Although microsurgical transsphenoidal approaches have been established as the standard surgical treatment for pituitary adenomas for decades, continuous efforts to improve surgical techniques and their outcomes are still being made. As an alternative to sublabial or septal incisions for transsphenoidal pituitary surgery, an endonasal microscopic technique has been reported. Otolaryngologists have used endoscopic techniques for the treatment of most inflammatory sinonasal disorders. Eventually, endoscopic sinus surgery replaced the conventional “open” method of sinus surgery. Encouraged by the increased visualization and positive results provided by endoscopy for sinonasal surgery, we have applied endoscopic techniques to transsphenoidal surgery. Initially, we used an endoscope in conjunction with an operating microscope while executing the standard conventional sublabial–transseptal approach. As we gained confidence using the endoscope as a visualizing tool, we developed an endonasal endoscopic transsphenoidal technique that did not require the use of a nasal speculum or transsphenoidal retractor. This endonasal endoscopic technique was used in 46 patients in this series. Our technique has continued to evolve. Although further technical refinement and instrument modifications are required, the short-term surgical results have been satisfactory and have provided for quick patient recovery and minimum morbidity. This report represents our early experience with endoscopic transsphenoidal surgery in 50 patients.

**Clinical Material and Methods**

**Patient Criteria**

Between September 1993 and June 1996, 50 patients with pituitary adenomas and several other lesions underwent operation via endoscopic techniques at the University of Pittsburgh Medical Center. Our patient population included 22 males and 28 females, ranging in age from 14 to 88 years (median 38 years). The histological diagnoses included 44 pituitary adenomas, one craniopharyngioma, one clival chordoma, one germinoma, one Rathke’s cleft cyst, one postcraniotomy cerebrospinal fluid (CSF) fistula, and one metastatic adenocarcinoma.

Among the 44 patients with pituitary adenomas, 13 patients had microadenomas, 16 had intrasellar macroadenomas, nine had macroadenomas with suprasellar extension, and six had invasive macroadenomas involving the cavernous sinus. Seven patients had recurrent pituitary adenomas and 25 had hormone-secreting adenomas (eight patients with Cushing’s disease and 17 patients with prolactinomas). Among the eight patients with Cushing’s disease, seven had resolution of hypercortisolism clinically and chemically. Of the 17 patients with prolactinomas, 10 improved clinically with normal serum prolactin levels, four improved clinically with elevated serum prolactin levels, and three had residual tumors in the cavernous sinus. Among the 19 patients with nonsecreting adenomas, 16 underwent total resection and three subtotal resection leaving residual tumor in the cavernous sinus. Postoperatively, all patients who had undergone endonasal endoscopic surgery had unobstructed nasal airways with minimal discomfort. More than half of the patients required only an overnight hospitalization.

**Keywords**

- chordoma
- craniopharyngioma
- Cushing’s disease
- endoscopy
- pituitary tumor
- prolactinoma
- transsphenoidal approach
Endoscopic transsphenoidal surgery

Fig. 1. Coronal (left) and sagittal (right) preoperative MR images obtained in a 33-year-old man who developed a visual disorder with a recurrent pituitary adenoma. The patient had previously undergone sublabial, transseptal, transsphenoidal resection of the pituitary adenoma twice, followed by conventional fractionated radiation treatment.

geries followed by conventional fractionated radiation treatments. Twenty-five patients had hormone-secreting pituitary adenomas (eight with Cushing’s disease, 17 with prolactinomas). Two of the patients with Cushing’s disease underwent two operations, respectively.

All of the patients with prolactinomas had received bromocriptine therapy previously. Sixteen could not tolerate bromocriptine. Another patient developed progressive pituitary dysfunction despite a good response to bromocriptine. One of the 17 prolactinomas was recurrent. Eight patients with Cushing’s disease had microadenomas. One of the eight had recurrent Cushing’s disease. Every patient of this subgroup had classic symptoms of hypercortisolism that could not be managed with medication.

Among 19 patients with nonsecreting pituitary adenomas, 11 patients presented with a visual disorder, five patients with symptoms of pituitary apoplexy, one patient with progressive growth of the tumor, and two with severe intractable frontal and retroorbital headaches. One patient who had a macroadenoma with suprasellar extension had undergone stereotactic gamma knife surgery for visual loss 3 months earlier. This patient presented with further progression of visual loss. Five of the nonsecreting adenomas were recurrent. Four patients in this group had previously undergone a single transsphenoidal operation and one patient had undergone transsphenoidal surgery twice, followed by fractionated conventional radiation treatment (Fig. 1).

Six patients had various other lesions. The first patient with a pituitary tumor developed an acute onset of oculomotor palsy. This patient was selected for endonasal endoscopic biopsy to obtain histological verification of an assumed diagnosis of metastatic carcinoma. The second developed a postoperative CSF leak after subfrontal resection of a craniopharyngioma. A CSF fistula was located at the sella on a cisternal contrast computerized tomography (CT) scan. Endoscopic reconstruction of the sella was performed using abdominal fat graft placement. The third patient had a sellar and suprasellar craniopharyngioma and presented with symptoms of a progressive visual disorder and partial anterior hypopituitarism. The fourth, who had a large clival chordoma, presented with ataxia, emotional lability, and a memory disorder. The fifth patient had a germinoma and presented with a partial sixth cranial nerve palsy. The last patient in this group had a Rathke’s cleft cyst and was referred for anovulatory irregular menstruation.

Our indications for surgical intervention among the patients with nonsecreting adenomas included visual impairment, pituitary apoplexy, severe intractable headache, progressive growth of the tumor, and progressive endocrine impairment. Surgical indications for hormone-secreting adenomas included unresponsiveness or intolerance to medical therapy and/or progressive hypopituitarism.

Perioperative Evaluation and Management

All patients underwent preoperative endocrine and visual function evaluations including formal visual field testing. Postoperative visual evaluations were performed only in patients who showed preoperative visual impairment. Formal postoperative endocrine evaluations were performed on all patients except for one, who was selected to be empirically treated with hormone replacement therapy because of her advanced age. Preoperative and postoperative magnetic resonance (MR) imaging was obtained in every patient, and CT scans were obtained preoperatively in most patients. The exquisite definition of the bony boundaries of the sinus, provided by thinly sliced axial and coronal CT scans, was essential to assess the symmetry and aeration of the sphenoid sinus and to decipher the relationship of the sphenoid sinus septum to the sella floor and carotid canals.

Most patients were treated with perioperative “stress doses” of hydrocortisone. Prophylactic antibiotic agents (1 g cefazolin or 1 g vancomycin and 80 mg gentamycin) were administered in a single intraoperative dose. A topical clindamycin solution (600 mg clindamycin/500 ml normal saline) was used to irrigate the nasal cavity and the sphenoid sinus throughout the procedure. An endocrinologist was involved in perioperative case management in all patients.

Operative Technique

A detailed description of our technique has been reported elsewhere.14 Our endoscopic transsphenoidal operation is performed via an endonasal technique without the use of a transsphenoidal retractor or nasal speculum. The operation is performed after general anesthesia has been induced in the patient via orotracheal intubation. The patient is maintained supine, with the head tilted to the left and the torso elevated gently. The patient’s head is fixed in this position using a three-pin head-fixation system. Lateral fluoroscopic equipment (C-arm) is used for intraoperative lateral images. The oropharyngeal cavity is packed with a roll of 2-in gauze. The face and nasal vestibules are then prepared using a 5% povidone–iodine solution. The periumbilical abdomen is also prepared for the harvest of a fat graft. The patient, C-arm fluoroscopic device, and the endoscopic/video camera equipment are then draped using aseptic techniques.

The first four patients in this series were treated via a sublabial-transseptal-transsphenoidal approach using the operating microscope as the primary instrument for tumor visualization. The endoscope was then used in addition to the operating microscope to explore the potential use of
endoscopic techniques. Encouraged by our experiences, the next 48 operations were performed using only endoscopes through the nasal cavity. Only one nostril was used in most patients. Two nostrils were required in the two patients with Cushing’s disease because of their very narrow nasal passages.

We used 4-mm rigid endoscopes with 0°- and 30°-angled lenses for 48 operations. Our endoscopes do not have a built-in work channel. Surgical instruments are inserted adjacent to the endoscope through the same nostril. The endoscope is held in the surgeon’s nondominant hand until an anterior sphenoidotomy is performed. Once the anterior sphenoidotomy is completed, the endoscope is mounted to an endoscope holder. This will provide the surgeon with a steady video image in addition to freeing both hands to maneuver surgical instruments simultaneously.

The nasal mucosa is decongested by local application of a decongestant solution and an injection of lidocaine containing epinephrine. The middle turbinate is then outfractured to access the sphenoidal recess and to identify the sphenoid sinus ostium. The nasal septum is fractured and pushed away from the rostrum of the sphenoid sinus; the contralateral sphenoid ostium is exposed submucosally. The sphenoid ostia are enlarged using Kerrison rongeurs. A 1.5- to 2-cm-wide anterior sphenoidotomy is performed. A high-speed drill is used on the thick bone, which is often at the inferior portion of the sphenoid rostrum. The sphenoid septum is removed. Pieces of bone are saved for reconstruction of the anterior wall of the sella turcica. The 0°-angled lens endoscope provides a pano-

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Fig. 2. Upper: Schematic drawing showing an endonasal endoscopic approach to the sella. No septal or alar incision is required. No speculum or retractor is used. Center and Lower: Intraoperative photographs. Center: An endoscope is held in the surgeon’s nondominant hand until an anterior sphenoidotomy is performed. Lower: Once the anterior sphenoidotomy is completed, the endoscope is mounted to an endoscope holder. This will provide the surgeon with a steady video image in addition to freeing both hands to maneuver surgical instruments simultaneously.

Fig. 3. Upper: Endoscopic view using a rigid endoscope with a 30°-angled lens after resection of the tumor shown in Fig. 1, demonstrating the bilateral optic nerves and optic chiasm. Lower: A close-up view revealing the optic system and the anterior cerebral arteries behind the arachnoidal membrane.
Endoscopic transsphenoidal surgery

ramic view of the sphenoid sinus that facilitates the identification of the optic and carotid protuberances, carotico-optic recesses, and clival indentation, in addition to the anterior wall of the sella. The 30°-angled lens endoscope visualizes the rostral structures better than the 0°-angled lens endoscope; however, the majority of the operation is performed using a 0°-angled lens endoscope, which facilitates anatomical orientation. The endoscope is now mounted to the endoscope holder (Fig. 2).

The anterior wall of the sella is identified and opened using a high-speed microdrill or curettes. For the removal of microadenomas, the opening of the anterior wall of the sella is performed adjacent to the tumor. The dura mater is opened in cruciate fashion using curved single-blade microscissors. Under direct endoscopic visualization, the tumor is removed using micropipituitary rongeurs, microsuction cannulas, and pituitary curettes while preserving the normal pituitary gland tissue. The removal of a macroadenoma requires the insertion of a 30°-angled lens endoscope into the sella that will directly visualize suprasellar anatomy (Figs. 1, 3, and 4). We try to preserve the arachnoidal plane, if possible. When the main tumor mass has been removed, subsequent detailed delicate tumor resection is performed at the tumor and pituitary interface using a microdissective technique. After complete removal of the tumor, a 2-cm curvilinear skin incision is made around the inferior margin of the umbilicus to harvest a free fat graft. The free fat graft is laid in the tumor resection cavity only when the resection cavity is large or if a CSF leak is encountered intraoperatively. During the procedure, a water-tight seal is confirmed by repeated Valsalva maneuvers. The anterior wall of the sella is reconstructed using the previously secured pieces of bone. When bone reconstruction is incomplete, the sphenoid sinus is packed with an absorbable gelatin sponge to provide additional support to the fat graft. 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. Obstructive nasal packing is not used.

Results

Postoperatively all of our patients who had undergone the endonasal endoscopic operation recovered with their nasal airways normal and unobstructed. Postoperative pain was reported to be minimal and the patients often did not require analgesic medication. Because of the potential occurrence of diabetes insipidus, every patient was kept in the hospital at least overnight. Among the 48 endonasal endoscopic procedures performed, 27 operations were completed with the patients needing to stay only 1 night in the hospital. Eight procedures were accomplished with the patients requiring a 2-night hospitalization and eight surgeries were completed with the patients staying for 3 nights in the hospital, primarily to observe them for the onset of diabetes insipidus. Among the 16 patients who required 2- to 3-day hospital stay postoperatively, two developed true transient diabetes insipidus and one patient, who had a craniopharyngioma, developed permanent diabetes insipidus. The remaining 13 patients had increased postoperative urine output and were without diabetes insipidus. There were four patients who required a 4- to 5-day hospitalization due to social reasons or CSF leakage. One patient with a metastatic adenocarcinoma had a protracted hospitalization due to postoperative CSF leakage and the need for subsequent radiation treatment.

Among the eight patients whom we treated for Cush- ing’s disease, six who underwent single operations had complete resolution of their symptoms and exhibited normalized cortisol levels postoperatively. Their other endocrine functions were normal. The other two patients required reoperation for incomplete reduction of cortisol levels after the first operation. One patient then experienced complete resolution of symptoms with postoperative panhypopituitarism. The other continued to have mildly increased cortisol levels and was eventually treated by stereotactic gamma knife surgery (Table 1).

Among the 17 patients with prolactinomas, 10 patients improved clinically with normalized prolactin levels, four improved clinically with elevated serum prolactin levels,
and three had residual tumors in the cavernous sinuses. Among the 10 patients who had normalized prolactin levels postoperatively, eight had a prolactin level of 10 ng/ml or less. Two of the patients with residual prolactinomas in the cavernous sinuses were treated with gamma knife surgery and the third patient was treated with a course of bromocriptine therapy (Table 2). One patient who underwent an operation for a recurrent prolactinoma followed by gamma knife surgery required postoperative thyroid replacement therapy. Another patient who had preoperative progressive hypopituitarism displayed a return to normal pituitary function postoperatively. Two patients who had anterior panhypopituitarism preoperatively continued to have anterior panhypopituitarism postoperatively.

Among the 19 patients with nonsecreting adenomas, 16 underwent total resection and three underwent subtotal resection leaving residual tumor in the cavernous sinus. One patient with residual tumor was treated by gamma knife surgery and another with conventional fractionated radiation treatments; the third patient was selected for observation only because of his advanced age (Table 3). Of the 19 patients with nonsecreting macroadenomas, 11 presented with progressive visual impairments. All 11 exhibited improvement in their vision and visual fields following surgery. Five patients who presented with pituitary apoplexy experienced resolution of their symptoms. Resolution of symptoms was also experienced by two

**TABLE 1**

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age (yrs)</th>
<th>Sex</th>
<th>Preop Low-Dose DXM (mg/day)</th>
<th>Preop High-Dose DXM (mg/day)</th>
<th>Peripheral ACTH (pg/ml)</th>
<th>Morning Cortisol (µg/dl)</th>
<th>Postop 24-Hr UFC (mg/day)</th>
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<td>F</td>
<td>207</td>
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<td>11</td>
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<td>39</td>
<td>F</td>
<td>288</td>
<td>26</td>
<td>5</td>
<td>22/3040</td>
<td>—</td>
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<td>3</td>
<td>28</td>
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<td>73</td>
<td>—</td>
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<td>—</td>
<td>10</td>
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<td>45</td>
<td>—</td>
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<td>—</td>
</tr>
<tr>
<td>6</td>
<td>19</td>
<td>M</td>
<td>662</td>
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<td>F</td>
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<td>19†</td>
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* The patients in Cases 4 and 6 underwent two operations. Normal values: 24-hour UFC, 20–100 mg/day; DXM sup test less than 20 mg/day; ACTH in peripheral vein, 19–52 pg/ml. Abbreviations: ACTH = adrenocorticotropin; DXM = dexamethasone; sup = suppression; UFC = urine-free cortisol; — = test not given.
† Twenty-four-hour UFC 10–50 mg/day.

**TABLE 2**

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age (yrs), Sex</th>
<th>Tumor Type</th>
<th>Prolactin (ng/ml)†</th>
<th>Relief of Symptoms</th>
<th>Adjunctive Treatments</th>
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<td>3</td>
<td>38, M</td>
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<td>3081 1500</td>
<td>partial</td>
<td>gamma knife surgery, pergolide</td>
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<td>49</td>
<td>improved</td>
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</tr>
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<td>improved</td>
<td>none</td>
</tr>
<tr>
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<td>macro, S, SS, &amp; CS</td>
<td>1131 152</td>
<td>improved</td>
<td>bromocriptine</td>
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<tr>
<td>9</td>
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<td>improved</td>
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<td>251</td>
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<tr>
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<td>improved</td>
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</tr>
<tr>
<td>12</td>
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<td>macro, S, &amp; CS</td>
<td>652 336</td>
<td>no change</td>
<td>gamma knife surgery</td>
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<tr>
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<td>87</td>
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</tr>
<tr>
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<td>macro, S</td>
<td>300</td>
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</tr>
<tr>
<td>15</td>
<td>29, F</td>
<td>macro, S</td>
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</tr>
<tr>
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<td>25, F</td>
<td>micro</td>
<td>349</td>
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<tr>
<td>17</td>
<td>14, F</td>
<td>micro</td>
<td>281</td>
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</table>

* CS = cavernous sinus; macro = macroadenoma; micro = microadenoma; S = sellar; SS = suprasellar.
† Normal prolactin level is less than 20 ng/ml.

![Fig. 5. Left: Sagittal MR image showing a craniopharyngioma at the sellar and suprasellar regions. The pituitary stalk was sectioned proximal to the origin of a craniopharyngioma. Right: Endoscopic view showing the optic nerves, optic chiasm, and stump of the pituitary stalk (30˚-angled lens).](image)
patients who had severe intractable frontal and retroorbital headaches. Among this group of 19 patients, nine had anterior hypopituitarism preoperatively and three of these had improved pituitary function postoperatively. Three patients who had normal anterior pituitary functioning preoperatively developed hypopituitarism postoperatively. Among those three patients, one elderly patient who presented with rapid progressive visual loss did not undergo endocrine testing postoperatively because of advanced age. Assuming hypopituitarism after total resection of a large tumor, the patient was treated empirically postoperatively with steroid and thyroid replacement therapy. Another patient who required postoperative fractionated conventional radiation treatment for residual tumor in the cavernous sinus showed a decreased pituitary–adrenal response and a low testosterone level. The third patient in this group, who had a large recurrent sellar and suprasellar adenoma that caused a visual disorder, developed panhypopituitarism postoperatively.

One patient with a craniopharyngioma in the sellar and suprasellar region underwent total resection of the tumor. The tumor was resected with distal stalk sectioning (Fig. 5). Preoperative pituitary function (hypogonadism only) deteriorated to panhypopituitarism, which required hormone replacement treatment including cortisol, thyroid, and Pitressin. Rapid improvement of vision was noted postoperatively. One patient who had a sellar and suprasellar germinoma underwent subtotal resection of the tumor followed by postoperative conventional fractionated radiation treatment. This patient had improvement of diplopia postoperatively and continued to exhibit anterior hypopituitarism after surgery, as demonstrated preoperatively. One patient with a large clival chordoma underwent subtotal resection of the tumor followed by postoperative gamma knife surgery. He had undergone ventriculoperitoneal shunt placement for obstructive hydrocephalus and had received fractionated conventional radiation treatment a few months earlier. We were also able to repair a postcraniotomy CSF fistula successfully by placing an abdominal free fat graft in a patient who had undergone a subfrontal resection of a craniopharyngioma previously. Another patient with a Rathke’s cleft cyst was treated by successful resection of the cyst (Table 4).

Two patients developed postoperative CSF leakage. The patient with metastatic adenocarcinoma developed a postoperative CSF leak after an endonasal endoscopic biopsy of the tumor. Another patient who had previously undergone transsphenoidal surgery also developed a postoperative CSF leak. The postoperative CSF leakages were successfully repaired endoscopically using an abdominal free fat graft. One patient developed an asymptomatic synchia between the inferior turbinate and the nasal septum. This synchia was found during a routine postoperative follow-up visit and did not require treatment. Another patient experienced chronic sphenoid sinusitis manifesting as postpharyngeal drainage at 6 weeks postoperatively. The infection resolved after a 5-day course of oral antibiotic medication (Table 5). No other complications were encountered.

Discussion

Microsurgical transsphenoidal surgery for pituitary adenoma has been the standard treatment for decades in the neurosurgical community. Among the different techniques for transsphenoidal pituitary surgery, the sublabial–transseptal approach and the transnasal–transseptal approach are used most commonly. Although Griffith and Veerapani reported an endonasal approach to the sella in 1987, the transsphenoidal approach via the endonasal route has not gained popularity. In 1994 Cooke and Jones reported their experiences in implementing an endonasal microscopic approach to the sella with no inci-
idence of nasal, septal, dental, or sinus complications. Our approach bears similarities to theirs as an endonasal approach; however, we do not use a nasal speculum or retractor.

Since the endoscope became popular in paranasal sinus surgery and has been recently adopted in other neurological surgical procedures, interest has increased in its possible use in transsphenoidal pituitary surgery. In 1989, Papay et al. reported a case of transseptal endoscopic repair of CSF leakage that occurred after transcranial pituitary surgery. In 1992, Jankowski et al. first reported the successful endonasal endoscopic resection of pituitary adenomas in three patients. They removed the middle turbinate to attain access to the sphenoid sinus. They performed the operation via one nostril in two patients and via both nostrils in another. They did not use intraoperative fluoroscopy. In their third case, they encountered technical difficulties due to septal hypertrophy in the sphenoid sinus and the hypertrophic hemorrhagic nature of the nasal mucosa. Despite the temptation to switch from the endonasal endoscopic technique to the traditional transseptal microscopic technique, they successfully finished the case with the endoscopic technique using both nostrils. Using our technique, we do not resect the middle turbinate; we simply shrink the nasal mucosa with the local application of a vasoconstrictor and we enlarge the ostium of the sphenoid sinus by an anterior sphenoidotomy. Shikani and Kelly reported one case in which an endoscopic biopsy of a pituitary tumor was obtained. Gamea et al. reported their experiences with sublabial-transseptal-transsphenoidal pituitary surgery using an operating microscope and an endoscope. In their report of 10 patients with pituitary tumors, they claimed that the rigid endoscope facilitated better dissection of the tumor away from the normal pituitary gland. Wurster and Smith briefly reported their experience using endoscopic pituitary surgery in two patients. Sethi and Pillay reported approximately 40 patients in whom they had performed endoscopic pituitary surgery via either the transnasal-transseptal or ethmoidectomy approach with a sphenoid retractor. Our technique differs from theirs in that we use an endonasal route rather than a transseptal one and do not use a retractor or speculum. Our endonasal technique eliminates the use of postoperative obstructive nasal packing.

In most cases, the operation can be done through one nostril. In our series of 48 operations in 46 patients, only two operations required a two-nostril technique because of a very narrow nasal airway. The use of thin-slice axial and coronal CT images is essential to avoid unexpected findings from anatomical variations in the sphenoid sinus. Magnetic resonance imaging alone will not provide the necessary detail of bone anatomy of the sphenoid sinus. After our experience with the first few cases in this series, CT scanning of the nasal cavity and sinus became one of the essential preoperative tests. The decision about which nostril is used is made on the basis of the nasal cavity anatomy and tumor location. The approach is made through the nasal cavity that possesses the larger space. Because the endonasal approach is an approach of a few degrees off midline, lateralized microadenomas are approached from the opposite nostril whenever possible.

Postoperative CSF leakage is a major possible complication in transsphenoidal surgery. In the first case in which we used an endonasal endoscopic procedure, postoperative CSF leakage occurred in a patient with metastatic adenocarcinoma to the sella. The patient underwent an endonasal endoscopic biopsy in which one portion of the tumor was procured using a pituitary rongeur in the sella. No fat graft was placed. The patient developed a postoperative CSF leak, which was repaired with endonasal endoscopic placement of an abdominal fat graft. Another patient who developed a recurrent pituitary adenoma after an earlier transsphenoidal operation developed a postoperative CSF leak. We were concerned about a possible postoperative CSF leak because of a wide defect of the bone and dura mater at the anterior wall and the floor of the sella resulting from the previous operation. There was a lack of surrounding supportive structures to hold an abdominal free fat graft. Pieces of bone were not available for bone reconstruction because of the previous transsphenoidal approach. We had to be cautious while packing the fat graft into the sella so as not to cause optic compression. Despite the placement of a generously sized fat graft into the sella, the patient developed a postoperative CSF leak. The CSF leak was repaired by placing a larger fat graft into the sella and sphenoid sinus on the 2nd postoperative day. In our series, abdominal fat grafts were placed into the sella when the tumor resection cavity was large or when an intraoperative CSF leak was encountered. Bone reconstruction was performed at the anterior wall of the sella, if possible. In cases of microadenoma, the fat graft was not placed. Although fibrin glue was not used in our cases, the use of fibrin glue made from the patient's own blood may facilitate a secure water-tight seal of the dural opening. A postoperative CSF leak was one reason for prolonging a patient's hospital stay.

More than half of our patients were able to be discharged the day after operation, mostly because they did not require obstructive nasal packing. Postoperative discomfort was minimal. The most common cause of delay in the patients' discharge in our series was postoperative diuresis requiring a differential diagnosis from diabetes insipidus. Judicious intraoperative fluid management may reduce the incidence of postoperative diuresis. Although late electrolyte imbalance may occur, it may be delayed so many days that the length of hospitalization should be individualized.

The visualization advantage of an endoscope, especially the 30°-angled lens endoscope, over an operating microscope was obvious in the suprasellar region; it eliminated the need for blind curettage for a suprasellar tumor. Surgeons who favor the conventional microscopic technique may use an operating microscope and an endoscope. When a transsphenoidal speculum is used, however, the surgeon’s operating space is limited by the tubular-shaped tunnel. A surgeon’s mobility is restricted while using surgical instruments through this tubular space under an endoscope. The endonasal technique without the use of a retractor provides the surgeon a larger operating space, permitting free maneuvering of surgical instruments in the nasal cavity. Another advantage of an endoscope is that it provides a panoramic view of the sphenoid sinus so that the surgeon can recognize the bony structures covering the carotid arteries and optic nerves. Although the incidence of injury to the hypothalamus, the carotid artery,
Endoscopic transsphenoidal surgery

and the optic system is low with the conventional microscopic technique,2,22 direct endoscopic visualization of those structures may further reduce the risk of injury.

The disadvantage of an endoscopic technique compared to the conventional microscopic surgery is that a surgeon has to operate in a two-dimensional view. Endoscopic images are still less clear and less sharp than the three-dimensional direct microscopic view. In two patients in our series, a 5-mm-diameter stereoscopic endoscope was used. Differentiation in distance perception was the main advantage of using the stereoscopic endoscope, which is now available commercially. Recently, addition of a lens cleansing tool that combines irrigation and suction techniques has eliminated the need for periodic removal of the endoscope from the surgical field for cleaning. The function of the lens cleansing tool resembles that of an automobile’s windshield wiper. Certainly, a learning curve exists for a surgeon who is not familiar with the endoscope. Its use requires different surgical skills from those necessary in microsurgical techniques because the endoscope must be handled with the nondominant hand and the surgical instruments with the other. The endoscope and surgical instruments have to enter parallel to each other in a single nostril. A surgeon inexperienced with this technique may become frustrated if the two instruments consistently strike each other in the small operating space. Practice will overcome this problem. The endoscope-holding device enables a surgeon to use both hands and simultaneously provides a continuous view on the monitoring screen.

The future potential applications of the endoscope in neurosurgical practice may be enhanced by computer-guided stereotactic technology, stereoscopic endoscopes, and the development of high-definition television monitors. Computer-assisted stereotactic technology and the three-dimensional stereoscopic endoscope have already been made available. A high-definition television system may further improve clarity and sharpness of images. The technique of endonasal endoscopic pituitary surgery can be simplified and refined and may benefit from the modification of surgical instruments.

Acknowledgments

The authors wish to thank Arthur P. Nestler, B.S.N., and Robin A. Coret, B.A., for their assistance in preparation of this manuscript.

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Manuscript received September 12, 1996. Accepted in final form January 16, 1997.

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