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Endoscopy Assisted Transsphenoidal Surgery for Pituitary Adenoma

Technical Note

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Summary

Inspired by an experience with endoscopic paranasal sinus surgery, an endoscope was applied in transsphenoidal pituitary surgery. This endoscopic transsphenoidal technique has been used in 45 cases of pituitary adenomas. Using a 4 mm rigid endoscope, the pituitary adenoma is removed through a nostril. A zero-degree endoscope is used for micro-adenomas. A combination of a 0-degree endoscope and a 30-degree endoscope is used for macro-adenomas that have extended to the suprasellar region. Although it is early in our experience with a small number of patients, the short-term surgical results have been encouraging with patients' short hospital stay and minimum morbidity. The endoscopic technique that has evolved with our experience is described with two cases of pituitary adenomas.

Keywords: Endoscopy; pituitary neoplasms; sphenoid sinus; transsphenoidal approach.

Introduction

The microsurgical transsphenoidal approach, via either a sublabial or septal incision, has been the standard surgical treatment for pituitary adenomas [1, 8]. Otolaryngologists have used endoscopic techniques to replace conventional "open" sinus surgery for the treatment of most inflammatory sinonasal disorders [14]. Encouraged by the visualization and results provided by endoscopes during sinonasal surgery, we decided to explore the potential of endoscopic techniques in pituitary surgery. We have used an endoscopic transsphenoidal technique in 45 cases of pituitary adenomas. Our technique has evolved with experience. Although further technical refinement and instrumental modifications are required, short-term surgical results have been satisfactory with quick patient recovery and minimum morbidity. This report describes a technique of endoscopic transsphenoidal surgery for pituitary adenoma via a nostril.

Operative Technique

Pre-operative evaluations include a magnetic resonance (MR) scan of the brain, coronal and axial views of a computed tomography (CT) scan focusing on the pituitary fossa and paranasal sinuses, a formal endocrine evaluation, and a formal visual examination. A CT scan of the paranasal sinuses is very important in order to decipher the bony anatomy of the nasal cavity and sphenoid sinus. Routine pre-operative testing required for general anesthesia is done in advance. The patient is admitted to the hospital on the day of surgery. The patients are informed that this surgical technique is unconventional before they sign consent form.

A single dose of intravenous antibiotics including either 1 G of cefazolin, or a combination of 1 G of vancomycin and 80 mg of gentamicin is administered as prophylactic antibiotics. Stress dose of hydrocortisone is administered intravenously.

The patient is anesthetized with orotracheal intubation. The patient is maintained in the supine position with the hips and the knees gently flexed in order to achieve ten degree elevation of the torso. The patient's head is tilted about ten degrees to the left and extended gently above the horizontal plane. The head is fixed in this position using a three-pin head fixation system. Lateral fluoroscopic equipment (C-arm) is applied to provide a lateral image of the nasal cavity, sphenoid sinus, and sella turcica. The eyes are protected with an application of ophthalmic ointment and covered with soft vinyl adhesives. The oropharyngeal cavity is packed with a 2-inch wide roll of gauze bandage, and the end of the roll is clamped with a hemostat to avoid missing removal at the end of surgery. The face and nasal cavity are then prepared with 5% povidone-iodine solution. The lower periumbilical abdomen is also prepared as the donor site for a free fat graft. The patient, C-arm fluoroscope, and endoscopic/video camera equipment are then draped following aseptic techniques.

We utilize 4 mm rigid endoscopes with 0- and 30-degree angled lenses. A lens cleansing irrigation-suction system is then attached to the endoscope. The endoscope is also attached to a closed circuit video system that provides a continuously monitored view and allows video filming of the surgery. The irrigation and suction device cleans the lens of the endoscope with a pedal controlled by the surgeon. An endoscope holding device is mounted to the head fixation system.

The width of the nasal cavity and the laterality of the tumor will dictate the side of the nasal cavity to be utilized to reach the sphenoid sinus. The wider side of the nasal cavity is always used. A laterally positioned micro-adenoma is ideally approached from the opposite side of the nose, because an approach via a nostril is a few degrees off from the midline. In most cases, the operation can be done through one nostril. In our experience, only two patients required an approach through both nostrils due to a very narrow nasal airway that limited simultaneous passage of the endoscope and operating instruments.

The nasal mucosa is decongested using 1/2" × 3" neurosurgical cottonoids moistened with decongestant solution. Under endoscopic visualization, the mucosa over the rostrum of the sphenoid, middle turbinate, and posterior septum is infiltrated with a solution of Lidocaine 1% with epinephrine 1/100,000. The entire operation is performed under endoscopic visualization. The endoscope is hand held until the anterior wall of the sella is exposed. The middle turbinate is gently pushed laterally to access the spheno-ethmoid recess and to identify the sphenoid sinus ostium. The sphenoid ostium is identified, and a trajectory to the sella is corroborated from time to time with fluoroscopic imaging. The mucosa at the anterior wall of the sphenoid sinus is then coagulated with a bipolar coagulator. The nasal septum attached to the anterior wall of the sphenoid sinus is fractured and pushed away. The sphenoid ostium is enlarged using Kerrison rongeurs performing an anterior sphenoidotomy (Fig. 1). In some cases, a high-speed drill is used to remove the thick bone from the rostrum of the sphenoid or the clivus. The sphenoidal septum is

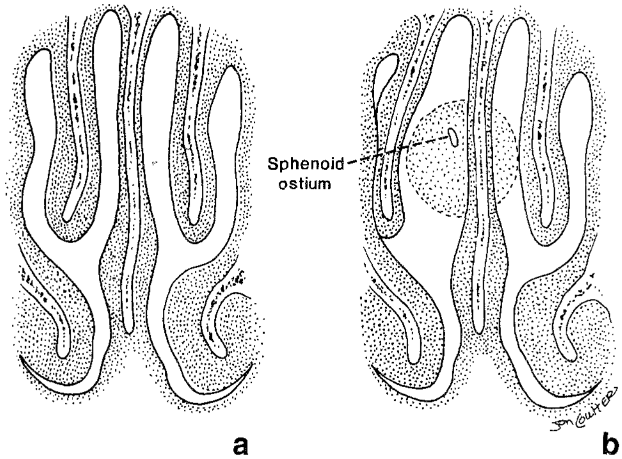
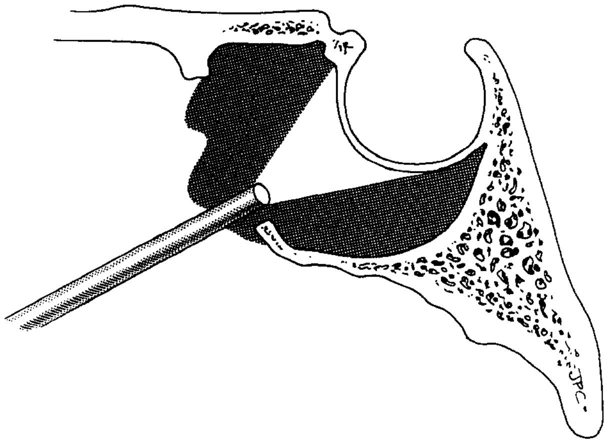


Fig. 1. A schematic drawing of the nasal cavity (a). The middle turbinate is pushed laterally. The dotted area is the site at which anterior sphenoidotomy will be performed via a right-sided nostril approach. The small island in the dotted area is the sphenoid ostium (b)

removed to expose the anterior wall of the sella. Pieces of the bone from the sphenoid septum are saved for the reconstruction of the sella. The anterior wall of the sella is exposed and confirmed with fluoroscopic visualization. The 0-degree endoscope provides a view of the clival indentation, the carotid protuberances, and the anterior wall of the sella. If the 30-degree endoscope is applied, it shows a panoramic view of the sphenoid sinus including the optic and carotid protuberances, carotico-optic recesses, and anterior wall of the sella (Fig. 2). However, the operation is performed using a 0-degree endoscope continuously.

When the anterior wall of the sella is exposed, the vertical dimension of the sella is identified with fluoroscopic control. At this point, the endoscope is mounted to the endoscope holding device. The 0-degree endoscope is placed at the rostral portion of the nasal cavity and surgical instruments are inserted caudally to the endoscope. Often the surgeon holds a suction cannula in one hand and other surgical instrument in the other. The anterior wall of the sella is opened with a microdrill or curettes, and then is enlarged with micro-Kerrison rongeurs. For the removal of micro-adenomas, the opening of the anterior wall of the sella is performed adjacent to the tumor. The dura mater is exposed. The dura mater is then opened in cruciate fashion using curved single bladed microscissors or a scalpel (Fig. 3). Before making an incision, the dura mater is coagulated with



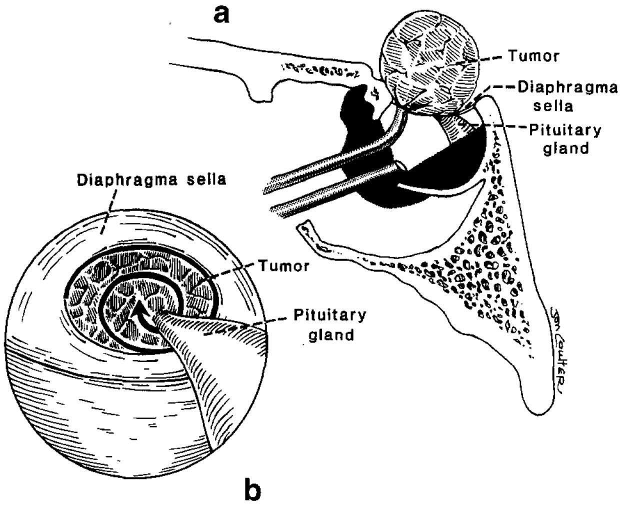


Fig. 4. Schematic sagittal drawing of the sella (a) and 30-degree endoscopic view of the suprasellar tumor (b). The suprasellar portion of the tumor is removed by starting around the edge of the diaphragma sella circumferentially, and heading toward the center of the tumor gradually with a curved suction cannula with a corkscrew motion

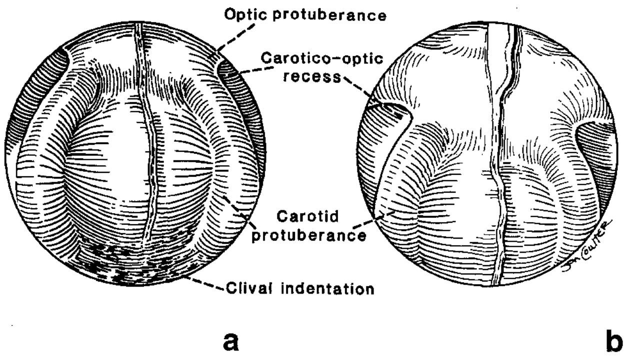


Fig. 2. Endoscopic view of the sphenoid sinus after completion of anterior sphenoidotomy and resection of the sphenoidal septum. A view with a 0-degree endoscope reveals the optic protuberances, carotico-optic recesses, carotid protuberances, and clival indentation in addition to the anterior wall of the sella (a). A view with a 30-degree endoscope provides a better panoramic view of the optic protuberances, caroticooptic recesses, carotid protuberances and upper portion of the anterior wall of the sella (b)

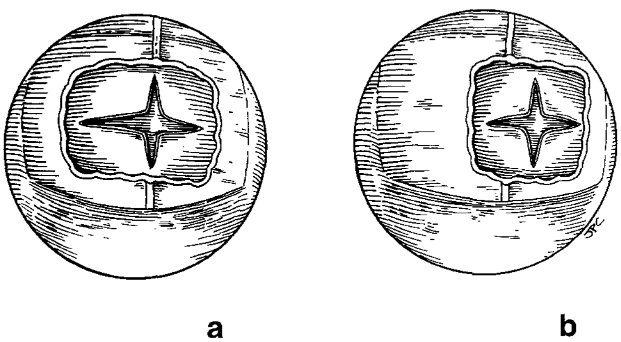


Fig. 3. Anterior wall of the sella is removed with a microdrill or curettes, and micro-Kerrison rongeur (a). In case of micro-adenoma, only the bone adjacent to the tumor is removed (b). The dura is opened in cruciate fashion, horizontally first then followed by a vertical incision

a single bladed bipolar coagulator. This single bladed bipolar coagulator has one wire cable at the core and another cable at the shell to permit functioning as a bipolar coagulator. If unexpected bleeding is encountered from the dural sinus during the dural incision, gentle packing with micro-cottonods will control bleeding. Bipolar coagulation may occasionally be required for dural bleeding. A horizontal dural incision is made first followed by a vertical incision. Often, the tumor tissue of micro-adenomas will spill out when the dura is opened. Precautionary measures are required so as not to lose a specimen through suctioning. A specimen is removed with a micro-pituitary rongeur. Once a sufficient amount of specimen has been gathered for pathologic analysis, the rest of the tumor is removed, mostly using straight and variously curved French number 5 or 7 suction cannulas. When a cavity is created by tumor removal, the endoscope is then advanced into the tumor cavity. This close-up endoscopic view will usually provide good distinction between the tumor tissue and the normal pituitary gland. Often, the tumor tissue is grayish in color that is in contrast to the normal pituitary gland which is pinkish orange in color. The posterior pituitary gland appears whitish yellow in color under the endoscope. The tumor is removed continuously using micro-pituitary rongeurs, suction cannulas and pituitary curettes all the while preserving normal pituitary

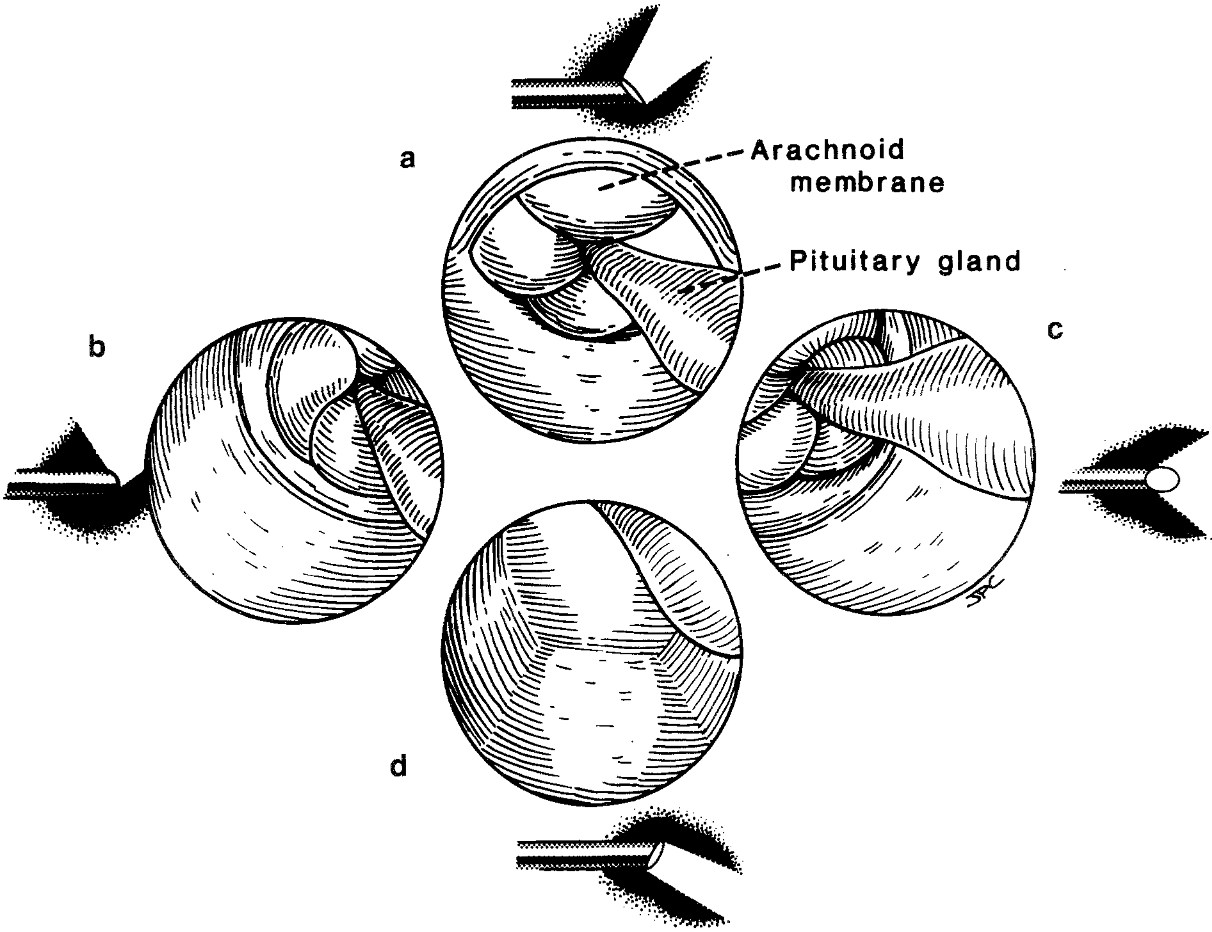


Fig. 5. The arachnoidal membrane will herniate down gradually when the suprasellar portion of the tumor has been completely removed. The center of the flower shaped arachnoidal membrane will be the pituitary stalk. Any normal looking pituitary gland tissue is preserved. When the 30-degree angled endoscope placed inside the sella is rotated, it will reveal a superior (suprasellar region) (a), lateral (lateral wall of the sella) (b, c), and inferior view (the floor of the sella) (d) of the sella. Any residual tumor is removed from every corner with the rotation of the endoscope

gland tissue. In addition to tumor removal in patients with hormone-secreting adenomas, a thin layer of normal pituitary tissue is excised with microscissors or a microdissector. However, in the patient who has a non-secreting adenoma and exhibits normal pituitary functioning, the tumor removal is then performed while preserving normal pituitary tissue as much as possible. In cases with micro-adenoma, the removal of the tumor does not take long. When the tumor has been completely removed, the preserved pituitary gland will be exposed at the tumor resection site. At this point, repeated Valsalva maneuvers are performed to find cerebrospinal fluid (CSF) leakage. If either the cavity left by the resected tumor is large, or if CSF leakage is encountered, a free fat graft is placed at the tumor resection site. The free fat graft material is obtained from the abdominal wall through a 2 cm periumbilical skin incision. The anterior wall of the sella is then reconstructed using a piece of bone saved from the septum of the sphenoid sinus.

The removal of macro-adenomas that are extended to the suprasellar region require the insertion of a 30-degree endoscope into the sella. When the 30-degree endoscope is placed, the endoscope is positioned at the caudal portion of the nasal cavity and the surgical instruments are inserted rostrally to the endoscope. This will provide a superior view toward the suprasellar tumor, a lateral view toward the lateral wall of the sella, and an inferior view toward the floor of the sella depending on the rotation of the angled endoscope. For removal of suprasellar tumors, the diaphragma sella is identified along the periphery of the tumor. The tumor is removed circumferentially along the edge of the diaphragma sella using a curved suction

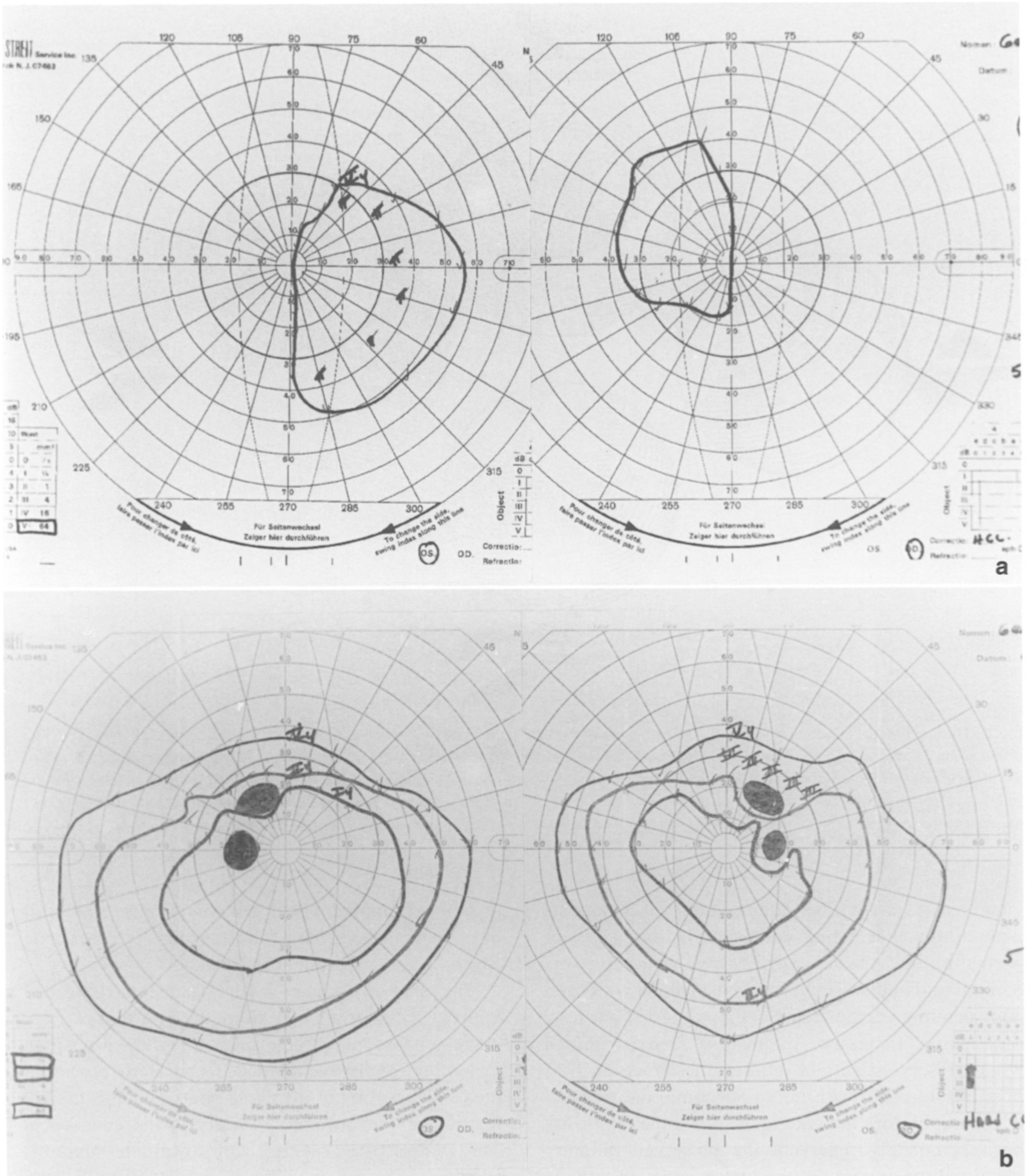


Fig. 6. Visual field of case 1, prior to (a), and 6 months after endoscopic surgery (b)

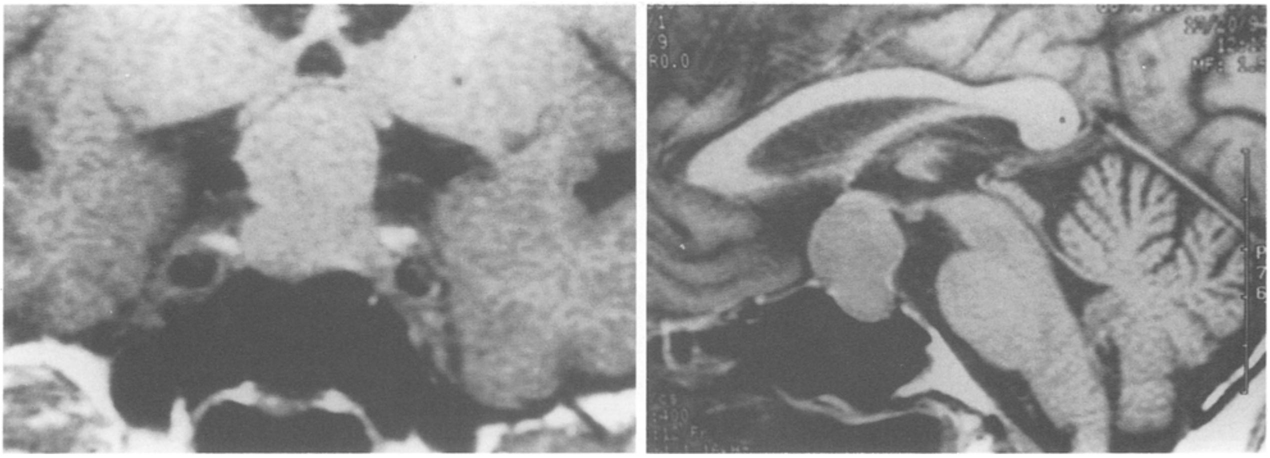


Fig. 7. MR scans of case 1 show a large pituitary tumor with suprasellar extension prior to endoscopic surgery

cannula (Fig. 4). The arachnoid membrane will herniate down along the edge of the diaphragma sella when the tumor is trimmed out by suctioning. The arachnoid membrane is kept intact, if possible. The tumor tissue is removed circumferentially at the periphery of the tumor leaving the eye of the tumor at the center as the last piece of the tumor to be removed. Normal pituitary gland tissue is preserved as much as possible. When all the tumor has been removed, the arachnoid membrane will then appear in view resembling the petals of a lily. The center of the flower-shaped arachnoid membrane will be the pituitary stalk. Sometimes, repeated Valsal maneuvers will facilitate the downward migration of the tumor. Rotating the 30-degree endoscope then permits inspection of the medial wall of the cavernous sinus and the floor of the sella (Fig. 5). Any residual tumor is thoroughly removed. No attempt is made to remove the intracavernous portion of the tumor.

As previously mentioned, after completion of the tumor removal, a 2 cm curvilinear skin incision is made around the inferior margin of the umbilicus to harvest a free fat graft. An appropriately sized portion of the free fat graft is placed in the sella. A water-tight seal is confirmed by repeated Valsalva maneuvers. A gentle in and out motion of the fat graft will be observed upon Valsalva maneuvers. If CSF leakage, or extreme extrusion of the fat graft is noticed upon Valsalva maneuver, a new proportionately adjusted segment of the fat graft is placed. The fat graft is placed as a single piece if possible rather than multiple small pieces to avoid dislodging a fragment. Again, the anterior wall of the sella is reconstructed with a piece of bone, if available. When bony reconstruction is not possible, the sphenoid sinus is packed with an absorbable gelatin sponge to provide further support to the fat graft. Absorbable gelatin film is laid at the middle meatus allowing air flow at the level of the inferior meatus. If the middle meatus is traumatized during the procedure, an absorbable gelatin film roll is used to prevent possible adhesions near the ostium of the maxillary sinus.

The patient is observed overnight in the hospital. Most often, analgesics are not required. Directly following an operation, the patient's endocrine condition is managed by an endocrinologist. The nasal cavity is examined the following day prior to the patient being discharged home. All patients obtained MR scans of the brain 6 weeks postoperatively and underwent formal endocrine evaluation a few weeks postoperatively. Postoperative visual examination is performed on patients who had visual disorder pre-operatively, or if required.

Illustration of Cases

Case 1

This 88-year-old woman with a pituitary adenoma was referred to the University of Pittsburgh Medical Center (UPMC) for stereotactic gamma surgery in August of 1994 when she presented with progressive visual impairment for one year. Her prolactin level was 22 ng/ml and other endocrine functions were normal. MR scan of the brain demonstrated a pituitary tumor which extended to the suprasellar region. Visual field examination revealed an incomplete bitemporal visual field defect. Stereotactic gamma surgery was performed on September 13, 1994.

A follow-up eye examination performed three months postoperatively revealed further deterioration of the visual field manifested as a complete bitemporal hemianopsia (Fig. 6 A). A repeated MR scan of the brain in December of 1994 demonstrated a questionable increase in the size of the tumor relative to the vertical dimension

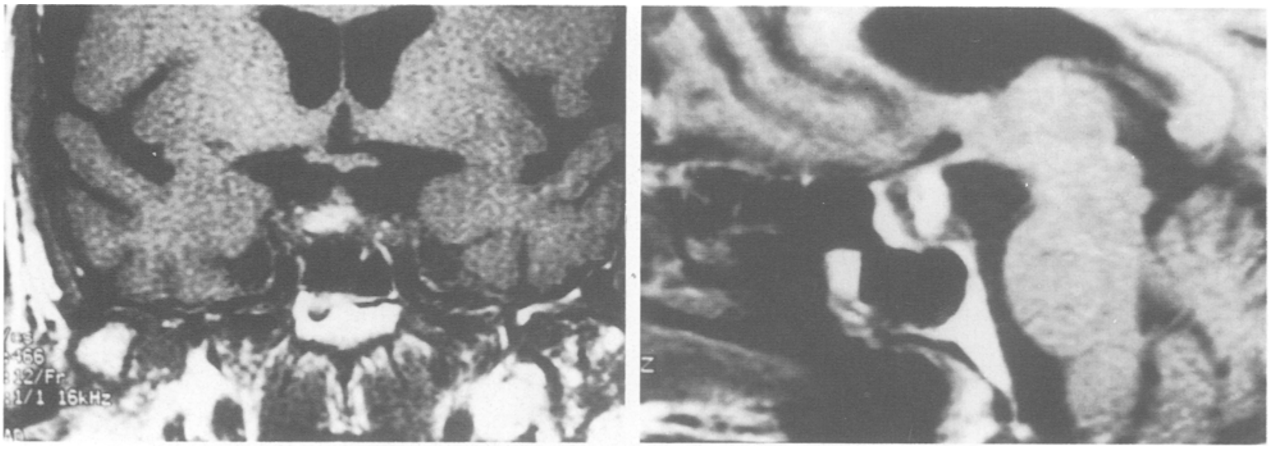


Fig. 8. Postoperative MR scans of case 1 demonstrate fat graft material in the sella with complete resection of the tumor

(Fig. 7). She underwent an endoscopic resection of the tumor on December 22, 1994. Total excision of the tumor was achieved. Her postoperative course was benign. She was ready to be discharged home the following day, but stayed two extra days in the hospital for social reasons. Subjective improvement of her vision was dramatic postoperatively. Considering that total removal of a large sized tumor following the previous gamma surgery was involved, we assumed that she had anterior hypopituitarism postoperatively. Because of her advanced age, a postoperative formal dynamic endocrine evaluation was not performed. Instead, hydrocortisone and thyroid supplementation were maintained continuously. An MR scan of the brain which was obtained 6 weeks postoperatively showed no evidence of the tumor (Fig. 8). Her visual fields recovered quite well demonstrated by an examination performed 6 months postoperatively (Fig. 6 b).

Case 2

This 17-year-old woman was referred to UPMC in January of 1995, with a 6-month history of headache, amenorrhea and galactorrhea. Prolactin level was 79 ng/ml and other endocrine functions were normal. She was treated with bromocriptine but could not tolerate it due to side effects. Her visual examination was normal. MR scan of the brain showed an intrasellar pituitary adenoma measuring 8 mm in diameter (Fig. 9). She underwent an endoscopic resection of the pituitary adenoma on February 3, 1995. She stayed overnight in the hospital postoperatively. Her prolactin level came down to 5 ng/ml postoperatively. Other endocrine functions were normal postoperatively. Her menstrual cycle has returned and breast discharge ceased. MR scan of the brain revealed no evidence of the tumor 6 weeks postoperatively (Fig. 10).

Discussion

Since 1910 when Harvey Cushing pioneered transsphenoidal pituitary surgery through a sublabial transseptal approach, microsurgical transsphenoidal surgery via a sublabial or septal incision for pituitary adenoma has been the standard treatment for pituitary surgery [13]. Among the different techniques for transsphenoidal pituitary surgery, the sublabial transseptal approach and transnasal transseptal approach are most commonly used [1, 6–8, 15, 16]. Although in 1987 Griffith and Veerapen introduced the endonasal approach to the sella, the transsphenoidal approach via the endonasal route has not gained popularity [5]. Cooke and Jones in 1994 reported their experiences of implementing the endonasal approach to the sella with no incidence of nasal, septal, dental, and sinus complications [3]. Our approach bears similarities to theirs as an endonasal approach, but we do not utilize a nasal speculum or retractor. Other than the approach, the remainder of their technique is similar to the standard microsurgical transsphenoidal pituitary surgery.

Since the endoscope became popularized in paranasal sinus surgery and was adopted in other neurosurgical procedures recently, interest has increased in its possible usage for transsphenoidal pituitary surgery [4, 9–11, 17]. In 1989, Papay *et al.* reported a case of transseptal endoscopic repair of CSF leakage that occurred after transcranial pituitary surgery [11]. In 1992, Jankowski *et al.* first reported the successful endonasal endoscopic resection of pituitary adenomas in three patients [9]. They removed the middle turbinate to attain access to the sphenoid sinus. In two patients, they performed the operation via one nostril and in another via both nostrils. They did not utilize an intra-operative fluoroscopic radiographic tool. In their third case, they encountered technical difficulties due to septal hypertrophy of the sphenoid sinus and to the hypertrophic hemorrhagic nature of the nasal mucosa. Despite the temptation to switch from the endonasal endoscopic technique to the traditional

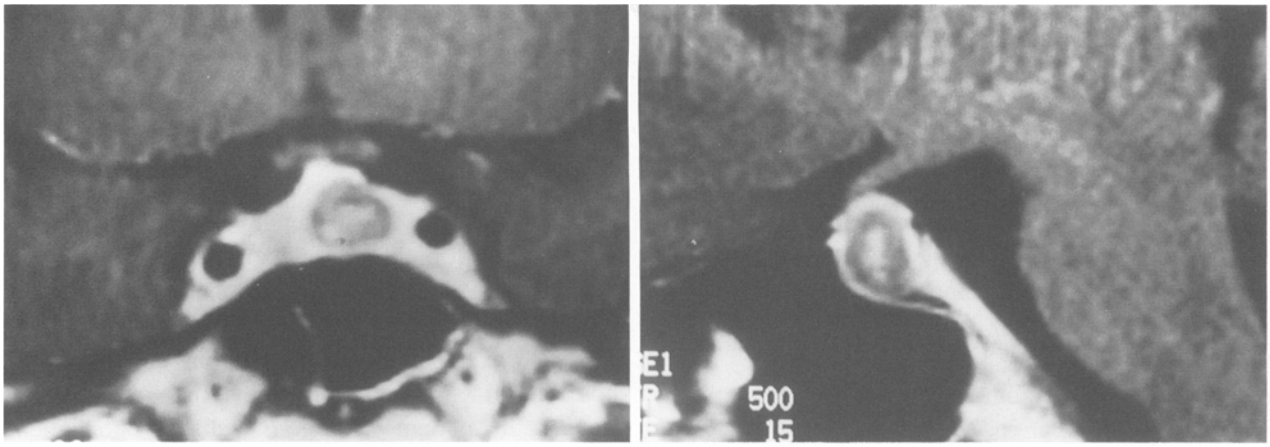


Fig. 9. MR scans of case 2 reveal an intrasellar pituitary tumor

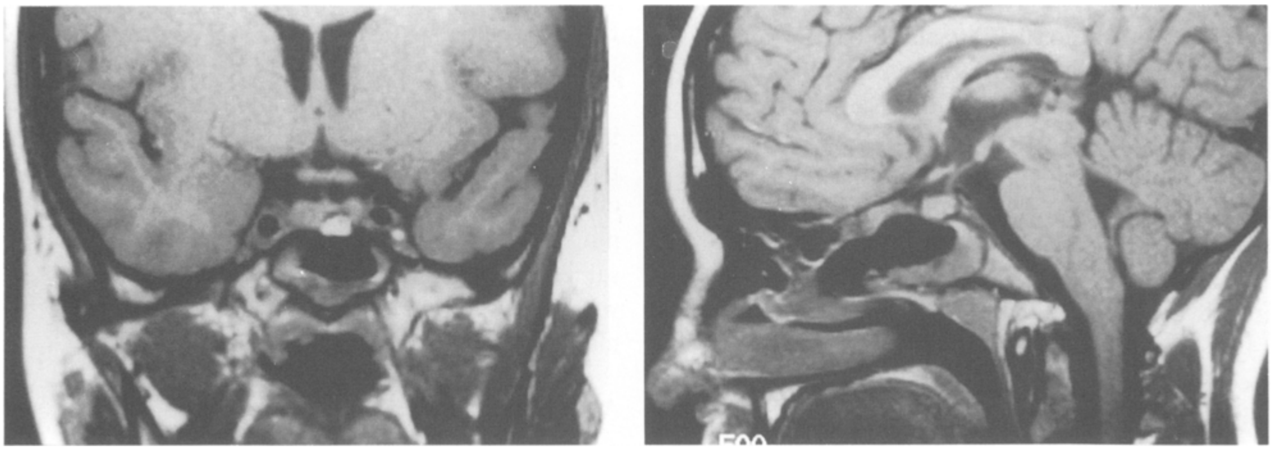


Fig. 10. Postoperative MR scans of case 2 show small fat graft material in the sella

transseptal microscopic technique, they successfully finished the case with the endoscopic technique using both nostrils. Contrary to Jankowski's technique, we do not resect the middle turbinate. The nasal mucosa is simply shrunk with local application and an injection of a vasoconstrictor. Only the ostium of the sphenoid sinus is enlarged by an anterior sphenoidotomy. Gamea *et al.* in 1994, reported their experiences of sublabial transseptal transsphenoidal pituitary surgery using an operating microscope and endoscope. In their report of 10 cases with pituitary tumors, they claimed that the rigid endoscope facilitated better dissection of the tumor away from the normal pituitary gland [4].

In most cases, the operation can be done through one nostril. In our series of 45 cases, only two patients required a two nostril technique due to a very narrow nasal airway. To evaluate the anatomical structure of the nasal cavity and sinuses, thinly sliced axial and coronal CT images are essential to avoid unexpected findings of anatomical variations in the sphenoid sinus. An MR scan alone will not provide the detailed bony anatomy of the sphenoid sinus. After experience with the first few cases of our series, a CT scan of the nasal cavity and sinus became one of the essential pre-operative tests. The decision on which nostril to be used is made on the basis of the nasal cavity anatomy and tumor location. The approach is made through the nostril which possesses the larger nasal space. Because the endonasal approach is a few degrees off midline, lateralized micro-adenomas are approached from the opposite nostril if possible.

Postoperative CSF leakage is a possible major complication. We encountered one incident of postoperative CSF leakage which occurred in a patient who had undergone previous sublabial transseptal transsphenoidal surgery in our series of patients with pituitary adenomas. This postoperative CSF leak was successfully repaired by endoscopic placement of a larger free-fat graft on the second postoperative day. In our first case of an endonasal endoscopic procedure, postoperative CSF leakage occurred in a patient with metastatic adenocarcinoma to the sella. He underwent an endonasal endoscopic biopsy which procured one bite of the tumor with a pituitary rongeur in the sella. No fat graft was placed. The patient developed postoperative CSF leakage which was repaired with endonasal endoscopic placement of an abdominal fat graft. Since then, most of the following cases were treated with abdominal fat grafts to plug the dural opening. Bony reconstruction is performed at the anterior wall of the sella, if possible. In cases of micro-adenoma, the fat graft was not placed if the resection of the tumor did not create a space large enough to accommodate the fat graft, and if CSF was not seen during the operation. No other cases of CSF leakage have been encountered. Although fibrin glue has not been used in our cases, usage of fibrin glue made out of the patient's own blood may provide a secure water-tight seal of the dural opening.

In two cases in our series, a 5 mm-diameter prototype stereoscopic endoscope was used. Differentiability in distance perception is the main advantage with the stereoscopic endoscope. Although the particular stereoscopic endoscope that we had used was not fully developed at the time, other stereoscopic endoscopes are now available commercially. Recently, the addition of a lens cleansing tool utilizing irrigation and suction techniques eliminates the surgeon's cumbersome maneuver of cleaning the lens by withdrawing the endoscope from, and returning it to the surgical field. Its function resembles that of an automobile's windshield wiper. Certainly, a learning curve exists for a surgeon who is not used to the endoscope. Its use requires different surgical skills from that necessary in microsurgical techniques due to the need for the surgeon to handle the endoscope in his nondominant hand and the surgical instruments in the other. Using one nostril, the endoscope and surgical instruments have to enter parallel to each other. An inexperienced surgeon may encounter frustration if the two instruments consistently strike each other in a small space. Practice will overcome this problem. The endoscope holding device enables a surgeon to have two free hands and a continuously steady view on the monitoring screen.

Among 45 patients with pituitary adenomas, total resection of the tumor was achieved in 34 patients and subtotal in 11 patients. Most of the residual tumors were located in the cavernous sinuses. For treatment of residual tumor, four patients underwent stereotactic gamma-knife surgery and one patient underwent conventional fractionated radiation treatments postoperatively. The remaining patients with residual tumor were either treated with bromocriptine or by observation with yearly MR scan of the brain. In addition to the patient with CSF leakage, one patient developed asymptomatic synechia of the nasal mucosa and another, postoperative sphenoidal sinusitis six weeks postoperatively which was successfully treated with 5-day antibiotics. Long-term follow-up is required for recurrence in the group of patients who were judged to have total resection of the tumor.

The future potential applications of the endoscope in neurosurgical practice will be enhanced by computer guided stereotactic technology, stereoscopic endoscopes, and the future development of high definition television monitors. The technique of endonasal endoscopic pituitary surgery can be simplified with further refinement of its technique and with the modification of surgical instruments.

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Comments

Obviously this is a controversial topic, because of the widespread acceptance of the microsurgical transsphenoidal approach. Nevertheless, the technique described by Jho seems attractive, particularly because it can be done without stripping the nasal mucosa, and patients seem to make a quick recovery from surgery.

A. Cohen

In this paper the operative technique is very well described although the neurosurgeon can think about problems that certainly will happen when working with the endoscope and an additional instrument through one nostril.

In the discussion and good overview is given of how the author came from the historical development of transsphenoidal surgery over E.N.T. endoscopic operations to endoscopic pituitary surgery.

The paper, being essentially a description of a surgical technique, does not provide details on neurological or ophthalmological outcome after this type or surgery.

Neurosurgeons though can have some difficulties in judging the validity of this technique.

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