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Endoscopic Endonasal Pituitary and Skull Base Surgery

Naokatsu SAEKI, Kentaro HORIGUCHI, Hisayuki MURAI,
Yuzo HASEGAWA, Toyoyuki HANAZAWA*, and Yoshitaka OKAMOTO*

*Departments of Neurosurgery and *Otorhinolaryngology,
Chiba University Graduate School of Medicine, Chiba*

Abstract

Here we describe the procedures of endoscopic pituitary and skull base surgery in our institute. We also review the literature to reveal recent advances in this field. Endonasal approach via the sphenoid ostium was carried out for pituitary lesions without the nasal speculum. Postoperative nasal packing was basically not needed in such cases. For meningiomas, craniopharyngiomas, and giant pituitary adenomas, which required intra-dural procedures, nasal procedures such as middle nasal conchotomy and posterior ethmoidectomy, and skull base techniques such as optic canal decompression and removal of the planum sphenoidale were carried out to gain a wider operative field. Navigation and ultrasonic Doppler ultrasonography were essential. Angled endoscopes allowed more successful removal of tumors under direct visualization extending into the cavernous sinus and lower clivus. If cerebrospinal fluid (CSF) leakage occurred during operation, the dural opening was covered with a vascularized mucoseptal flap obtained from the nasal septum. Lumbar drainage system to prevent postoperative CSF rhinorrhea was frequently not required. Angled suction tips, single-shaft coagulation tools, and slim and longer holding forceps, all of which were newly designed for endoscopic surgery, were essential for smoother procedures. Endonasal endoscopic pituitary surgery allows less invasive transsphenoidal surgery since no postoperative nasal packing and less dependence on lumbar drainage are needed. Endoscopic pituitary surgery will be more common and become a standard procedure. Endoscopic skull base surgery has enabled more aggressive removal of extrasellar tumors with the aid of nasal and skull base techniques. Postoperative CSF leakage is now under control due to novel methods which have been proposed to close the dural defect in a water-tight manner. Endoscopic skull base surgery is more highly specialized, so needs special techniques and surgical training. Patient selection is also important, which needs collaboration with ear, nose, and throat specialists. As a safe and successful procedure in skull base surgery, this complex procedure should be carried out only in specialized hospitals, which deal with many patients with skull base lesions.

Key words: endoscope, pituitary tumor, skull base surgery

Introduction

Endoscopic endonasal transsphenoidal surgery has advantages such as less invasive surgical management and more aggressive tumor removal of extrasellar lesions.[6,10,11,14,16,17] In 2003, we began endoscope-assisted surgery.[16,17] In 2006, we completely switched to the endoscopic endonasal approach without using the operating microscope or nasal speculum.[16,17] Here we describe the procedures of endoscopic pituitary and skull base surgery in our institute.

Preoperative Imaging Studies

Preoperative evaluation of the nasal cavity is important to obtain images of the surgical field. Computed tomography (CT) evaluation of the lateral nasal cavity is one such preoperative procedure.[16] The extent of pneumatization of the sphenoid sinus is one of the factors to determine accessibility to the sella turcica. The CT slice parallel to the transsphenoidal approach is useful to show the anatomical structures of the nasal cavity and its surrounding structures.[16] The ethmoid sinus structures such as the middle nasal concha, uncinate process, ethmoid bulla, posterior ethmoid sinus, and superior nasal concha can be excised to gain a wider surgical corridor at the common nasal pathway.[17] Well-developed and pneumatized concha bullosa is a rather easy shape of the nasal cavity to gain a wider surgical corridor at the nasal cavity by lateralizing and pressing away from the nasal passage. Reconstruction of bone CT is useful for education of trainees, to preoperatively imagine the anatomy and imitate the surgical procedure.

Instruments

Endoscopes with 0, 30, and 70 degrees should be prepared. Angled endoscopes are not easy to handle for trainees. However, by making the best use of angled endoscopes, we can gain access to and manipulate lesions which are difficult to approach under the operating microscope. Surgical instruments useful for endoscopic surgery include the rotating Kerrison punch, single-shaft bipolar coagulator, high speed drill, angled aspirator, cut through forceps, alligator forceps, and dissecting forceps. Long, angled, rotating, single-shafted tools are mandatory. The same positioning as in surgery under the operating microscope is used. The head is tilted to the contralateral side.

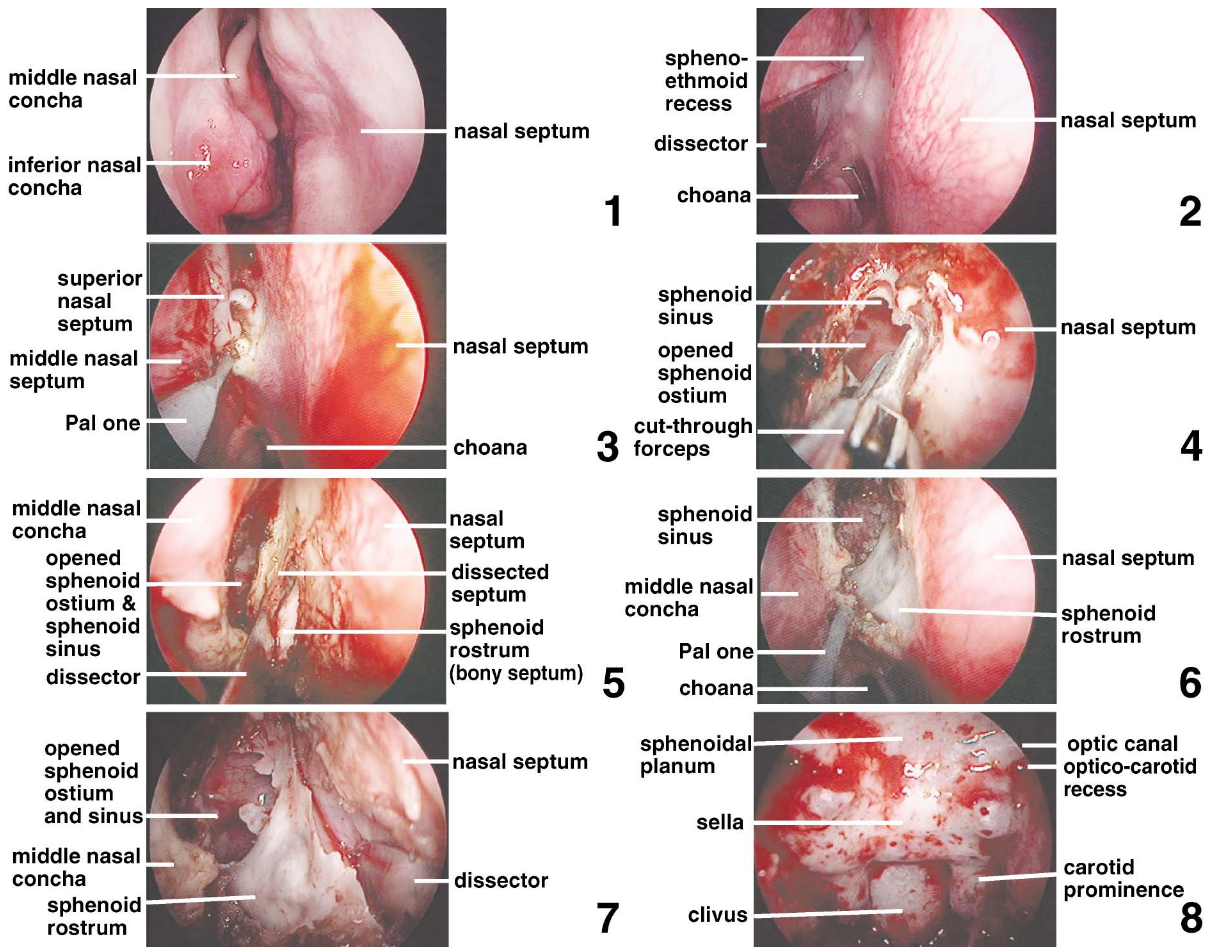


Fig. 1 With the 0 degree endoscope located at the upper part of the nose, the right nasal cavity is observed. Usually the inferior and middle nasal conchas come into view.
Fig. 2 To gain a view of the common nasal pathway, lateralization of the middle nasal concha is needed. After lateralization, the sphenoid ostium becomes visible at the sphenoethmoid recess. In this case, the ostium is underdeveloped.
Fig. 3 After confirming the location of the sphenoid ostium, coagulation of the mucosa around the sphenoid ostium is carried out.
Fig. 4 The sphenoid ostium is enlarged with the cut-through forceps.
Fig. 5 After coagulation of the mucosa, the mucous membrane is dissected on the nasal septum side.
Fig. 6 Septal mucosa is coagulated to avoid intra- and postoperative bleeding from the nasal mucosa.
Fig. 7 The sphenoid rostrum and vomer are visible.
Fig. 8 After removing the sphenoid rostrum and the mucosa of the sphenoid sinus, a panoramic view is obtained of the sella turcica, clivus, carotid prominences, optico-carotid recess, optic canal, and planum sphenoidale.

Standard Unilateral Approach

With the 0 degree endoscope placed at the upper part of the nostril, the inferior and middle nasal conchas usually come into view (Fig. 1). To gain a view of the deeper common nasal pathway, lateralization of the middle nasal concha is needed (Fig. 2). After lateralization, the sphenoid ostium becomes visible at the bottom of the sphenoethmoid recess. The size of the sphenoid ostium varies. In the well-pneumatized sphenoid sinus, the sphenoid ostium is large and clearly visible. Reoperated cases usually have an enlarged ostium. After confirming the location of the sphenoid ostium, coagulation of the surrounding mucosa is carried out (Fig. 3). Then, the sphenoid ostium is enlarged with the cut-through forceps (Fig. 4). After coagulation of the mucosa, the mucous membrane is dissected on the nasal septum side (Fig. 5). Dissected septal mucosa needs sufficient coagulation to confirm hemostasis (Fig. 6). The sphenoid rostrum and vomer then become visible (Fig. 7). The left sphenoid ostium is identified by dissecting the contralateral mucosa of the nasal septum. After exposing the rostrum of the sphenoid sinus, it is drilled and removed. After removing the mucosa in the sphenoid sinus, we obtain a panoramic view of the sella turcica, clivus, carotid prominences, and tuberculum sellae (Fig. 8). Identification of the opticocarotid recess shows sufficient exposure on the lateral side. The inferior side of the sella turcica needs to be drilled away toward the clivus. This procedure helps to gain an upward view with the angled scopes. After such a procedure, the dura is exposed (Fig. 9).

The dura is opened widely in a plus-shaped or x-shaped manner and the tumor is removed with a ring-curette (Fig. 10). The dura at the dorsum sellae becomes visible (Fig. 11). Angled endoscopes are useful to identify the surrounding structures such as the medial wall of the cavernous sinus in order not to overlook residual adenoma (Fig. 11). The highly angled (70 degrees) endoscope is used to explore the

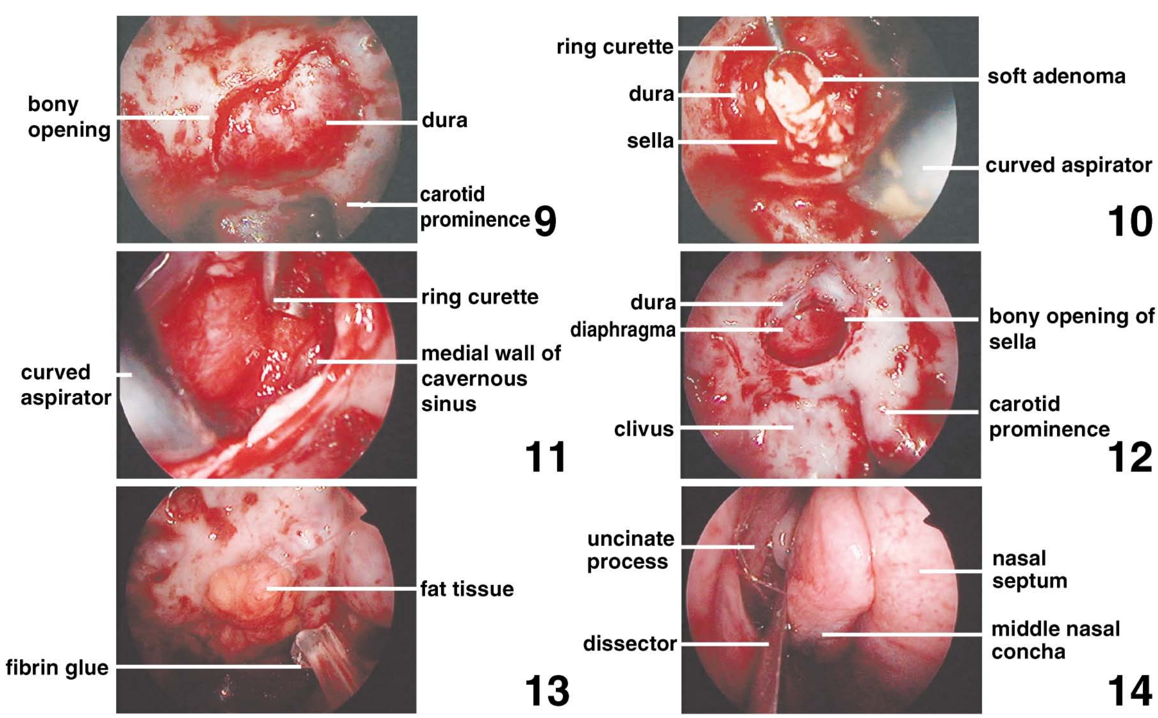


Fig. 9 The bony structure at the sellar floor is drilled away and the dura is exposed. This case is a growth hormone-secreting microadenoma.

Fig. 10 The dura is opened in a plus-shaped or x-shaped manner and removal of the tumor is carried out with a ring-curette.

Fig. 11 A 30-degree angled endoscope is useful to identify the surrounding structures such as the medial wall of the cavernous sinus in order not to overlook the residual adenoma.

Fig. 12 Total removal of the tumor is confirmed when the surrounding normal structures in the sella such as the residual normal gland, the arachnoid membrane, and diaphragm become visible.

Fig. 13 Abdominal fat is packed to fill the cavity. Fibrin glue is applied to stabilize the fat at the dural defect.

Fig. 14 The middle nasal concha is medialized to narrow the enlarged sphenoid ostium.

residual adenoma around the tuberculum sellae. Total removal of the tumor is confirmed by the surrounding structures in the sella such as the residual normal gland, arachnoid membrane, and diaphragm (Fig. 12).

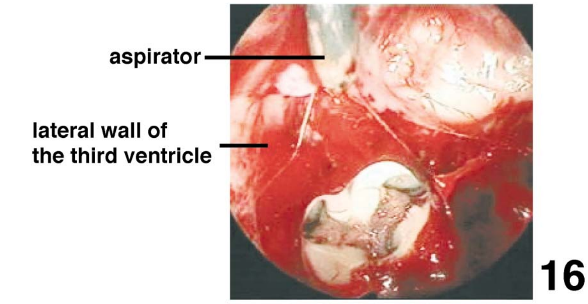
The sellar floor is reconstructed with fat. The abdominal fat is packed to fill the cavity. Fibrin glue is applied to stabilize the fat at the dural defect (Fig. 13). The middle nasal concha is medialized to narrow the enlarged sphenoid ostium (Fig. 14).

Extended Approach

The extended approach is usually carried out for giant pituitary adenomas, craniopharyngiomas, tuberculum sellae meningiomas, and clival chordomas. The binasal approach is chosen. In order to carry out the approach comfortably and smoothly, we perform various procedures to widen the surgical corridor including middle nasal conchotomy, superior nasal conchotomy, removal of uncinate process and ethmoid bulla, and posterior ethmoidectomy, singly or combination. Several representative cases of extrasellar lesions are presented below.

Giant pituitary adenoma extending into the third ventricle: A 67-year-old woman presented with chief complaints of recent memory loss and visual field narrowing. She had undergone conventional transsphenoidal surgeries twice, craniotomy, and conventional radiotherapy. Malignant change of the pituitary adenoma was suspected clinically. T_1-weighted magnetic resonance (MR) imaging with contrast enhancement of this recurrent giant pituitary adenoma revealed the tumor extending to the level of the foramen of Monroe (Fig. 15). Superior and middle nasal conchotomies were performed. The tumor in the sella and suprasellar portions was soft and removable. At the final parts of the tumor removal, the 70-degree angled endoscope showed the anterior third ventricle (Fig. 16). The residual adenoma was aspirated. The panoramic view of the 30-degree angled endoscope showed the middle and posterior part of the third ventricle. The fornix, foramen of Monroe, choroid plexus, massa intermedia, and structures of the ventricle and aqueduct were visible (Fig. 17). Postoperative MR imaging with contrast enhancement one month after the surgery showed that the main mass lesion was excised. Temozolomide was effective to control the residual tumor.

Suprasellar craniopharyngioma: A 43-year-old



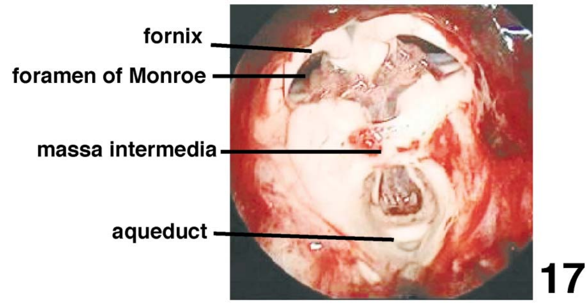


Fig. 16 **After removal of the lower half of the tumor, the 70-degree angled endoscope shows the anterior third ventricle floor. The residual adenoma was aspirated.**
Fig. 17 **Panoramic view of the 30-degree angled endoscope. The middle and posterior parts of the third ventricle were visible. The fornix, foramen of Monroe, choroid plexus, massa intermedia, and aqueduct were visible.**

Fig. 15 **T_1-weighted magnetic resonance images with contrast enhancement show the sellar and suprasellar giant pituitary adenoma extending to the level of the foramen of Monroe.**

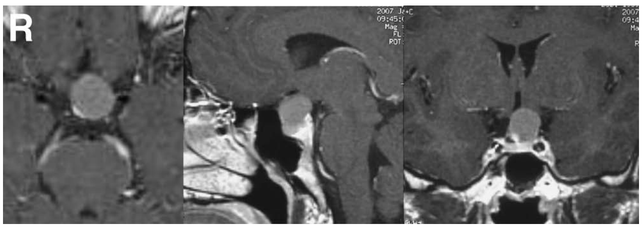


Fig. 18 **T_1-weighted magnetic resonance images with contrast enhancement showing the cystic craniopharyngioma in the left suprasellar region, 15 mm in size, with slight enhancement of the right inferior portion.**

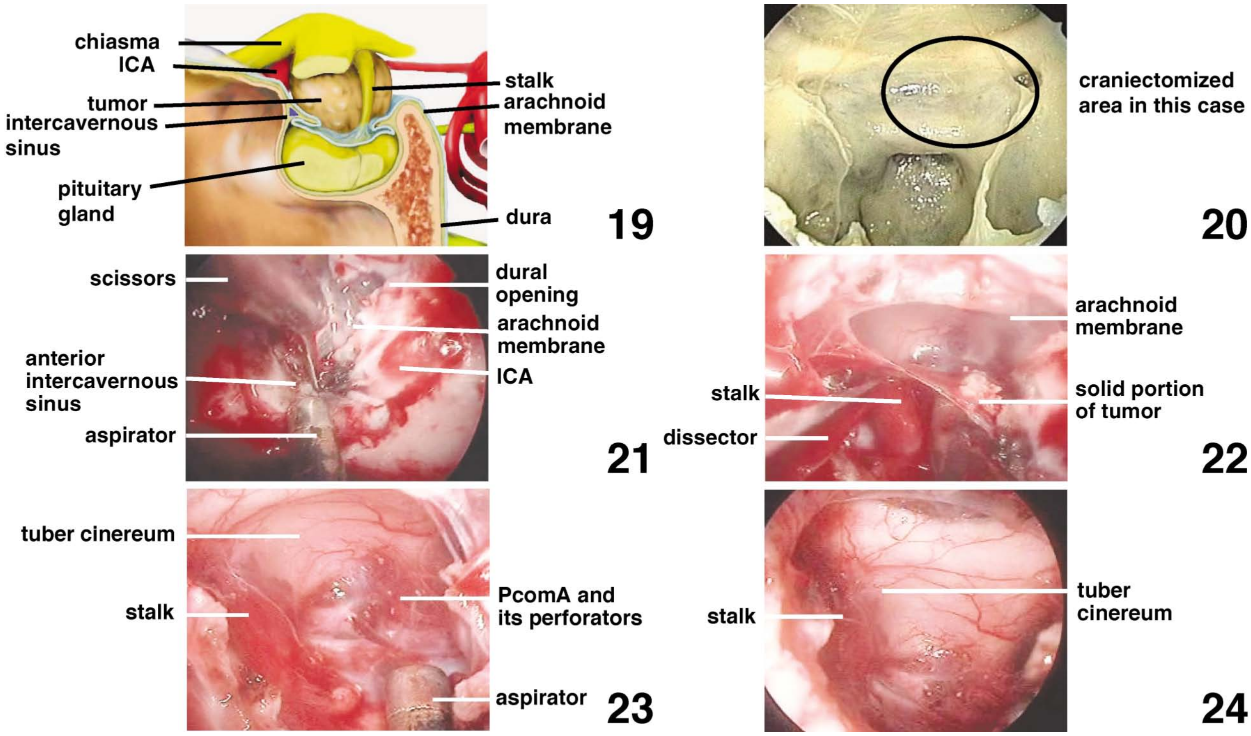


Fig. 19 **Preoperative illustration demonstrating the tumor in relation to the dura, anterior intercavernous sinus, arachnoid membrane, and pituitary gland. The tumor was on the diaphragm sellae, and the optic chiasm and left optic nerve were compressed upward. ICA: internal carotid artery.**
Fig. 20 **Autopsy specimen showing the craniectomized area encircled in a *black line*.**
Fig. 21 **After bony removal at the sellar wall and tuberculum sellae area and dural opening, the anterior intercavernous sinus was coagulated and incised. ICA: internal carotid artery.**
Fig. 22 **Cyst content was aspirated and the cyst membrane was dissected from the surrounding structures. The pituitary stalk was visible and the tumor adhered to its lower part.**
Fig. 23 **After cyst wall removal, the posterior communicating artery (PcomA) and its perforators became visible. The tumor origin was located at the junction of the stalk and upper surface of the pituitary gland.**
Fig. 24 **The 30-degree endoscope was useful to observe the subchiasmal area such as the stalk and tuber cinereum.**

man presented with a chief complaint of left visual field defect. He had noticed headache and left visual field disturbance for the last few days. T_1-weighted MR imaging with contrast enhancement showed the cystic mass lesion in the left suprasellar region, 15 mm in size, with slight enhancement of the right inferior portion (Fig. 18). Craniopharyngioma was suspected. Preoperative neuroimaging demonstrated the tumor in relation to the dura, anterior intercavernous sinus, arachnoid membrane, and pituitary gland. The tumor was on the diaphragm sellae, and the optic chiasm and left optic nerve were compressed upward (Fig. 19). The extended approach was chosen. The autopsy showed the craniectomized area in this case (Fig. 20). After bony removal at the sellar wall and tuberculum sellae area, the anterior intercavernous sinus was coagulated and incised (Fig. 21). Cyst content was aspirated and cyst membrane was dissected from the surrounding structures. The pituitary stalk was visible and the tumor adhered to its lower part around the diaphragm (Fig. 22). After cyst wall removal, the posterior communicating artery and its perforators became visible. The tumor origin was located at the junction of the stalk and upper surface of the pituitary gland (Fig. 23). The 30-degree endoscope was useful to observe the subchiasmal area such as the stalk and tuber cinereum. The angled endoscope provided an excellent surgical view of the subchiasmal region (Fig. 24). The sellar floor was reconstructed with fat tissue. Postoperatively the visual field defect disappeared. T_1-weighted MR imaging one month after the surgery showed successful removal of the tumor.

Tuberculum sellae meningioma: A 43-year-old woman complained of left visual field defect for several months. T_1-weighted MR imaging showed a homogeneous mass lesion in the suprasellar area on the left. Tuberculum sellae meningioma was suspected (Fig. 25). Black and white reversed T_2-weighted MR imaging demonstrated the tumor intensity extending into the left optic canal in both axial and coronal images. Preoperative neuroimaging demonstrated the tumor in relation to the dura, arachnoid membrane, and pituitary gland (Fig. 26). The tumor was supposed to extend into the optic canal. The patient underwent binasal endonasal surgery. The autopsy demonstrated the craniectomized area in this case (Fig. 27). The left optic canal was opened to full length. After dural opening, the solid and hard tumor was internally decompressed. The tumor was resected from the dural attachment around the tuberculum sellae. The tumor invading the dura at the optic canal was incised with scissors and excised with the cut-through forceps (Fig. 28). The tumor extending into the optic canal was totally removed. The left optic canal was opened and the full length of the optic nerve was exposed (Fig. 29). The sellar floor was reconstructed with fat. Lumbar drainage was placed for one week postoperatively. T_1-weighted MR imaging one month after the surgery demonstrated that the mass was removed. The visual symptom disappeared postoperatively.

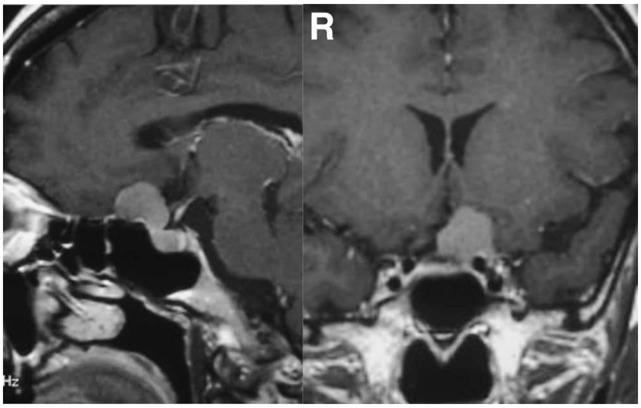
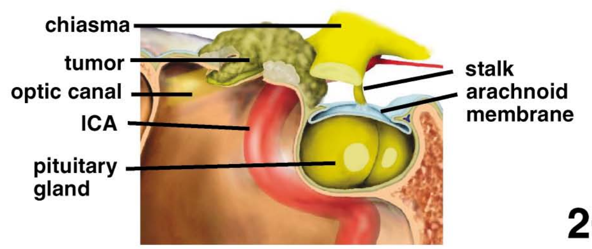
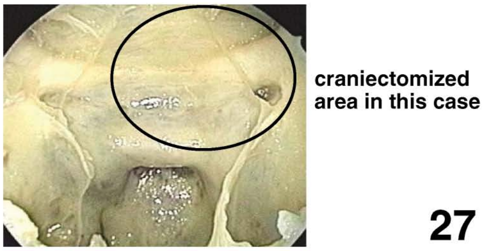


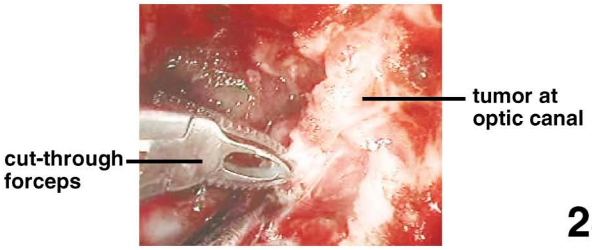
Fig. 25 **T_1-weighted magnetic resonance images showing the homogeneous tuberculum sellae meningioma in the left suprasellar area.**

Sellar Floor Reconstruction

Endoscopic endonasal approaches for ventral skull base lesions have evolved in the past decade. With these endoscopic developments, many pathologies can be treated within the intra-arachnoidal space, avoiding brain retraction and not requiring excessive neurovascular manipulations.[4,6,10,12,14] However, one of the challenges of endoscopic endonasal skull base approaches is the reconstruction of large defects of the skull base.[5] Various endoscopic techniques have been described to reconstruct the ventral skull base for preventing cerebrospinal fluid







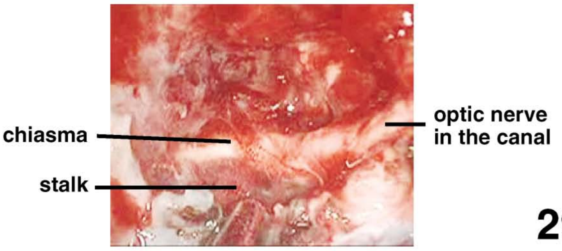


Fig. 26 **Preoperative schema demonstrating the tumor in relation to the dura, arachnoid membrane, and pituitary gland. ICA: internal carotid artery.**
Fig. 27 **Autopsy specimen demonstrating the craniectomized area encircled in a *black line*.**
Fig. 28 **The left optic canal was opened to full length. After dural opening, the solid and hard tumor was internally decompressed. The tumor was excised with cut-through forceps from the dural attachment around the tuberculum sellae. The tumor extending into the optic canal was totally removed.**
Fig. 29 **The final view of the surgical field. The left optic canal was opened and the optic nerve in the optic canal was exposed.**

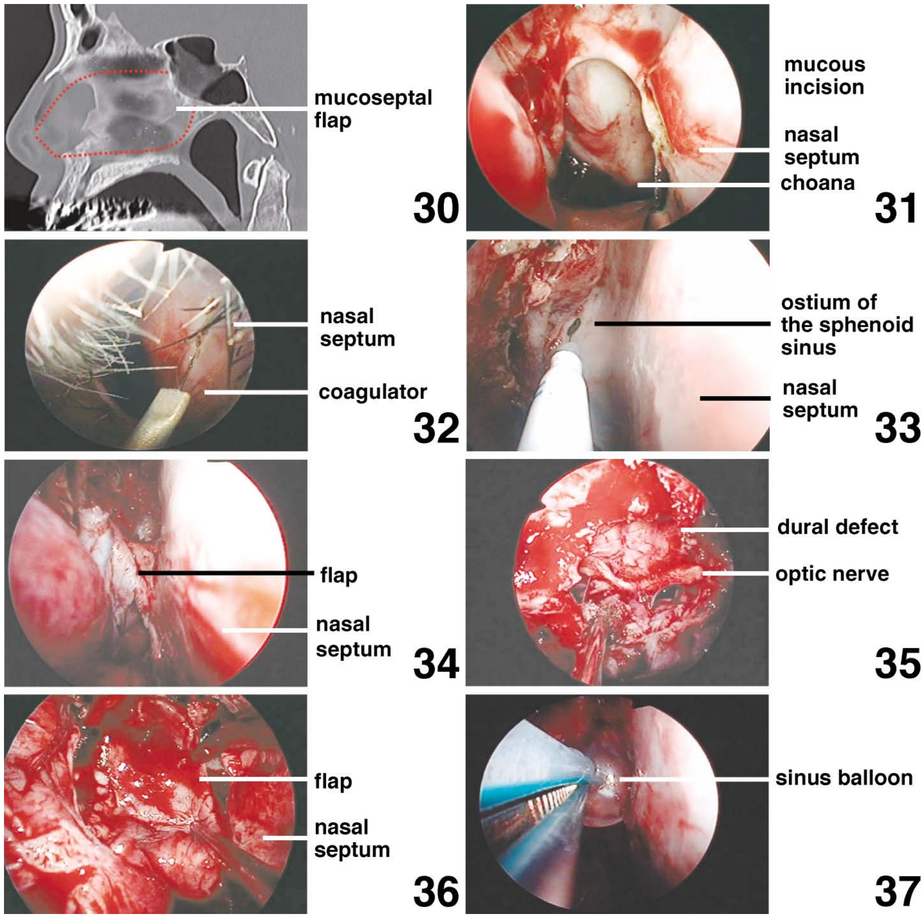


Fig. 30 The design to harvest the nasal septal flap is shown. The mucoperichondrial flap is based on the posterior septal branch of sphenopalatine artery.
Fig. 31 The vertical mucous incision is made at the medial side of the nasal septum around the choana. The incision is extended anteriorly to the base of the nasal cavity.
Fig. 32 The anterior vertical incision is made at the mucocutaneous junction at the nasal septum with unipolar electrocautery.
Fig. 33 The incision at the sphenoid ostium is made superiorly.
Fig. 34 The nasal septal flap is usually placed in the nasopharynx or the maxillary sinus until use in reconstruction.
Fig. 35 There is a large dural defect after removal of the tuberculum sellae meningioma.
Fig. 36 In the reconstruction phase, the nasal septal flap is laid directly on the large dural defect. Fibrin glue is used to avoid translocation of the flap.
Fig. 37 A sinus balloon catheter is finally placed as support.

(CSF) leaks, and can be divided into 4 methods: Conventional sellar floor reconstruction using autografts such as fat, muscle, fascia lata, and bone, and artificial grafts such as neo-veil, Surgicel, and others[1,16]; dural suturing with or without dural substitute[13]; the vascularized mucoseptal flap method[7–9,11]; and the multilayer method using dural and bony substitute.[2,3,15] Those methods are used singly or in combination as required by the practical situation.

We previously used fat grafts or fascia lata with insertion of external lumber drains for closure of large dural defects after endoscopic endonasal skull base approaches. Recently, we have adapted the use of the nasal septal flap vascularized by the posterior septal branch of sphenopalatine artery combined with a balloon catheter without insertion of lumbar drainage for closure of large dural defects.[9] Here we describe our surgical technique using a nasal septal flap combined with a balloon catheter. First we decide the design to harvest the nasal septal flap as a mucoperichondrial flap based on the posterior septal branch of sphenopalatine artery (Fig. 30). The middle nasal turbinate is usually dissected for facilitating visualization from the nasal septum to the pedicle of the flap. The sphenoid ostium is easily identified and the flow in the donor artery of the flap is usually confirmed with a micro-Doppler probe. Then, the first incision is performed along the floor of the nasal cavity from the choanae to the inter-cutaneomucous point of the nasal vestibule with unipolar electrocautery (Fig. 31). The nasal septum is infiltrated with 1% lidocaine with epinephrine in a 1/250,000 ratio for hemostasis. The anterior vertical incision is made with unipolar electrocautery or turbinate scissors (Fig. 32) and the superior incision to the sphenoid ostium is made (Fig. 33). The incision is extended within 1.0–1.5 cm below the most superior aspect of the nasal septum. The mucosa of the nasal septum is elevated with a dissector. The pedicle of the flap formed in the width from the sphenoid ostium to the choana is extended laterally to the level of the sphenopalatine foramen. The nasal septal flap is usually placed in the nasopharynx or the maxillary sinus until use in reconstruction (Fig. 34). In the reconstruction phase, the nasal septal flap is laid directly on the large dural defect with fibrin glue (Figs. 35 and 36). Fat grafts are applied outside the flap as reinforcements. A sinus balloon catheter is finally placed as support (Fig. 37). Postoperative CT is performed on the 1st and 7th postoperative days to assess for postoperative hemorrhage, positions of the flap and the balloon catheter. External lumber drains are not inserted. Prophylactic intravenous antibiotics are administered for 7–10 days after surgery. Otorhinolaryngological endoscopic assessments are regularly performed at outpatient clinics.

Conclusion

Endonasal endoscopic pituitary surgery now allows less invasive transsphenoidal surgery without postoperative nasal packing and less dependence on lumbar drainage. Endoscopic pituitary surgery will be more common and become a standard procedure. Endoscopic skull base surgery has enabled more aggressive removal of extrasellar tumors with the aid of nasal and skull base techniques. Recent development of several tight dural closure methods helps to reduce postoperative CSF leakage. Such endoscopic skull base surgery is more highly specialized, so needs special techniques and surgical training. Patient selection is also important, which requires collaboration with ear, nose, and throat specialists. To be acknowledged as a safe and successful procedure in skull base surgery, this complex procedure should preferably be carried out only in specialized hospitals, which deal with many patients with skull base lesions.

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Address reprint requests to: Naokatsu Saeki, M.D., Department of Neurosurgery, Chiba University Graduate School of Medicine, 1–8–1 Inohana, Chuoh–ku, Chiba 260–8670, Japan.
e-mail: nsaeki@faculty.chiba-u.jp