresses the latter cause by measuring how wide the speculum can be opened without compressing or damaging to the optic nerves, orbital apices, or optic canals. The distance between the middle turbinate and the contralateral optic canal was also determined, because the posterior part of this turbinate is the largest structure blocking nasal access to the anterior wall of the sphenoid sinus and causes the speculum to be deflected toward the opposite side and closer to the nerve contralateral to the turbinate.

MATERIALS AND METHODS

We analyzed 12 cadaveric specimens. The nasal cavity and the anterior wall of the sphenoid sinus were reached by drilling the cribriform plate and ethmoid sinuses from above through the floor of the anterior fossa while preserving the optic nerves, chiasm, turbinates, nasal septum, and sellar region. The mucosa overlying the roof of the nasal cavity and the superior turbinate was removed while preserving the middle turbinate and nasal septum. The bone covering the optic nerves along the superior and lateral walls of the sphenoid sinus was removed (*Fig. 1*). The distances measured at the level of the anterior wall of the sphenoid sinus were: 1) between the optic nerves at the intersection with the anterior wall of sphenoid sinus and 0.5 and 1.0 cm inside the sinus behind the anterior sinus wall; 2) the distance between the medial edge of the posterior part of the middle turbinate and the point of intersection between the contralateral optic nerve and the anterior wall of the sphenoid sinus, and 3) the width of the middle turbinates (*Fig. 1*, *Table 1*). A transsphenoidal bivalve speculum was inserted into the right nostril and between the nasal septum and middle turbinate, as would be done in the direct endonasal approach, to reach the anterior wall of the sphenoid sinus (*Figs. 1* and *2*). In the posterior nasal cavity, a vertical mucosal incision was made at the junction of the posterior nasal septum and crest of the sphenoid bone. The posterior attachment of the septum to the sphenoid face was then pushed

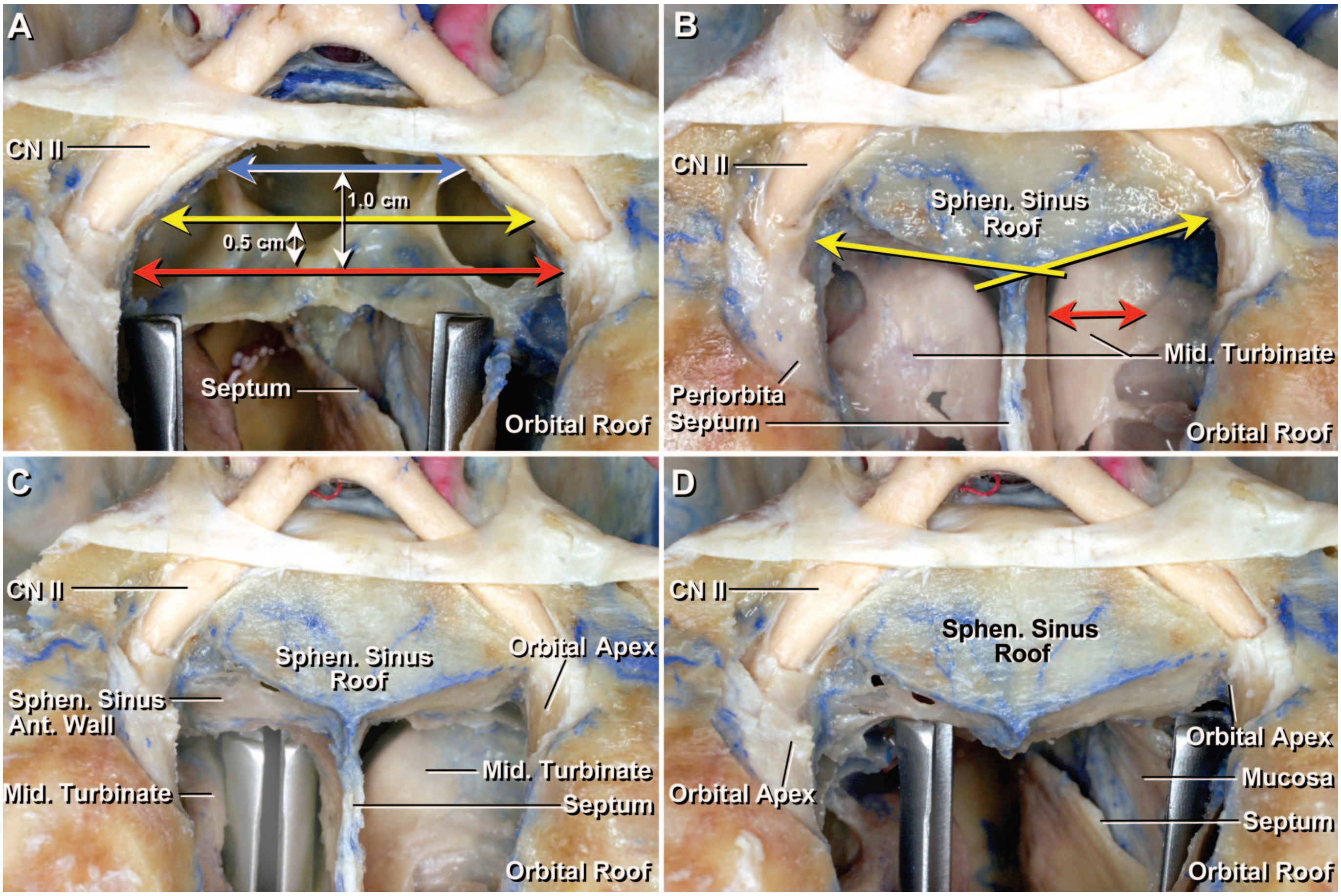


FIGURE 1. A, *anterior superior view of the optic nerves and sphenoid sinus. The cribriform plate and medial part of the floor of the anterior fossa were opened to provide this anterior superior view of the optic nerves, nasal cavity, and sphenoid sinus. The average distance between the optic nerves at the anterior wall of the sphenoid sinus (*red line*) was 2.93 cm (range, 2.71–3.09 cm). The distances between the optic nerves 0.5 (*yellow line*) and 1 cm (*blue line*) behind the anterior wall and within the sphenoid sinus averaged 2.62 cm (range, 2.47–2.71 cm) and 1.58 cm (range, 1.39–1.74 cm), respectively.* B, *the* yellow lines *show the distances between the posterior part of the medial edge of the middle turbinate and the contralateral optic nerve (*yellow arrow*) at the anterior wall of the sphenoid sinus. The distance from the right middle turbinate to the left optic nerve averaged 2.77 cm (range, 2.65–2.98 cm) and from the left middle turbinate to the right optic canal averaged 2.73 cm (range, 2.61–2.93 cm). The* red arrow *shows the width of the middle turbinate (average, 0.84 cm; range, 0.57–2.93 cm). The turbinate on either side could predominate.* C, *the right middle turbinate has been compressed laterally and the speculum has been inserted to the right of the nasal septum, as would be done in the endonasal direct transsphenoidal approach directed through the right nostril.* D, *the septum has been detached from the face of the sphenoid and the speculum blades have been opened. The middle turbinate on the side of the nostril into which the speculum is inserted displaces the speculum toward the opposite side. The best structural guide to the midline is the crest on the face of the sphenoid along which the septum attaches.* Ant., *anterior;* CN, *cranial nerve;* Mid., *middle;* Sphen., *sphenoid.*

off the midline by the medial blade of the speculum. At this point, the speculum was placed up to the anterior face of the sphenoid bone and opened to determine toward which side of the speculum would be deflected (*Figs. 1, C* and *D*, and *2, C* and *D*).

RESULTS

The distance between the optic nerves at the level of the anterior wall of the sphenoid sinus averaged 2.93 cm (range, 2.71–3.09 cm). One and one-half cm backward from the midpoint of anterior wall of the sphenoid sinus and inside the sphenoid sinus, the distances between both optic nerves had decreased to an average of 2.62 cm (range, 2.47–2.71 cm) and 1.58 cm (range, 1.39–1.74 cm), respectively.

The speculum, when opened, was commonly deflected off the midline toward the opposite side by the middle turbinate in the nostril in which the speculum was inserted. The average distance between the posterior part of the medial edge of the middle turbinate and the point of intersection of the contralateral optic nerve with the anterior wall of the sphenoid sinus averaged 2.75 cm (range, 2.61–2.98 cm) (*Fig. 1*). The distance from the right and

TABLE 1. Measurements of 12 specimens

Site of measurement	Average (range, cm)
Distance between both optic nerves at anterior wall of sphenoid sinus	2.93 (2.71–3.09)
Distance between both optic nerves at 0.5 cm inside sphenoid sinus	2.62 (2.47–2.71)
Distance between both optic nerves at 1.0 cm inside sphenoid sinus	1.58 (1.39–1.74)
Distance between medial surface of the posterior part of the right middle turbinate and the left optic nerve at anterior wall of sphenoid sinus	2.77 (2.65–2.98)
Distance between medial surface of posterior part of the left middle turbinate and the right optic nerve at the anterior wall of the sphenoid sinus	2.73 (2.61–2.93)
Width of left middle turbinate	0.74 (0.57–0.96)
Width of right middle turbinate	0.94 (0.59–1.03)
Width of right and left turbinates combined	0.84 (0.57–1.03)

left middle turbinate to the contralateral optic nerves was approximately the same: right middle turbinate to left optic nerve, average 2.77 cm (range, 2.65–2.98 cm) and left middle turbinate to right optic nerve, average 2.73 cm (range, 2.61–2.93 cm). The width of the posterior part of the left middle turbinate averaged 0.74 cm (range, 0.57–0.96 cm) and the right averaged 0.94 cm (range, 0.59–1.03 cm).

DISCUSSION

Schloffer (9) was the first to operate on a patient through the transsphenoidal route. Currently, there are two main routes used for transsphenoidal surgery. One is the sublabial approach and the other is the endonasal approach. The sublabial approach, which has been widely used, was refined by Jules Hardy (4), who introduced the combination of the operating microscope and the radiofluoroscope to transsphenoidal surgery.

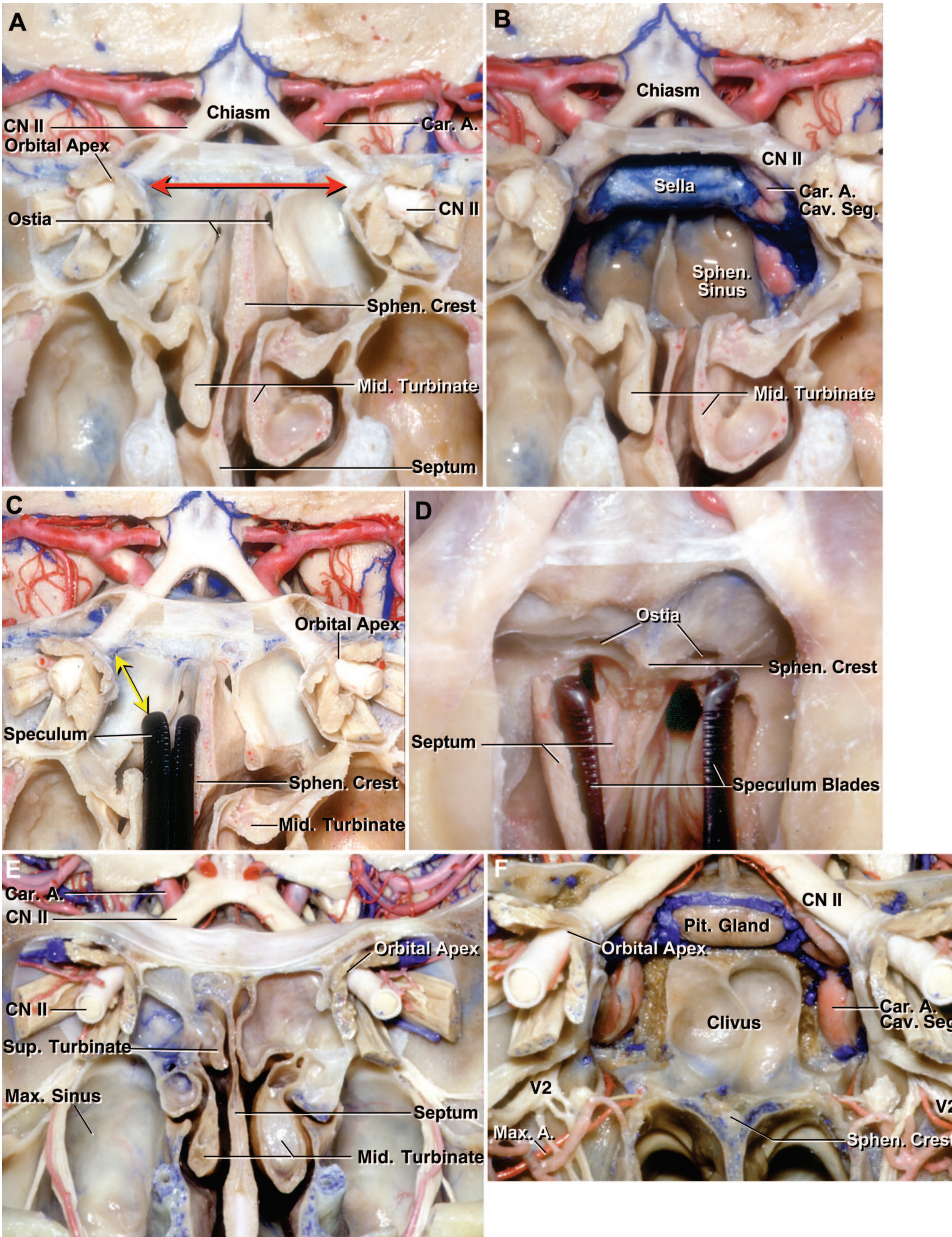
The endonasal approach, directed through the nose without a sublabial incision, is subdivided into three categories: the transseptal, transethmoidal, and direct approaches (5). The transseptal approach uses an incision in the columella between the nares, elevation of the septal mucosa using subperichondral dissection, and exposure of the anterior wall of the sphenoid sinus. The transethmoidal approach reaches the sphenoid sinus by opening the ethmoid air cells.

In the direct endonasal approach, described by Griffith and Veerapen (3), the anterior wall of the sphenoid sinus is reached through the nostril and between the nasal septum and turbinates without gingival incision or mucosal dissection along the nasal septum. Rhoton (8) has provided an extensive discussion of this approach and designed a speculum suited for this route. The target area for the nasal part of the direct endonasal procedure is the anterior wall of the sphenoid sinus. The goal in opening the speculum at the anterior wall of the sphenoid sinus is to provide an opening into the sphenoid sinus sufficient to expose the anterior sellar wall or adjacent target area, but not opening the speculum so widely that it will damage the optic nerves in the optic canals or orbital apex and the neural structures in the wall of the sphenoid sinus.

Careful attention should be directed to the relationship of the exposure to the midline because the middle turbinate on the side of the nostril in which the speculum is inserted commonly deflects the speculum to the opposite side. The crest on the face of the sphenoid sinus at the site of attachment of the nasal septum provides a consistent approximation of the midline (8), which can be aided by fluoroscopy or image guidance (*Figs. 1 and 2*). Positioning the blades of the speculum with the sphenoid crest in the midline usually requires that the posterior part of the middle turbinate be pushed or crushed laterally. The opening between the medial edge of the middle turbinate and the nasal septum is usually only a few millimeters wide and is, in many cases, insufficient to admit either an endoscope or an endonasal speculum. Thus, it is necessary to push the turbinate laterally, usually with a handheld speculum, such as the Killian, to introduce the transsphenoidal speculum or an endoscope. Resection of the middle turbinate has been used in the past (6), but the senior author (ALR) has not found this necessary in any of more than 1000 transsphenoidal operations. The nasal septum should be separated from the sphenoid crest before opening the speculum widely. Opening the speculum widely before separating the nasal septum from the sphenoid face will force a speculum blade toward the ipsilateral optic canal and orbital apex.

Care should be taken in opening the speculum at the anterior wall of the sphenoid sinus beyond 2.0 to 2.5 cm, and this distance narrows significantly (to less than 1.5 cm) if the speculum is advanced into the sphenoid sinus. It is important to remember that the blades of the speculum are pushing several millimeters of soft and osseous tissue from the turbinates and lateral nasal wall laterally ahead of the tips of the blades. The transsphenoidal speculum usually encounters the firm resistance of the middle turbinates and the lateral nasal wall as it is opened, thus limiting the extent of the opening of the blades. This natural resistance, which tends to limit speculum opening, may be absent in some cases in which the strength of the bone has been reduced by extensive erosion of bone by tumor, reoperations done after extensive bone removal at an earlier operation, and softening of the osteoporotic bone associated with Cushing's disease and long standing steroid usage. In these cases, the speculum should be opened gently.

Excessive spreading of the bivalve speculum in the sphenoid sinus has been reported to cause a fracture of the medial orbital wall with visual loss (1). Advancing the speculum into the sphenoid sinus has been advocated (10). However, the speculum opening has to be significantly reduced if the specu-


A
Chiasm
CN II
Orbital Apex
Car. A.
CN II
Ostia
Sphen. Crest
Mid. Turbinate
Septum
B
Chiasm
CN II
Sella
Car. A.
Cav. Seg.
Sphen.
Sinus
Mid. Turbinate
C
Orbital Apex
Speculum
Sphen. Crest
Mid. Turbinate
D
Ostia
Sphen. Crest
Septum
Speculum Blades
E
Car. A.
CN II
Orbital Apex
CN II
Sup. Turbinate
Max. Sinus
Septum
Mid. Turbinate
F
CN II
Pit. Gland
Orbital Apex
Clivus
Car. A.
Cav. Seg.
V2
V2
Max. A.
Sphen. Crest

lum is placed in the sphenoid sinus because the distance between the optic nerves decreases progressively as the speculum is advanced posteriorly in the sinus. The finding of air in the orbital apex on x-ray or imaging studies suggest that there has been a fracture of the optic canal orbital wall. Postoperative visual deficits associated with the fracture into the orbit and optic canal may be managed by a transethmoidal approach to the medial orbit to decompress the optic canal (1).

Placing the speculum in the sinus also increases the risk of damaging the structures in the wall of the sinus including the optic and maxillary nerves and the nerves passing through the superior orbital fissure (8). The maxillary nerve and the medial edge of the superior orbital fissure may produce prominences in the lateral wall of the sphenoid sinus, as do the optic nerves and carotid arteries. The bony sinus wall shielding these structures from a speculum placed within the sinus may be extremely thin or completely absent in some areas. It is not surprising that the nerves in the wall of the sinus are vulnerable to compression by the transsphenoidal speculum and also to surgical manipulation or heat from coagulation within the sinus (8).

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COMMENTS

As in the past, Rhoton and his collaborators have provided a precious anatomic "pearl." This report should be a mandatory reading for all neurosurgeons, otolaryngologists, and plastic surgeons who perform transsphenoidal microsurgery.

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This is an excellent addition to the literature, typical of the anatomical quality presented from Rhoton's laboratory. The importance of this anatomy and measurements cannot be overemphasized, particularly from two advantages. First, we often ask how wide a speculum can be opened. This article shows the range well. Additionally, we often ask how much force should, or can, be used to open the speculum. Understanding which bones (i.e., turbinbates) are offering resistance must be known.

Second, the skewed approach through bone nares clearly leads the surgeon toward the opposite carotid artery if care is not taken to insure the midline. While adequate room usually is available through the unilateral approach, extra attention must be given to not injure the optic nerves or carotid arteries.

The authors note that "postoperative visual deficits associated with fractures into the orbit and optic canal may be managed by a transethmoidal approach to the medial orbit to decompress the optic canal." In cases that I have reviewed and experienced, this has not been of any benefit. Conservative observation with steroids has been equally effective.

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When endoscopic or endoscopic assisted procedures versus microsurgical techniques for pituitary surgery are presented every few months, it is refreshing for a senior pituitary surgeon to offer a logical methodology to the endonasal speculum-guided approach to the sphenoid sinus. Even if the endoscope offers a wonderful panoramic view within the sphenoid sinus, frequently solving midline

FIGURE 2. A, *anterior view of a coronal section through the orbital apex, posterior part of the middle turbinates, and in front of the anterior wall of the sphenoid sinus and sphenoid ostia. Note the prominence of the posterior part of the middle turbinates especially on the left side. The optic nerves converge as they proceed posteriorly from the orbital apex toward the chiasm.* B, *the sphenoid sinus has been opened to expose the clivus, anterior sellar dura, and intracavernous segment of the carotid arteries. The middle turbinates form a prominence at the anterior-inferior margin of the sphenoid sinus that tends to deflect the transsphenoidal speculum to the opposite side. The space between the medial edge of the turbinates and the contralateral orbital apex may be less than the distance between the optic nerves at the anterior wall of the sphenoid sinus.* C, *the endonasal speculum has been inserted into the left nostril. The prominent left middle turbinate deflects the specimen toward the right side and closer to the right optic canal (*yellow line*). The turbinates must be pushed laterally to position the speculum so that the sphenoid crest, after separating from the nasal septum, is positioned in the center between theblades of the opened speculum. Forcefully opening the speculum before separating the nasal septum from the sphenoid crest could force a speculum blade into the ipsilateral optic nerve.* D, *view from above after opening the cribriform plate and roof of the nose. After compressing the turbinates laterally and pushing the posterior part of the nasal septum to the opposite side, the blades of the speculum can be inserted below the sphenoid ostia with the sphenoid crest in the midline.* E, *anterior view of another coronal section through the orbital apex, posterior part of the middle concha, and in front of the anterior wall of the sphenoid sinus. The middle turbinates form an obstacle at the anterior-inferior margin of the sphenoid sinus.* F, *the sella has been opened and the second trigeminal division has been exposed at the anterior-inferior margin of the sphenoid sinus. The optic nerves converge as they proceed posteriorly toward the chiasm so that the width of speculum opening that is permitted without damaging the optic nerves becomes progressively less in proceeding backward in the sphenoid sinus. The optic and maxillary nerves, carotid arteries, and medial edge of the superior orbital fissure create overlying prominences in the lateral wall of the sphenoid sinus.* A., *artery;* Car., *carotid;* Cav., *cavernous;* CN, *cranial nerve;* Max., *maxillary;* Mid., *middle;* Pit., *pituitary;* Seg., *segment;* Sphen., *sphenoid;* Sup., *superior.*

problems by discovering the protuberance of the carotid arteries, the anatomical study presented by Rhoton, who is a pituitary surgeon and a clinical neuroanatomist, is of paramount interest for pituitary surgeons. The close relationship of anatomical structures in the wall of the sphenoid sinus can be reached and are dangerous by itself. Not so much has been reported by the authors about endonasal specula itself on different types, under which I prefer those that open more at the tip (distal) and less in the nostril (proximal). The view of the surgeon on the floor of the sphenoid sinus is limited by the middle turbinator, the largest structure blocking the access to sphenoid sinus. However, Rhoton reports that in more than 1000 cases, he never was forced to remove the middle turbinator. In our series with pituitary adenomas, it was a necessary procedure for a few exceptions. However, it will be necessary for extended endoscopical approaches, including the parasellar extension to the cavernous sinus, which we've recently learned from endoscopy pioneers in Italy and elsewhere. The authors state that the speculum opens more on one side than on the other, deflecting the midline. This disadvantage probably can be solved by turning around the speculum.

I support the strong recommendation of the authors that the speculum should not be inserted into the sphenoid sinus for different reasons: limitation of view and danger to compress and damage the important anatomical structures. Thinking about the important neighboring structures, including the exact measurements of anatomical distances, the unforgettable German anatomist Johannes Lang, well known through many international conferences, comes to mind. Johannes Lang was not a surgeon like Rhoton, but he could prepare cadavers and think like a neurosurgeon.

Besides the stimulating endoscopic anatomy, we are informed about important neuroanatomical landmarks, which are cultivating the transsphenoidal approach on a high level. Garcia and Rhoton contributed a great work from their famous laboratory and are thanked for their continuous support.

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Garcia and Rhoton have studied the anatomical relationships of the nasal cavity, sphenoid septum, and optic nerves. With the increasing use of the direct endonasal approach for transsphenoidal adenomectomy, these measurements are of importance for surgeons to prevent optic nerve damage by opening the speculum. In addition, these anatomical data will be important for surgeons approaching suprasellar lesions via the extended transsphenoidal approach. I agree with the authors that lateral displacement of the ipsilateral middle turbinate is helpful to insure that the speculum blades are positioned on either side of the midline anterior sphenoid crest. Nostril size usually dictates the extent of opening for a Hardy speculum, although the nostril can be enlarged with an incision.

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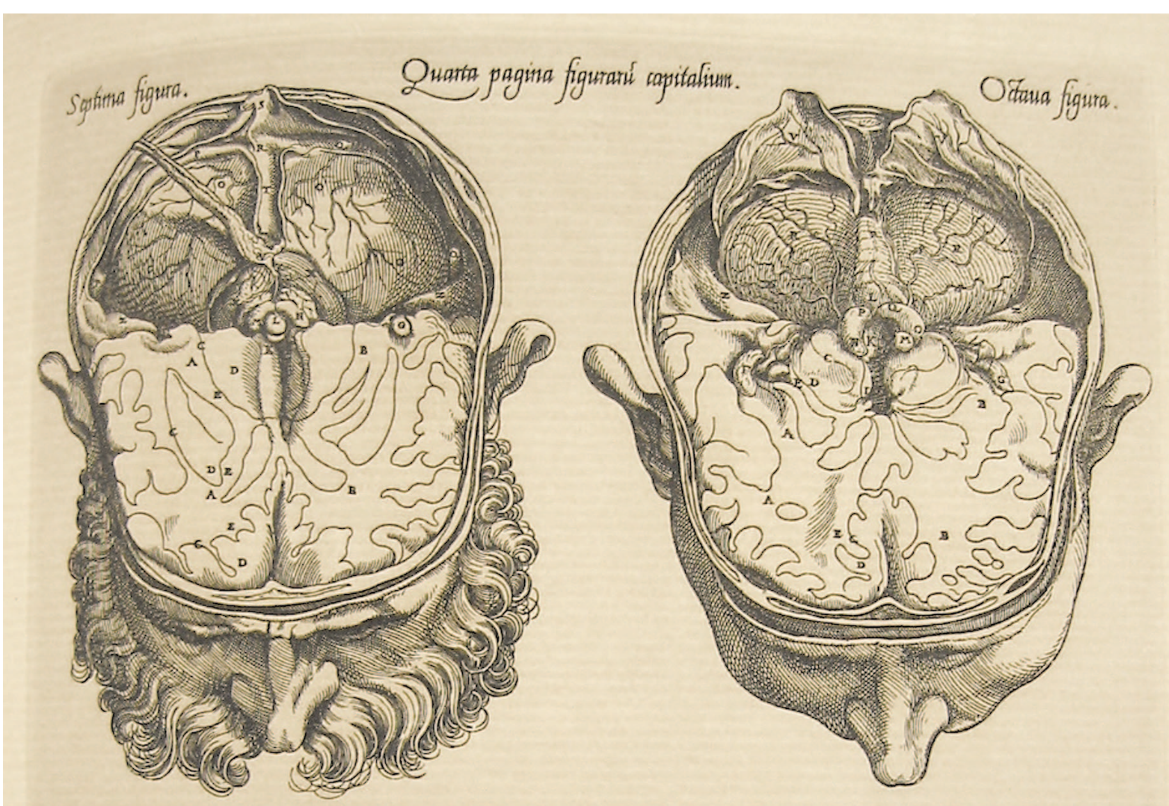

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