

# Combined Transcranial-endonasal Reconstructive Surgery for Cerebrospinal Fluid Leakage Resulting from Traumatic Anterior Skull Base Fractures Involving the Parasellar Region

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## Abstract

Extensive traumatic anterior skull base fractures from the frontal sinus to the parasellar region are frequently accompanied by multiple dural defects that cause persistent cerebrospinal fluid (CSF) leakage. Conventional transcranial reconstruction using a frontal periosteal flap is frequently insufficient, and parasellar dural defects are often deep, complex, and difficult to identify. In this report, we describe a combined transcranial–endonasal reconstructive technique and report our experience. Simultaneous combined transcranial and endoscopic surgery was performed in three patients with CSF leakage resulting from traumatic anterior skull base fractures. Dural defects were thoroughly identified from the transcranial and endonasal surgical fields, and covered using a multilayer sealing technique. The anterior regions of the anterior skull base were reconstructed using a free fascial flap and frontal periosteal flap; posterior and parasellar regions were reconstructed using a fat graft, vascularized nasoseptal flap, and endonasal balloon. Suturing the transcranial grafts to the parasellar dura mater was performed collaboratively by the transcranial and endonasal surgeons. In our cases, complete cessation of CSF leakage was achieved without perioperative lumbar drainage in all patients. Mean time to postoperative ambulation was 7 days (range, 3–11). No surgical complications occurred. Simultaneous transcranial and endonasal procedures were helpful to detect all sites of CSF leakage and secure reconstructive grafts. The combined transcranial and endonasal reconstructive technique achieved secure skull base reconstruction without recurrence of CSF leakage, and allowed early postoperative ambulation. This technique can be a reliable surgical option to repair CSF leakage resulting from extensive anterior skull base fractures.

Keywords: combined transcranial and endonasal approach, cerebrospinal fluid leak, endoscope, skull base reconstruction

## Introduction

Complex comminuted fractures extending from the anterior skull base to the parasellar region often result in multiple osteodural defects and refractory

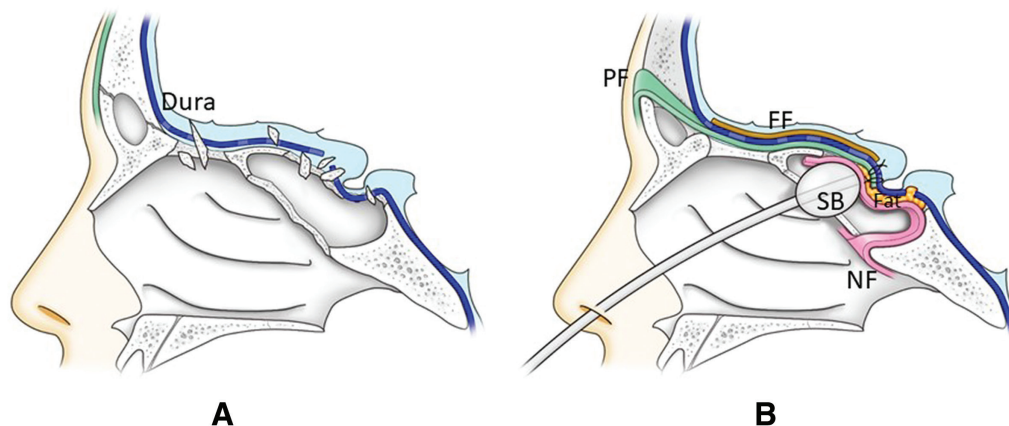
cerebrospinal fluid (CSF) leakage, which has the potential to cause fatal bacterial meningitis.

Although transcranial reconstruction using a frontal periosteal flap through a bifrontal craniotomy is a common approach, it tends to fail because the anteriorly based pericranium may not extend posteriorly enough. Furthermore, traumatic fractures around the parasellar region often have a non-planar complex configuration, which causes difficulty in appropriately applying the graft to the edge of dural defects. Up to 17% of patients with anterior skull

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**Fig. 1** Schema of the combined transcranial and endoscopic endonasal technique. (A) Preoperative. (B) Postoperative. A free fascial flap is placed as an inlay and sutured to disrupted dura mater. A periosteal flap covers the frontoethmoid sinus, and planum sphenoidale. A nasoseptal flap covers the clivus, sella floor, tuberculum sellae, and planum sphenoidale. Fat grafts filling any dead space between the fascial graft/periosteal flap and nasoseptal flap are shown. FF: free fascial flap, NF: nasoseptal flap, PF: periosteal flap, SB: sinus balloon

base fractures that extend to the cribriform plate or sphenoid sinus experience persistent CSF leakage after repair with a frontal periosteal flap.<sup>1,2)</sup>

Endoscopic endonasal repair using a vascularized nasoseptal flap is quite effective for managing CSF leakage from the parasellar region.<sup>3,4)</sup> However, the area that a vascularized nasoseptal flap can cover is confined to the clivus, sella turcica, tuberculum sellae, and posterior planum sphenoidale. Furthermore, the success rate of endoscopic endonasal repair is lower for high-flow CSF leakage associated with osteodural defects.<sup>5)</sup> To address these issues, we have developed a novel multilayer sealing technique that combines both a transcranial periosteal flap and endonasal nasoseptal flap. This describes our experience.

### Case Report

We reviewed the clinical and radiological records of three patients (all males, with mean age 56.3 years [range, 31–73]) who underwent combined reconstructive surgery for CSF leakage resulting from extensive anterior skull base fractures, at Japanese Red Cross Nagoya Daini Hospital from January 2017 to December 2018. Two patients had previously undergone transcranial reconstruction using a periosteal flap during emergent hematoma removal on the day of admission. Before combined surgery, all patients were conservatively managed with strict bed rest for at least 7 days (mean time, 9.7 days [range, 7–11]).

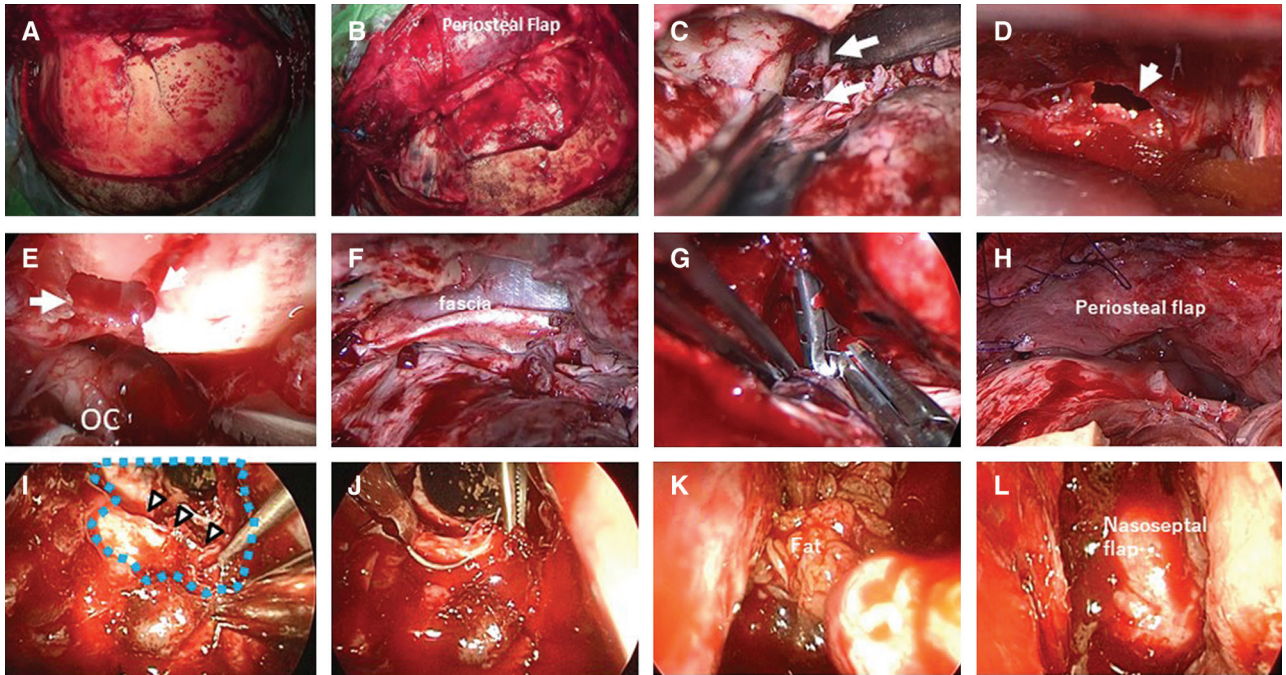
#### Surgical strategy of the combined technique

Endonasal and transcranial approaches were performed simultaneously, which requires two

neurosurgical teams (two operating surgeons and their assistants), one endoscopic system for the endonasal approach, and one exoscopic system for the transcranial approach. A microscope can be used as a substitute for the exoscope; however, this complicates the set-up and reduces the available surgical space. The endoscope and exoscope are fixed using floor-standing endoscopic holders (UniARM, Mitaka Kohki Co., Tokyo, Japan and EndoArm, Olympus Co., Tokyo, Japan), and manipulated by the assistants while the operating surgeons perform the procedure.

Figure 1 illustrates the concept of our technique. Multilayer sealing with a combination of free autografts and vascularized pedicle flaps is performed from each surgical field. An endonasal balloon then supports the inferior aspect to minimize pulsation pressure. The periosteal flap is exclusively used for reconstruction of the frontal sinus, cribriform plate, planum sphenoidale, and tuberculum sellae; the nasoseptal flap is used for reconstruction of the clivus, sella floor, tuberculum sellae, and planum sphenoidale. Both vascularized flaps are stacked in layers from the tuberculum sellae to the planum sphenoidale, as the reconstruction in this region tends to be fragile.

The tip of the transcranial periosteal flap is sutured to the disrupted dura mater edge around the tuberculum sellae with cooperation from the endonasal surgeon, owing to its deep location. Any dead space between the fascial graft/periosteal flap and nasoseptal flap is filled with an autologous fat graft harvested from the abdomen. We do not routinely place a lumbar CSF drainage catheter.



**Fig. 2** Intraoperative open and exoscopic transcranial views. (A) Coronal skin incision and reflection of scalp flap. A comminuted frontal bone fracture is observed. (B) Bifrontal craniotomy and anteriorly based vascularized periosteal flap. (C–E) Dural disruption and wide clefts (arrow) in the cribriform plate (C), planum sphenoidale (D), and tuberculum sellae (E) are observed. (F) The free fascial flap is placed as an inlay and sutured to disrupted parasellar dura mater. (G) Suturing the periosteal flap to the disrupted dural edge is performed in collaboration with the endonasal surgeon. (H) The periosteal flap is placed extradurally along the floor of the anterior skull base from the frontoethmoid sinus to the planum sphenoidale. Intraoperative endoscopic view of endonasal surgery (I) Skull base defects are observed at the planum sphenoidale (dotted blue line). The arrowheads indicate the edge of the disrupted dura mater around the tuberculum sellae. (J) The tip of the periosteal flap is sutured to the edge of the disrupted dura. (K) An abdominal free fat graft is placed to obliterate the dead space. (L) A nasoseptal flap is placed over the entire parasellar region. OC: optic chiasm

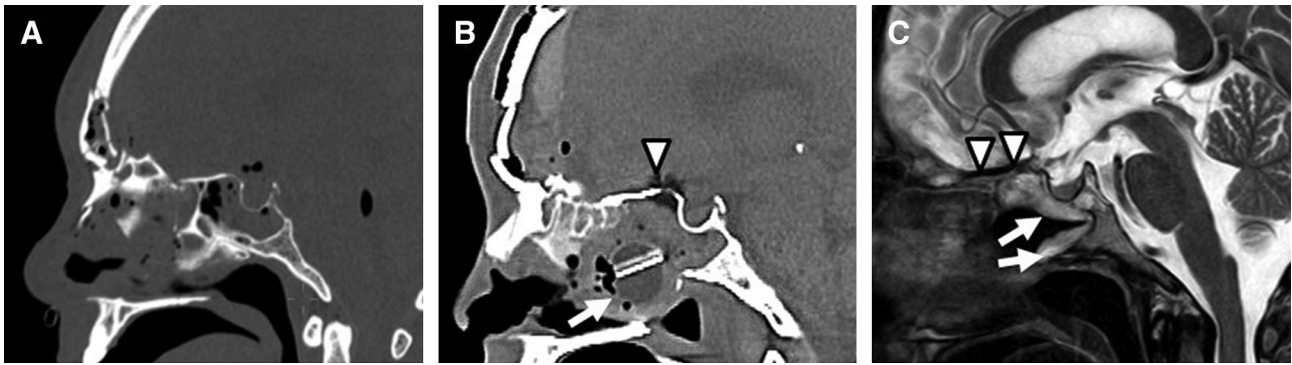
### Exoscopic transcranial approach

After induction of general anesthesia using endotracheal intubation, the patient is positioned supine, with the upper body elevated 15°. The head is fixated using a Sugita 4-point head holder and tilted 15° to the right. The abdomen is prepared with povidone-iodine solution for fat and fascial graft harvesting. A coronal skin incision is made and the scalp flap reflected anteriorly (Fig. 2A). At the time of skin incision, the scalp flap is separately elevated, leaving the frontal periosteum. After bifrontal craniotomy, the frontal sinus is cranialized in the standard fashion, and the periosteal flap is harvested for anterior cranial base reconstruction (Fig. 2B). Using the operative exoscope (VITOM, Karl Storz GmbH & Co., Tuttlingen, Germany), we widely dissect the anterior skull base dura mater, and the endocranial surface of the anterior skull base is inspected all over to detect osteodural defects (Figs. 2C–E). A free fascial graft is first placed as an inlay, and then, a periosteal flap is

placed extradurally along the floor of the anterior skull base as far posteriorly as possible to cover the frontoethmoid sinus and planum sphenoidale; the tip of the periosteal flap is sutured to the edge of tuberculum sellae dura mater with cooperation from endonasal surgeon (Figs. 2F–H, and 3B). The inside and outside of the dura mater can be sandwiched between the fascia and periosteal flap to achieve a more secure closure.

### Endoscopic endonasal approach

Using a zero degree rigid endoscope with a floor-standing type endoscopic holder, a vertical incision is made in the right nasal septal mucosa several millimeters caudal to the mucocutaneous junction. After submucoperichondrial/submucoperiosteal dissection, a wide sphenoidotomy is performed to expose bony defects of the planum sphenoidale, parasellar region, and clivus (Fig. 2I). The skull base defects are prepared to receive the flap by drilling existing bony septations in the vicinity of



**Fig. 3** Radiological findings of an illustrative case. (A) The preoperative computed tomography (CT) image shows an anterior skull base fracture extending from the frontoethmoid sinus to the parasellar region. (B) The postoperative sagittal CT image shows fat grafts filling the dead space around the tuberculum sellae (arrowhead) and the endonasal balloon reinforcing the multilayer barrier (arrow). (C) The postoperative sagittal magnetic resonance image 6 months after the surgery shows the layers of the fascial flap and the periosteal flap (arrowheads) and nasoseptal flaps (arrow).

the defect and circumferentially removing the mucosa. Dural defects are identified, and a periosteal flap inserted from the transcranial operative field is spread out as a dural overlay graft, which is sutured to the edge of tuberculum sella dura mater using 6-0 nylon (Fig. 2J). A fat graft is placed in the dead space, and a right nasoseptal overlay flap is placed to cover the entire operative field (Fig. 2K and L). Fibrin glue and an endonasal balloon are used to reinforce the multilayer barrier. The balloon is removed between postoperative days 3 and 7 followed by endoscopic nasal cavity examination to confirm the absence of CSF leakage.

## Results

CSF rhinorrhea stopped soon after surgery in all three patients. Lumbar drainage was not required intra- or postoperatively. The operation times were 301, 304, and 456 min (mean, 353 min), and the intraoperative blood loss volumes were 80, 50, and 600 mL (mean, 243 mL), respectively. Patients started bedside rehabilitation on postoperative day 1. Mean time to ambulation was 7 days (range, 3–11). Mean follow-up was 17 months (range, 12–21). No patient experienced meningitis, nasoseptal flap necrosis, mucocele, epistaxis, recurrent CSF leakage, or other complications. Simultaneous transcranial and endonasal procedures were helpful to detect all sites of CSF leakage and secure the reconstructive grafts.

### Illustrative case

A 33-year-old male with rhinorrhea after a head injury caused by a fall was transferred to our

hospital. CT of the head demonstrated an anterior skull base fracture from the frontal sinus to the sphenoid bone associated with pneumocephalus (Fig. 3A). CSF rhinorrhea persisted despite bed rest for 7 days and the patient underwent a combined transcranial and endoscopic reconstructive surgery. Inspection through a bifrontal craniotomy revealed multiple dural disruptions and bony defects in the frontal sinus, cribriform plate, and tuberculum sellae. Endoscopic endonasal inspection showed optic chiasm injury and brain tissue prolapsing into the ethmoid sinus. Multilayer sealing was performed as described above (Figs. 3B and 3C). CSF rhinorrhea ceased soon after surgery and the endonasal balloon was removed on postoperative day 7. His postoperative course was uneventful although bilateral hemianopsia and anosmia has remained. No recurrence of CSF rhinorrhea has been observed for 17 months.

## Discussion

Transcranial and/or endonasal approaches for treatment of CSF leakage resulting from anterior skull base fracture can be selected alone or in combination, depending on the location of the leakage. The transcranial approach is usually selected for reconstruction of the frontal sinus, cribriform plate, and planum sphenoidale and is useful and effective in patients undergoing emergency craniotomy for intracranial hematoma removal. This approach uses a highly vascularized periosteal flap for repair.<sup>6–8)</sup> However, the flap may not reach large defects of the parasellar region and can be difficult to fix to deep dural defects.<sup>6)</sup>

The endoscopic approach is useful to repair dural defects around the sphenoid sinus and upper clivus.<sup>9–11)</sup> This approach can clearly visualize parasellar dural defects and uses a nasoseptal flap for coverage. However, a nasoseptal flap cannot reach anteriorly located anterior skull base defects<sup>12)</sup> and is not effective for large dural defects that result in high-flow CSF leakage. Wengier et al. reported that 9 of 77 patients who underwent endoscopic nasoseptal flap skull base reconstruction experienced CSF leakage in the early postoperative period; high-flow CSF leakage was observed intraoperatively in all nine.<sup>5,13)</sup>

Although combined transcranial–endonasal surgery has been reported as a safe and effective alternative approach for resection of giant pituitary tumors,<sup>14–16)</sup> its use for anterior skull base CSF leak repair has not been well studied. This approach provides good visualization of the dural defects and surrounding neurovascular structures from both the endonasal and transcranial sides, allowing clear identification of all sites of leakage. Moreover, it allows collaboration of transcranial and endonasal surgeons to suture the periosteal flap to the disrupted parasellar dura, which prevents graft migration.

In extensive fractures with large dural defects, multilayered combined repair can be effective in preventing brain sag and high-flow CSF leakage.<sup>6,7,17)</sup> Our technique uses a periosteal flap, free fascial flap inlay, free fat graft, and nasoseptal flap and was effective in all patients, resulting in immediate and complete cessation of CSF leakage. This secure reconstruction technique can allow early ambulation and be beneficial in patients who are unable to maintain bedrest.

CSF leakage associated with traumatic anterior skull base fracture can be repaired by either transcranial or endonasal surgery in many cases. However, simultaneous combined transcranial–endonasal reconstructive surgery is useful especially when it is difficult to identify the location of CSF leak at the extensively fractured anterior skull base or when there are multiple CSF leak sites that cannot be repaired by either approach alone.

However, technique limitations include the need for two neurosurgical teams and two optical devices. Its application in patients requiring urgent hematoma removal may not be practical.

In conclusion, the combined transcranial–endonasal reconstructive technique is effective for repair of CSF leakage resulting from multiple dural defects due to anterior skull base fractures from the frontal sinus to the parasellar region. This technique can result in cessation of CSF leakage and promotes early ambulation.

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## Conflicts of Interest Disclosure

The authors declare no potential conflicts of interest.

## References

- 1) Bell RB, Dierks EJ, Brar P, Potter JK, Potter BE: A protocol for the management of frontal sinus fractures emphasizing sinus preservation. *J Oral Maxillofac Surg* 65: 825–839, 2007
- 2) Gabrielli MF, Gabrielli MA, Hochuli-Vieira E, Pereira-Fillho VA: Immediate reconstruction of frontal sinus fractures: review of 26 cases. *J Oral Maxillofac Surg* 62: 582–586, 2004
- 3) Hadad G, Bassagasteguy L, Carrau RL, et al.: A novel reconstructive technique after endoscopic expanded endonasal approaches: vascular pedicle nasoseptal flap. *Laryngoscope* 116: 1882–1886, 2006
- 4) McCoul ED, Anand VK, Singh A, Nyquist GG, Schaberg MR, Schwartz TH: Long-term effectiveness of a reconstructive protocol using the nasoseptal flap after endoscopic skull base surgery. *World Neurosurg* 81: 136–143, 2014
- 5) Snyderman CH, Kassam AB, Carrau R, Mintz A: Endoscopic reconstruction of cranial base defects following endonasal skull base surgery. *Skull Base* 17: 73–78, 2007
- 6) Archer JB, Sun H, Bonney PA, et al.: Extensive traumatic anterior skull base fractures with cerebrospinal fluid leak: classification and repair techniques using combined vascularized tissue flaps. *J Neurosurg* 124: 647–656, 2016
- 7) Safavi-Abbasi S, Komune N, Archer JB, et al.: Surgical anatomy and utility of pedicled vascularized tissue flaps for multilayered repair of skull base defects. *J Neurosurg* 125: 419–430, 2016
- 8) Ziu M, Savage JG, Jimenez DF: Diagnosis and treatment of cerebrospinal fluid rhinorrhea following accidental traumatic anterior skull base fracture. *Neurosurg Focus* 32: E3, 2012
- 9) Cavallo LM, Solari D, Somma T, Cappabianca P: The 3F (Fat, Flap, and Flash) technique for skull base reconstruction after endoscopic endonasal suprasellar approach. *World Neurosurg* 126: 439–446, 2019
- 10) Eloy JA, Kuperan AB, Choudhry OJ, Harirchian S, Liu JK: Efficacy of the pedicled nasoseptal flap without cerebrospinal fluid (CSF) diversion for repair of skull base defects: incidence of postoperative CSF leaks. *Int Forum Allergy Rhinol* 2: 397–401, 2012
- 11) Hayashi Y, Iwato M, Kita D, Fukui I: Spontaneous cerebrospinal fluid leakage through fistulas at the clivus repaired with endoscopic endonasal approach. *Surg Neurol Int* 6: 106, 2015

- 12) Mao S, Li M, Li D, et al.: Septal floor rotational flap pedicled on ethmoidal arteries for endoscopic skull base reconstruction. *Laryngoscope* 129: 2696–2701, 2019
- 13) Wengier A, Ram Z, Warshavsky A, Margalit N, Fliss DM, Abergel A: Endoscopic skull base reconstruction with the nasoseptal flap: complications and risk factors. *Eur Arch Otorhinolaryngol* 276: 2491–2498, 2019
- 14) D'Ambrosio AL, Syed ON, Grobelny BT, Freda PU, Wardlaw S, Bruce JN: Simultaneous above and below approach to giant pituitary adenomas: surgical strategies and long-term follow-up. *Pituitary* 12: 217–225, 2009
- 15) Nishioka H, Hara T, Usui M, Fukuhara N, Yamada S: Simultaneous combined supra-infrasellar approach for giant/large multilobulated pituitary adenomas. *World Neurosurg* 77: 533–539, 2012
- 16) Ojha BK, Husain M, Rastogi M, Chandra A, Chugh A, Husain N: Combined trans-sphenoidal and simultaneous trans-ventricular-endoscopic decompression of a giant pituitary adenoma: case report. *Acta Neurochir (Wien)* 151: 843–847; discussion 847, 2009
- 17) Gabriel PJ, Kohli G, Hsueh WD, Eloy JA, Liu JK: Efficacy of simultaneous pericranial and nasoseptal “double flap” reconstruction of anterior skull base defects after combined transbasal and endoscopic endonasal approaches. *Acta Neurochir (Wien)* 162: 641–647, 2020

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