



Wassily Kandinsky (1866-1944). *Study for Winter II*, 1910.

Microscopic paraseptal sphenoidotomy for pituitary tumors is a minimally invasive approach that simplifies transsphenoidal surgery.

Microscopic Paraseptal Sphenoidotomy Approach for Pituitary Tumors

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Background: *Dissection of mucosa from the nasal septum during a transsphenoidal approach may lead to significant morbidity. Endoscopic techniques that obviate this dissection and its complications have been successful for pituitary operations. These techniques, however, are generally not stereoscopic, can add significant costs, and in many instances require additional surgical personnel.*

Methods: *We have exposed 11 sella lesions with the operating microscope without intranasal dissection or use of endoscopy. A paraseptal approach was utilized by following the middle turbinate to the nasopharynx and performing a bilateral sphenoidotomy.*

Results: *Of the 11 sella lesions addressed through this approach, 6 were macroadenomas (2 secreting and 4 nonsecreting), 1 was a craniopharyngioma, 1 was a Rathke's cleft cyst, and 2 were cerebrospinal fluid leaks into the sphenoid sinus. In 1 case, an ectopic pituitary adenoma was biopsied. Subtotal or near total tumor resection or successful repair of cerebrospinal fluid leaks was achieved. In all cases, the exposure was satisfactory. A fat graft was used in 6 cases. Postoperatively, no nasal packing was used and there were no nasal complications. Vision improved in all 5 cases with preoperative visual impairment. Complications included diabetes insipidus (1), impaired taste (1), and delirium tremens (1), all of which were transient.*

Conclusions: *Microscopic sphenoidotomy is a safe and effective alternative to traditional transeptal or endoscopic exposures of the sella.*

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Introduction

Transsphenoidal surgery for pituitary tumors had a long historical road in the 20th century, starting as a transnasal approach by Schloffer in 1907 and culminating with the endoscopic techniques of the modern era.^{1,2} In 1909, Halstead introduced the sublial transeptal approach, which was subsequently adopted in 1910 by Cushing.³ However, this approach was not universally accepted and was later abandoned in favor of the intracranial subfrontal approach, first performed by Krause in 1905 and widely supported by Dandy.⁴ Even the most arduous proponents of the transsphenoidal approach were converted to the transcranial approach due to cerebrospinal fluid (CSF) leaks, meningitis, hypothalamic and vascular injuries, and the impression that vision improved more after intracranial operations. This was epitomized in 1914 by Dandy⁴ when he stated that “the nasal route is impractical and can never be otherwise. At best, the exposure is scarcely larger than the circumference of a lead pencil. There are, in fact, no instances where a transsphenoidal attack on a hypophyseal tumor can be justified.”

After 1940, few centers in the United States and Europe continued to use the transsphenoidal approach, until the 1950s when Hardy,⁵ aided by the operating microscope, reintroduced and popularized it. Further technologic advancements, such as the use of the endoscope for paranasal sinus surgery, led to the introduction of the endoscopic approach as a minimally invasive technique to the sella,^{6,8} an approach popularized in 1997 by Jho and Carrau.⁹⁻¹¹

In this article, we describe a modification of the endoscopic approach that uses the operating microscope to perform an anterior sphenoidotomy. This approach combines the minimally invasive elements of the endoscopic approach with the 3-dimensional view and superb image clarity of the microscope. This article describes the pertinent nasal surgical anatomy and the microscopic parasseptal sphenoidotomy technique, as well as the use of this approach in treating 9 pituitary tumors and 2 CSF leaks through the sphenoid sinus.

Methods

From June 1998 to June 2000, 11 consecutive patients (6 men and 5 women) underwent a microscopic sphenoidotomy approach to the sella for pituitary lesions or to repair CSF leaks. Their mean age was 40 years. In these 11 patients, lesions included macroade-

noma (6), sellar craniopharyngioma with suprasellar extension (1), ectopic pituitary adenoma of the sphenoid sinus (1), Rathke's cleft cyst (1), and CSF leaks through the sphenoid sinus (2). Of the 7 adenomas, 5 were nonsecreting, 1 secreted prolactin, and 1 secreted growth hormone. All macroadenomas had large suprasellar extensions and, in some cases (4 of 6), parasellar extensions. The patient with a prolactin-secreting macroadenoma was noncompliant with bromocriptine treatment preoperatively. Three patients presented with visual loss, 2 with pituitary apoplexy, 1 with acromegaly, 1 with hypopituitarism, 1 with epistaxis, 1 with headache, and 2 with CSF leakage. Of the 2 patients presenting with CSF leakage, 1 had a spontaneous leak related to idiopathic intracranial hypertension, and the other developed a leak after resection of a recurrent anterior clinoid meningioma with orbital extension. All patients were evaluated with magnetic resonance imaging (MRI) of the sella with and without gadolinium (8), computed tomography (CT) (9), and CT-metrizamide (1). All patients were followed with postoperative MRI of the sella, usually 3 months after surgery and then yearly.

Surgical Anatomy

The nasal cavity is divided by a vertical septum into 2 paired cavities. Each half has a medial wall (the nasal septum), a lateral wall (the nasal conchae or turbinates), a roof, and a floor. The lateral wall contains ridges called conchae or turbinates that participate in the drainage and ventilation of the paranasal sinuses. The inferior turbinate is the largest and most apparent one on inspection of the nasal cavity through the ante-

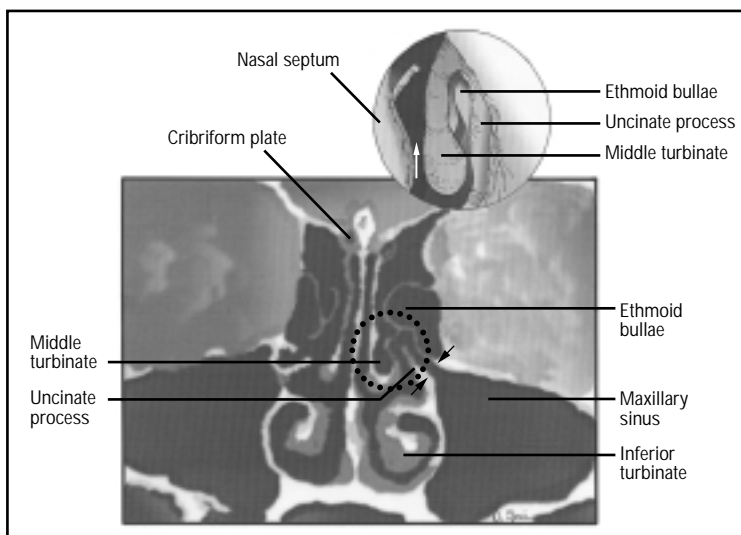


Fig 1. — Coronal view of the anterior cranial fossa at the level of the cribriform plate. The inset demonstrates the direction of the surgical approach (white arrow) between the middle turbinate and the nasal septum. The opening to the maxillary sinus is indicated (black arrows).

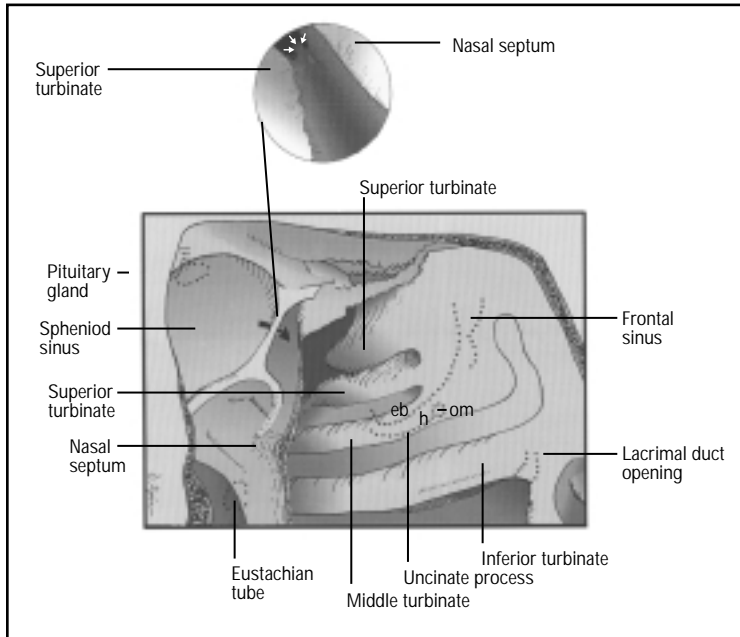


Fig 2. — Oblique lateral view of the nasal cavity after removal of the nasal septum. The turbinates and sphenoid sinus ostium (inset) are illustrated. Dotted lines show structures hidden by the respective turbinates (eb = ethmoid bullae, h = hiatus semilunaris, om = ostium to the maxillary sinus). From Rhoton AL Jr, Natori Y. Medial (transethmoidal and transsphenoidal) approaches. In: Rhoton AL Jr, Natori Y, eds. *The Orbit and Sellar Region: Microsurgical Anatomy and Operative Approaches*. New York, NY: Thieme Medical Publishers; 1996:292-294. Modified with permission.

rior nasal aperture. The eustachian tube is found on the lateral wall of the nasopharynx, at the posterior tip of the inferior turbinate. The inferior turbinate covers the inferior meatus, which receives the opening of the nasolacrimal duct.^{12,13}

The middle turbinate forms a gentle anterior curve and has almost a diagonal course from superiorly to inferiorly (Fig 1). It can be divided into 3 parts. The most anterior third is entirely vertical and inserts to the base of the skull, at the lateral edge of the cribriform plate and the lamina papyracea. The middle third runs in a horizontal direction, with the posterior third being its tapering continuation. The middle meatus receives drainage from the frontal sinus anteriorly and the maxillary sinus posteriorly. The middle turbinate may be reflected superiorly to expose the sickle-like uncinate process anteriorly, and the ethmoid bullae (reflecting the middle ethmoidal air cells) posteriorly. Between these structures is a cleft called the hiatus semilunaris, an important anatomic landmark for endoscopic surgery of the maxillary, ethmoid, and frontal sinuses.¹⁴ As shown in Fig 2, the posterior end of the middle turbinate roughly corresponds to the floor of the sphenoid sinus. The sphenopalatine artery and its branches are located at the

lateral nasal wall between the posterior termination of the middle and inferior turbinates.¹⁵

Superior and posterior to the middle turbinate is the superior turbinate, which defines the superior meatus that drains the anterior and middle ethmoidal cells. Rarely, a supreme turbinate may exist above the superior one (Fig 2).¹⁵ Between the superior turbinate and the anterior aspect of the sphenoid bone is the sphenoid-ethmoidal recess, which receives the ostium of the sphenoid sinus and drainage from the posterior ethmoidal cells. The ostium of the sphenoid sinus can be slit-like, oval, or round and is sometimes duplicated (Fig 3).¹⁵

The sphenoid sinus varies in size and shape, with average dimensions of 2 × 2 cm. Usually a single septum divides the sinus into 2 noncommunicating asymmetrical cavities. Each cavity connects with the sphenoid-ethmoidal recess and the nasal cavity by an ostium in its superior-anterior wall. In a small percentage of cases, more than 1 major septum may exist, separating the sinus into 3 or more cavities. Sphenoid sinuses are classified as conchal, preconchal (presellar), and sellar, as their respective degree of pneumatization increases. Occasionally the sinus may extend into the roots of the pterygoid processes, the anterior clinoids, or the greater sphenoid wings. Directly superiorly, the bulge of the sella turcica is evident, indicating the position of the pituitary gland. The pituitary gland may normally

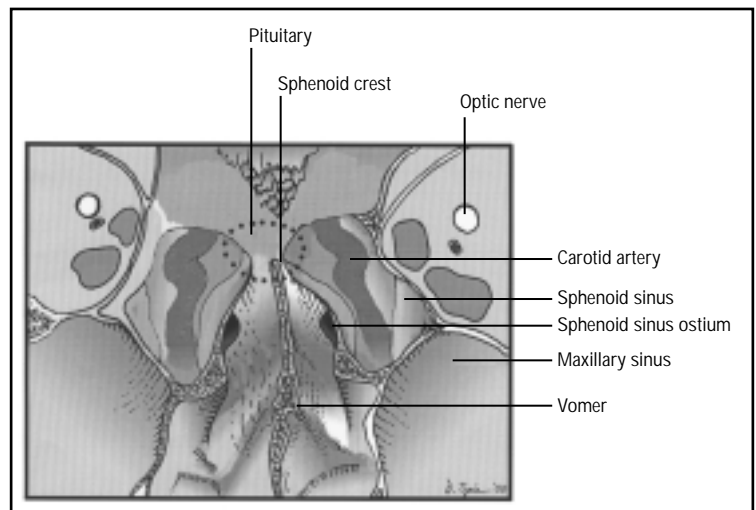


Fig 3. — Illustration of a coronal view of the anterior cranial fossa at the level of the planum sphenoidale. The ostia of the sphenoid sinus and the course of the carotid arteries in the lateral wall of the sinus (dotted line) are demonstrated. From Rhoton AL Jr, Natori Y. Medial (transethmoidal and transsphenoidal) approaches. In: Rhoton AL Jr, Natori Y, eds. *The Orbit and Sellar Region: Microsurgical Anatomy and Operative Approaches*. New York, NY: Thieme Medical Publishers; 1996:292-294. Modified with permission.

overlap with the cavernous carotid artery and may account for the cavernous sinus extension observed with many macroadenomas. On the lateral wall of the sinus are 2 bulges, 1 produced by the optic nerve as it courses the optic canal (antero-superiorly) and another produced by the cavernous carotid artery (postero-inferiorly). Between the two bulges is the opticocarotid recess. These bulges, may be unnoticeable or obvious, depending on the degree of pneumatization. In a significant percentage of cases (4% to 25%), there is no bone separating the carotid artery from the sinus mucosa. The bony wall dehiscence occurs less frequently over the optic nerve.^{12,13}

In well-pneumatized sinuses, below the ridge of the cavernous carotid, the course of the maxillary nerve (V2) can be seen as it approaches the foramen rotundum and the pterygopalatine fossa. Slightly more inferiorly, the vidian nerve may be seen as it runs along the base of the pterygoid plate.

Surgical Technique

A vasoconstrictor such as Afrin is used as a nasal spray as the patient enters the preoperative holding area. After induction of general anesthesia, cocaine pledgets are inserted through a nasal speculum as far poste-

riorly as possible through each nostril. The head is placed in a Mayfield head holder (Ohio Medical Instrument Co, Cincinnati, Ohio), lifted up and rotated 20° so that it faces the surgeon. The right nasal aperture is used for the dissection except in cases where there are prominent septal deviations or asymmetric sellar and suprasellar tumor extensions. In those cases, the approach is through the aperture opposite to the deviation or asymmetric tumor extension. Preoperative sinus CT scans are not performed unless there is history of sinusitis or previous surgery. Fluoroscopy was used early on in the series and is recommended at least until the technique becomes familiar.

After removing the pledgets, the operating microscope is used with a nasal speculum to identify the inferior and middle turbinates (Fig 1). The middle turbinate is gently displaced laterally with an elevator and the speculum is advanced in the often narrow space between the middle turbinate and the nasal septum. The elevator is advanced medial to the turbinate towards the nasopharynx, identifying the posterior end of the turbinate. At this point, the dissection moves superiorly, toward the sphenoidal recess. The posterior end of the middle turbinate is often removed with scissors, allowing identification of the superior turbinate and the sphenoidal recess. The sphen-

Results of Microscopic Paraseptal Sphenoidotomy to the Sella for Tumor Resection or Cerebrospinal Fluid Leak Repair

Patient	Age	Sex	Pathology	Presentation	Complications	Follow-up (months)	Follow-up State
1	56	F	NFA	Decreased vision	-	7	Vision improved
2	48	F	NFA	Apoplexy, right ophthalmoplegia	-	8	Vision improved
3	39	M	NFA	Apoplexy, cranial nerve III palsy	Delirium tremens	9	Vision improved
4	45	M	Prolactinoma	Decreased vision	-	13	Vision improved
5	49	M	NFA	Hypopituitarism	-	16	No change
6	46	M	GH secreting adenoma	Acromegaly	Transient diabetes insipidus	18	Acromegaly improved
7	42	M	Ectopic NFA	Epistaxis, headache	-	18	No change
8	30	M	Craniopharyngioma	Decreased vision, hypopituitarism	-	12	Vision improved
9	37	F	-	CSF rhinorrhea	-	19	Leak resolved
10	50	F	-	CSF rhinorrhea, headache	Transient decreased taste	8	Leak resolved
11	31	M	Rathke's cleft cyst	Headache	-	4	Stable

NFA = nonfunctioning adenoma
 GH = growth hormone
 CSF = cerebrospinal fluid

noid sinus ostium is usually found in the medial-posterior part of the recess near the posterior insertion of the nasal septum (Figs 2 and 3).¹⁵ The ostium marks the most superior extent of the sphenoidotomy. The ipsilateral anterior wall of the sphenoid sinus is then removed with rongeurs. To expose the contralateral side, the junction of the sphenoidal crest (or rostrum) and the vomer is fractured with a Freer elevator, starting superiorly where the crest is thinner. The nasal mucosa on the contralateral side is dissected from the anterior wall of the sinus. A retractor is placed just outside the sphenoid sinus. The remaining contralateral anterior sphenoid sinus wall is then removed to complete the sphenoidotomy.

The septa within the sinus are identified and removed, preserving their origin for orientation. The sinus mucosa is partially or completely removed and the sella is identified. Fluoroscopy may be used at this point to confirm the position of the floor of the sella.

The floor of the sella is then removed to expose the dura. After a cruciate incision is made in the dura, removal of the tumor or repair of the CSF leak proceeds using microsurgical technique under high magnification. In cases of macroadenomas, after an initial central decompression, we proceed with a bayoneted #4 Penfield dissector to identify the lateral aspect of the tumor. As the tumor is always extra-arachnoid and arachnoid projections are commonly found centrally through the diaphragma sella, this technique reduces the risk of CSF leakage and allows a more complete tumor removal. Furthermore, if a CSF leak occurs, it is at the end of the case after the majority of the tumor has already been removed. In the event of a CSF leak, fibrin glue is used to seal the fat graft in the sphenoid sinus, and a lumbar drain is inserted for 3 to 5 days. A small fat graft is harvested through a periumbilical incision and placed in the sella after resection of a macroadenoma or repair of a CSF leak. In cases of macroadenomas, a small piece of bone (from bank

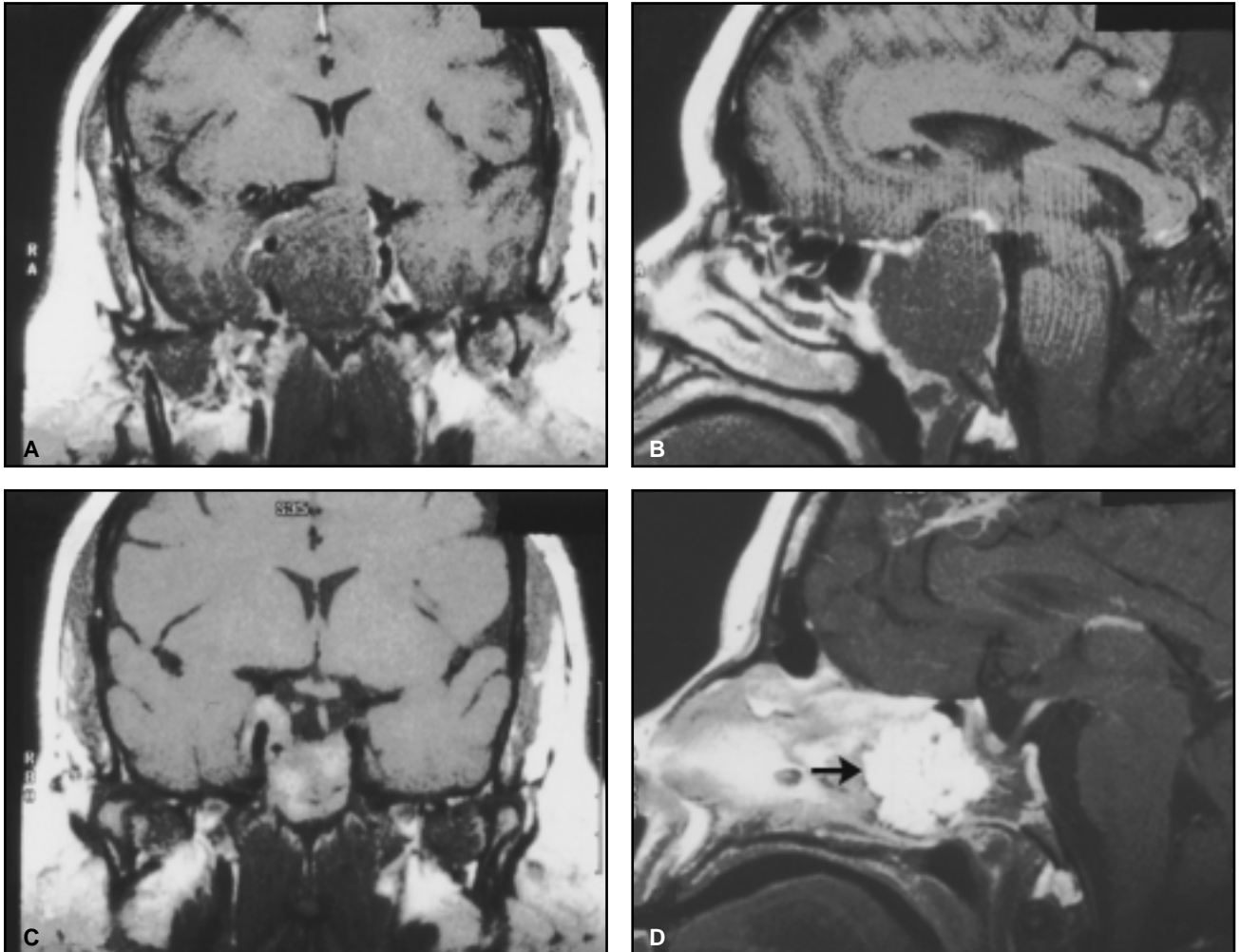


Fig 4A-D. — Patient 2 presented with acute loss of vision, ophthalmoplegia, and pituitary apoplexy. A microscopic parasellar sphenoidotomy approach was used, and the majority of the tumor was removed. The patient experienced a gradual improvement in both visual loss and oculomotor nerve function over the next 6 months. Preoperative (A, B) and postoperative (C, D) coronal and sagittal MR images are shown. The decompression of the optic chiasm and the pituitary stalk are seen as well as the fat graft (black arrow) in the postoperative sagittal image.

bone iliac crest or from the sphenoid rostrum, if sufficient) can be placed at the floor of the sella to prevent an empty sella syndrome. After the self-retaining retractor is removed, the laterally displaced middle turbinate is brought to its normal medial position with a #1 Penfield dissector, and suction is applied to the hiatus semilunaris. Nasal packing is not used. A gauze dressing is placed at the nares to absorb any drainage. The operation usually lasts 2 to 3 hours, with the sphenoidotomy portion typically requiring less than 30 minutes. The average blood loss is 150 mL.

Results

Eleven patients underwent a microscopic parasellar sphenoidotomy approach to the sella for tumor resection or CSF leak repair (Table). All patients with tumors underwent subtotal resections ranging from 70% to 99% of the tumor volume, except 1 patient with

an ectopic pituitary adenoma involving the clivus and sphenoid sinus who underwent a biopsy. All 5 patients with impaired vision or ophthalmoplegia had significant improvement (Figs 4 and 5). The patient with a prolactinoma had a prolactin level one fifth of the preoperative level and continued treatment with bromocriptine. Patients with hypopituitarism did not show significant changes in their pituitary function postoperatively, and no new replacement hormones were necessary. Both patients presenting with CSF rhinorrhea showed resolution of their symptoms (Fig 6). Three complications occurred, and all were transient: diabetes insipidus (1 patient), decreased taste (1), and delirium tremens related to alcohol withdrawal (1). There were no new CSF leaks, carotid artery injuries, or nasal complications such as sinusitis or septal perforation. Patients were typically discharged 1 to 3 days after surgery. Follow-up ranged from 4 months to 19 months (average 12 months). No patients required reoperation or radiotherapy during the follow-up period.

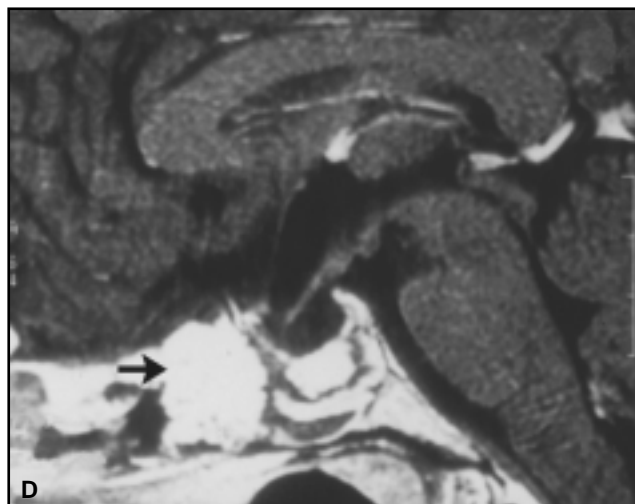
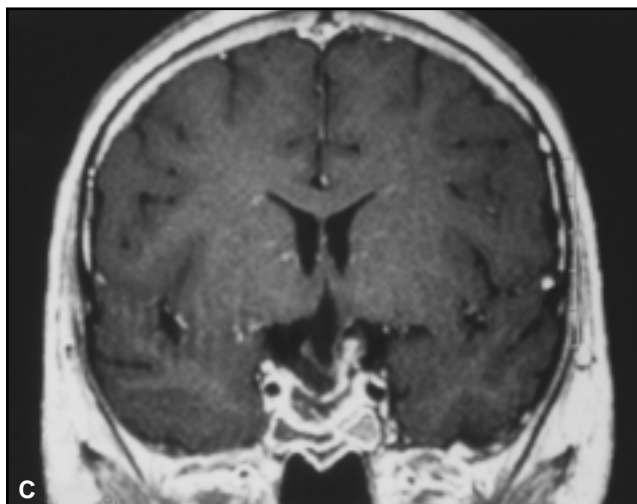
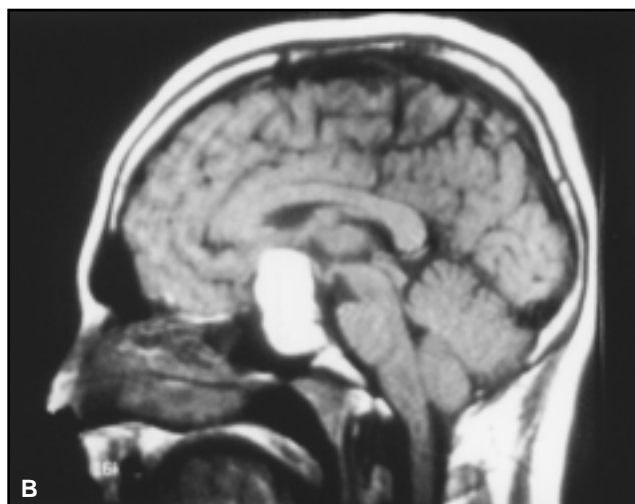
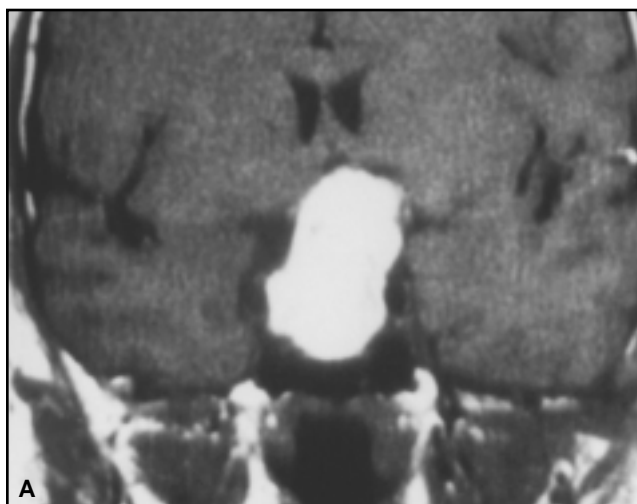


Fig 5A-D. — Patient 8 presented with loss of vision, bitemporal field cuts, and hypopituitarism. Noncontrast coronal and sagittal T1-weighted MR images demonstrate hyperintense signal, raising the possibility of a craniopharyngioma (A, B). Postoperative MR images (with contrast) show the extent of tumor resection (C, D). The patient's visual function significantly improved. A fat graft is also shown in the postoperative sagittal image (D, black arrow).

Discussion

This report describes results with the use of the microscopic parasseptal sphenoidotomy approach to the sella in 11 patients. Although the study is small and follow-up is short, the results demonstrate the feasibility of the technique and the adequacy of subtotal resection in the case of macroadenomas to decompress the optic chiasm. As is the case with the endoscopic endonasal approach, there is a comparable lack of nasal-related complications for the microscopic approach. Such complications occur frequently after traditional transseptal approaches and were summarized by Ciric et al¹⁶ in 1997. The traditional transnasal approach

requires repair of the nasal mucosa, which is often tedious and creates a risk of septal perforation.¹⁷ Septal perforations, with an incidence rate of 0.3% to 40%, are bothersome to the patient when they occur in the anterior part of the nasal septum and are more frequent with reoperations. For the rare occurrence of an S-shaped septum, the approach is taken through the side with maximum exposure anteriorly, and a partial septoplasty is performed posteriorly to optimize exposure for the sphenoidotomy. The incidence of postoperative sinusitis after traditional transnasal approaches ranges from 1% to 15% and is associated with nasal packing.¹⁶ Although it provides excellent exposure, the sublabial approach may lead to upper lip numbness, collumellar retraction, cosmetic deformity, wound dehiscence, and increased patient discomfort.¹⁶ In their first 50 patients treated endoscopically, Jho and Carrau¹⁰ reported only 1 patient with chronic sinusitis and another with synechia of the nasal mucosa. Heilman et al¹⁸ and Yaniv and Rappaport¹⁹ in 1997 presented a similar modification of the endoscopic technique in that the endoscope was used initially to perform a sphenoidotomy and the microscope was subsequently introduced for tumor removal. In all of these reports, the incidence of nasal complications has been minimal compared to traditional transseptal approaches. Other complications such as diabetes insipidus, CSF leakage, and hypopituitarism have been comparable with both endoscopic and transseptal approaches. In fact, Sheehan et al²⁰ compared a group of patients who underwent the sublabial approach with a group who were operated on endoscopically and found no differences in outcome regarding vision and anterior pituitary function. Cappabianca et al²¹ compared 10 patients with pituitary adenomas treated endoscopically with 20 patients treated with traditional transsphenoidal surgery and found that hospital stay was shorter in the endoscopic group. As experience with the endoscope has steadily increased, more difficult tumors such as clival chordomas, meningiomas, and CSF leaks through the anterior cranial fossa have been successfully treated.²² For CSF leaks, successful endoscopic closure of the fistula has been reported from 94% to 98%.^{23,24}

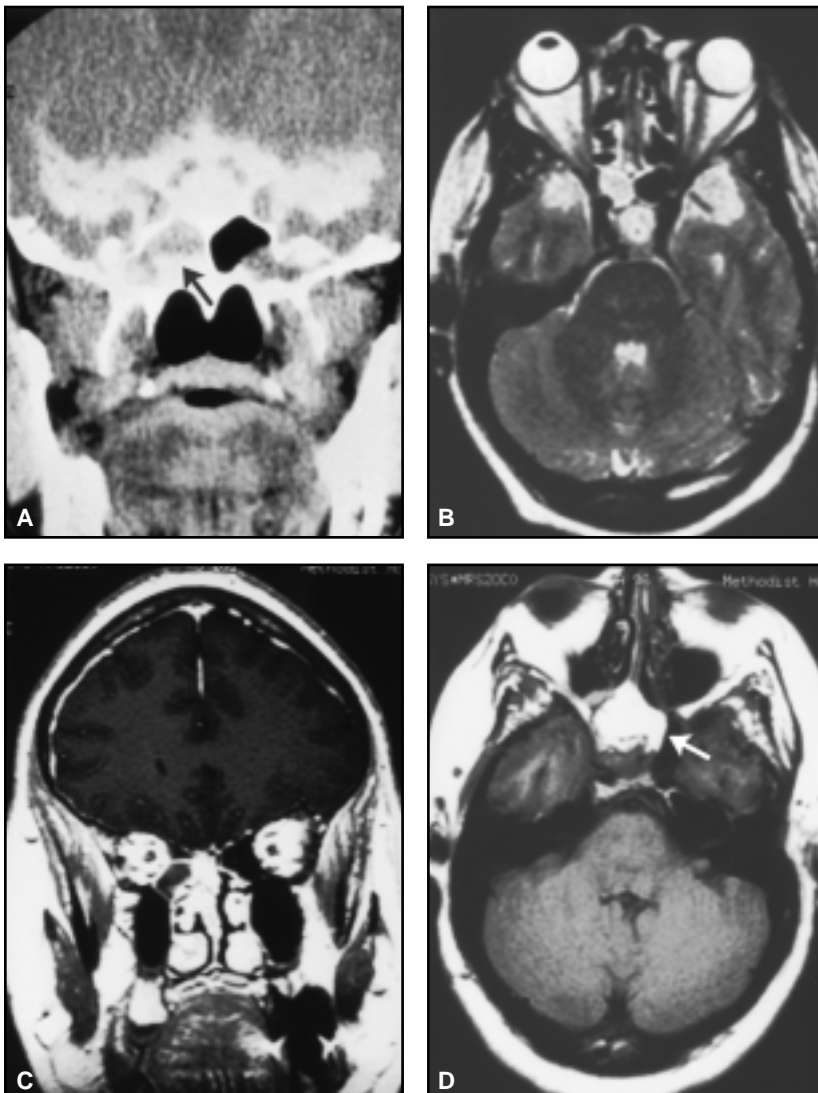


Fig 6A-D. — Patient 10 presented with a 6-month history of spontaneous rhinorrhea through the right nostril. A metrizamide computed tomograph shows the contrast to leak into the right sphenoid sinus through a defect in the wall of the sinus (A, black arrow). Also evident on axial T2-weighted MRI sequences are basal arachnoid cysts in the medial temporal lobes bilaterally, as well as opacification of the right sphenoid sinus (B). Postoperative MRI (T1-weighted, coronal and sagittal image, C and D) shows the fat graft in the sphenoid sinus (D, white arrow) and the good radiographic appearance of the middle and inferior turbinates after successful closure of the fistula through a microscopic sphenoidotomy approach.

Thus, endoscopic techniques are gaining acceptance among neurosurgeons and otorhinolaryngologists as the approach of choice for pituitary lesions. The minimally invasive nature of these techniques, which produces substantially fewer nasal complications compared to transseptal approaches, is undisputed. However, disadvantages include a potential lack of binocular vision, the need for additional personnel and instrumentation, and a definite learning curve, as instruments are inserted parallel to the endoscope. In certain cases, especially with fibrous vascular tumors, bleeding can become difficult to control, necessitating a conversion to open techniques.²⁵

The technique described here is similar to endoscopic approaches to the sphenoid sinus except that an operating microscope is used. It relies on the same anatomic landmarks and the performance of an anterior sphenoidotomy to provide access to the sphenoid sinus. The microscopic sphenoidotomy can be performed by a neurosurgeon without assistance from an otolaryngologist and without additional training in the use of endoscopy. It is a minimally invasive technique that is less disruptive to nasal anatomy than are traditional approaches. It is not necessary to dissect the nasal mucosa away from the septum to adequately expose the sella. Bony resection is comparable to traditional transnasal transsphenoidal approaches, and the exposure is not significantly different once the sphenoid sinus has been opened. Dissecting only the mucosa that covers the ostium and anterior wall of the sphenoid sinus results in no uncovered bone in the nasal cavity at the conclusion of the operation. The sphenoid sinus opens freely into the nasal cavity through what it is essentially an enlarged ostium. Thus, this approach does not require nasal packing or extenteration of the sinus mucosa. Since this technique does not require postoperative nasal packing, it is more comfortable for patients. In addition, it allows binocular vision with easier control of bleeding and use of both operating hands in a direct eye-hand coordination. The operative posture is more natural with a microscope, since the surgeon does not have to look back and forth between the operative field and a monitor.

The principal disadvantages of microscopic parasseptal sphenoidotomy, compared to the endoscopic technique, are that it relies on the principles of key-hole surgery and it lacks the ability to provide close-up views of important structures and "around corner" views provided by the 30° endoscopes. Although some endoscopists believe better tumor resections can be achieved with the close-up views provided by the endoscope, transsphenoidal surgery for pituitary macroadenomas may be viewed as a decompressive procedure to safely remove as much tumor as possible.

As these tumors are generally slow growing, radical resections of tumor extension into the cavernous sinus are probably unnecessary, even if a tool such as the endoscope is available and helpful.²⁶ The endoscope has advantages, however, in defining the tumor-normal gland interphase or in viewing the laterally hidden carotid arteries. In the future, a combination of microscopic sphenoidotomy with endoscopic inspection of the lateral and superior sella wall may become the procedure of choice and is recommended for those entering the field of endoscopic pituitary surgery.

Conclusions

Microscopic sphenoidotomy provides excellent exposure for lesions involving the sella or sphenoid sinus that can be easily performed by a neurosurgeon without assistance from an otolaryngologist or additional training in the use of endoscopy. This approach is more comfortable for patients and has fewer potential complications than traditional transsphenoidal approaches. Use of the microscope allows more familiar instrumentation, a less constrained operative corridor, better control of bleeding, and shorter operative times.

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