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Pedicled temporalis muscle flap salvage reconstruction for recalcitrant cerebrospinal fluid leaks following extended endoscopic endonasal approach for pituitary adenomas

Zhenye Li
Beijing Tiantan Hospital, Capital Medical University
Zehao Xiao
Beijing Tiantan Hospital, Capital Medical University
Jiwei Bai
Beijing Tiantan Hospital, Capital Medical University
Chunhui Liu
Beijing Tiantan Hospital, Capital Medical University
Haibo Zhu
Beijing Tiantan Hospital, Capital Medical University
Lei Cao
Beijing Tiantan Hospital, Capital Medical University
Sen Cheng
Beijing Tiantan Hospital, Capital Medical University
Ding Nie
Beijing Tiantan Hospital, Capital Medical University
Songbai Gui
Beijing Tiantan Hospital, Capital Medical University
Yazhuo Zhang
Beijing Tiantan Hospital, Capital Medical University
Chuzhong Li
lichuzhong@ccmu.edu.cn

Beijing Tiantan Hospital, Capital Medical University

Case Report

Keywords: temporalis muscle flap, cerebrospinal fluid leak, skull base reconstruction

Posted Date: June 28th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-10044536/v1

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Additional Declarations: No competing interests reported.

Abstract

Purpose

To evaluate the efficacy and feasibility of pedicled temporalis muscle flap (TMF) reconstruction for recalcitrant postoperative cerebrospinal fluid (CSF) leaks following extended endoscopic endonasal approach (EEEA) for pituitary adenomas (PAs).

Methods

Patients with PAs who underwent repair of postoperative CSF leaks following EEEA using pedicled TMF between January 2021 and December 2025 at our institute were retrospectively reviewed.

Results

A total of 8 patients were included in this study, and all patients had Grade 3 intraoperative CSF leaks during the last EEEA. No patient had an available pedicled nasoseptal flap for reconstruction. The median follow-up duration was 7.5 months (IQR, 3.5–21.0). Durable CSF leak control was achieved in all patients, with no recurrence observed during follow-up.

Conclusion

The pedicled TMF is a reliable and effective salvage reconstructive technique for managing recalcitrant postoperative CSF leaks following EEEA for PAs, particularly in patients with unavailable conventional vascularized intranasal flaps.

Introduction

Advances in extended endoscopic endonasal approach (EEEA) have enabled more aggressive resection of pituitary adenomas (PAs)[1]. Nevertheless, the larger skull base defects created by EEEA continue to pose significant reconstructive challenges[2]. The pedicled nasoseptal flap (NSF), owing to its reliable vascularity and broad coverage, remains the primary reconstructive option for large ventral skull base defects following EEEA[3–5]. Despite these advantages, recurrent cerebrospinal fluid (CSF) leaks may still occur because of flap necrosis, persistent hydrocephalus with elevated intracranial pressure, or impaired healing of the reconstruction[6].

Failure of the initial reconstruction substantially reduces the likelihood of successful revision repair. In some cases, repeated reconstructive attempts may still fail to control CSF leaks, leading to severe intracranial infection and potentially fatal meningitis[7, 8]. Under these circumstances, salvage

reconstruction using vascularized tissue should be strongly considered. When intranasal vascularized flaps are unavailable, regional extranasal vascularized flaps may serve as effective salvage options[9].

The temporoparietal fascia flap (TPFF) has been used for reconstruction of large and recurrent skull base defects due to its robust vascularity and flexibility[10–12]. Nevertheless, patients with refractory PAs often experience malnutrition and radiation-related tissue atrophy, leading to thinning of the scalp, galea, and pericranium. Consequently, these weakened tissues may be unable to provide sufficient support for extensive skull base reconstruction, thereby increasing the risk of reconstructive failure[13].

In this setting, the temporalis muscle flap (TMF) may help overcome these limitations. As a well-vascularized flap with substantial tissue bulk and sufficient reach, the TMF can provide durable coverage and structural support for complex skull base defects[14]. Previous studies have demonstrated the feasibility of TMF reconstruction following expanded endoscopic nasopharyngectomy for recurrent nasopharyngeal carcinoma[15]. However, the application of pedicled TMF reconstruction for recalcitrant postoperative CSF leaks has rarely been reported.

In the present study, we retrospectively analyzed patients with recurrent postoperative CSF leaks following EEEA for PAs who underwent TMF reconstruction after failed prior repair attempts, to evaluate the efficacy and feasibility of this salvage reconstructive strategy.

Materials and methods

Patients

We retrospectively reviewed all patients who underwent repair of postoperative CSF leaks following EEEA between January 2021 and December 2025 at our institute. Demographic, clinical, radiological, and treatment-related data were retrospectively collected from the medical records. Intraoperative CSF leaks during the last EEEA were graded as Grade 0 (no CSF leak), Grade 1 (small “weeping” leak without obvious or with only small diaphragmatic defect), Grade 2 (moderate leak with definite diaphragmatic defect), or Grade 3 (large CSF leak with supradiaphragmatic or clival dural defect) according to a previously described classification system[16].

The inclusion criteria for the study were (1) histopathological diagnosis of pituitary adenoma, (2) prior treatment via EEEA, (3) recurrent postoperative CSF leak after at least one failed repair and (4) reconstruction using a pedicled TMF. Patients with insufficient medical data were excluded. All patients or legal guardians provided informed consent to participate in this study. The study was approved by the Ethics Committee of Beijing Tiantan Hospital.

Surgical Procedure

Devitalized tissue surrounding the skull base defect was debrided, and the CSF leak site was precisely localized under endoscopic visualization. For harvesting of the TMF, a right-sided curvilinear frontotemporal incision was made anterior to the tragus above the zygomatic arch, extending superiorly approximately 2 cm above the superior temporal line before curving anteriorly within the frontal hairline. Interfascial dissection of the deep temporal fascia was performed to expose the temporal fat pad while preserving the frontal branch of the facial nerve. The periosteum was incised above the superior temporal line, and subperiosteal dissection was performed to mobilize the temporalis muscle. The muscle was elevated from the temporal fossa toward the zygomatic arch and released from the medial surface of the zygomatic arch while preserving the vascular pedicle.

The endoscopic transnasal transmaxillary transpterygoid approach (EETTA) was used to establish a surgical corridor between the infratemporal fossa and the nasal cavity. A right gingivobuccal incision was made followed by subperiosteal dissection of the anterior maxillary wall. A bony window was created through the canine fossa to access the maxillary sinus. The posterior wall and lateral wall of the maxillary sinus were removed to provide exposure of the pterygopalatine fossa and infratemporal fossa. The root of the pterygoid process was further drilled to enlarge the surgical corridor. Adipose tissue within the infratemporal fossa was removed, and the maxillary artery and its branches were coagulated and divided. The lateral aspect of the temporalis muscle within the infratemporal fossa was then exposed. The infratemporal crest was drilled away, and the superior head of the lateral pterygoid muscle was detached from the skull base to achieve wide exposure of the pterygomaxillary fissure.

The pedicled TMF was transposed into the nasal cavity through the infratemporal and transmaxillary corridor without torsion or excessive tension on the vascular pedicle. Autologous fascia lata was placed as the primary underlay layer to reconstruct the dural defect, and the TMF was subsequently positioned as a vascularized second layer to reinforce skull base closure and obliterate dead space. Finally, the reconstruction was buttressed with iodoform gauze packing and supported using an inflated Foley catheter balloon. The surgical procedure of pedicled TMF reconstruction is illustrated in Fig. 1.

D, Harvesting of the pedicled temporalis muscle flap E, Transposition of the pedicled TMF through the EETTA corridor into the nasal cavity F, Axial MRI showing the pedicled TMF (white arrow)

TMF=temporalis muscle flap, EETTA=endoscopic transnasal transmaxillary transpterygoid approach

Follow-up

Patients generally underwent serial contrast-enhanced magnetic resonance imaging (MRI) and endoscopic nasal examinations when feasible.

Statistical analysis

Continuous variables were summarized as medians with interquartile ranges (IQRs), whereas categorical variables were summarized as frequencies and percentages.

Results

Patient and Tumor Characteristics

A total of 8 patients were included in this study, including 2 males and 6 females, with a median age of 50.5 years (IQR, 31.0-55.5). Prior to TMF reconstruction, 6 patients had undergone one previous CSF leak repair, whereas 2 patients had undergone two repair attempts. The median interval between TMF reconstruction and the most recent CSF leak repair was 21.5 days (IQR, 12.0–31.5). At the time of TMF reconstruction, four patients had a KPS score of 90, whereas the remaining four patients had KPS scores of 80, 60, 30, and 10, respectively. No patient had an available pedicled nasoseptal flap for reconstruction.

All patients had Grade 3 intraoperative CSF leaks during the last EEEA. Skull base reconstruction was performed using fascia lata combined with fat graft in 5 patients, while the remaining 3 patients underwent reconstruction with a pedicled nasoseptal flap alone, a pedicled nasoseptal flap combined with fascia lata, or fascia lata combined with muscle graft. Bacterial meningitis was present in all patients before TMF revision repair, and concomitant fungal meningitis was identified in 3 patients.

The median preoperative tumor volume was 79.6 cm^3 (IQR, 21.9–107.9 cm^3). Most tumors exhibited extensive cavernous sinus invasion, with 7 classified as Knosp grade 4 and 1 as Knosp grade 2. All tumors were nonfunctioning PAs with suprasellar extension and third ventricular compression. Five patients had undergone two previous EEEA tumor resections, whereas one patient each had undergone one, three, and four prior EEEA resections. Additionally, three patients had a history of craniotomy for tumor resection. Four patients had a history of radiotherapy, including external beam radiation therapy (EBRT) in two patients and SRS in two patients. Patient characteristics are summarized in Table 1.

Table 1 Patient characteristics	
Characteristic	Value
Age (years)	50.5 (31.0–55.5)
Gender	
Male	2 (25.0%)
Female	6 (75.0%)
BMI	23.6 (17.8–26.1)
Preoperative KPS	
≤70	3 (37.5%)
>70	5 (62.5%)
Tumor volume(cm^3)	79.6 (21.9–107.9)
Highest Knosp grade	
2	1 (12.5%)
4	7 (87.5%)
Hormonal subtype	
Nonfunctioning	8 (100.0%)
Functioning	0 (0.0%)
Suprasellar extension with third ventricular compression	
Yes	8 (100.0%)
No	0 (0.0%)
Reconstruction technique during the last EEEA tumor resection	
Pedicled nasoseptal flap	1 (12.5%)
Pedicled nasoseptal flap + fascia lata	1 (12.5%)
Fascia lata + fat graft	5 (62.5%)
Fascia lata + muscle graft	1 (12.5%)
Prior radiotherapy	
No	4 (50.0%)
BMI=body mass index, EBRT= external beam radiation therapy, SRS= stereotactic radiosurgery, EEEA= extended endoscopic endonasal approach, TMF= temporalis muscle flap	

Table 1 Patient characteristics	
EBRT	2 (25.0%)
SRS	2 (25.0%)
Number of prior EEEA tumor resections	
1	1 (12.5%)
2	5 (62.5%)
3	1 (12.5%)
4	1 (12.5%)
Number of prior craniotomy tumor resections	
0	5 (62.5%)
1	3 (37.5%)
Number of prior CSF leak repairs	
1	6 (75.0%)
2	2 (25.0%)
Interval between current and the most recent repair (days)	21.5 (12.0–31.5)
Meningitis before TMF revision repair	
Bacterial meningitis only	5 (62.5%)
Bacterial + Fungal meningitis	3 (37.5%)
BMI=body mass index, EBRT= external beam radiation therapy, SRS= stereotactic radiosurgery, EEEA= extended endoscopic endonasal approach, TMF= temporalis muscle flap	

Clinical outcomes and complications

The median follow-up duration was 7.5 months (IQR, 3.5–21.0). Successful CSF leak closure was achieved in all patients, and no recurrent CSF leak was observed during available follow-up. One patient with a preoperative KPS score of 10 died one month after TMF reconstruction due to multiple organ failure secondary to severe fungal meningitis, without evidence of recurrent CSF leak.

Post-operative complications included frontal branch injury of the facial nerve in 1 patient, maxillary nerve (V2) injury in 1 patient, and Vidian nerve injury in 1 patient. Frontal branch injury presented with ipsilateral loss of forehead rhytids and impaired eyebrow elevation. V2 injury resulted in hypoesthesia involving the cheek, upper lip, and lateral nasal region, whereas Vidian nerve injury manifested as decreased lacrimal secretion.

Scalp wound healing was uneventful in all patients. Postoperative lumbar drainage was performed in all patients. In addition, 2 patients underwent ventriculoperitoneal shunt placement for the management of hydrocephalus. Except for the patient who died during the perioperative period, postoperative MRI and endoscopic nasal examinations were performed in all remaining patients and demonstrated a viable TMF. Representative cases are shown in Figs. 2 and 3.

TMF=temporalis muscle flap, CSF=cerebrospinal fluid, EEEA=extended endoscopic endonasal approach

TMF=temporalis muscle flap, CSF, cerebrospinal fluid, EEEA, extended endoscopic endonasal approach

Discussion

Skull base reconstruction remains a major challenge in EEEAs. The introduction of vascularized NSF reconstruction has significantly decreased the incidence of postoperative CSF leaks after EEEAs. In contemporary series of EEEAs for craniopharyngiomas using NSF reconstruction, postoperative CSF leak rates generally range from 5% to 12%, with even higher rates observed in high-risk and earlier cohorts[17, 18]. Giant invasive PAs with extensive suprasellar extension may also present substantial reconstructive challenges because they are frequently associated with aggressive suprasellar exposure, large dural defects, high-flow CSF leaks and enlarged postoperative empty sellar cavities. Reconstruction becomes even more difficult in recurrent tumors, in which a pedicled NSF is often unavailable because of prior surgery.

Successful skull base reconstruction depends on multiple factors, including watertight closure, vascularized tissue coverage, sufficient structural support and effective cerebrospinal fluid pressure control[19, 20]. In an experienced endoscopic endonasal skull base surgery center, multiple failed repairs in patients with PAs often indicate particularly complex reconstructive conditions and unfavorable patient-related factors. Persistent CSF leaks may lead to severe bacterial or fungal meningitis, resulting in progressive hydrocephalus and intracranial hypertension that further compromise subsequent skull base reconstruction. Prior to the adoption of TMF reconstruction, recalcitrant postoperative CSF leaks remained a devastating complication in our practice, and reliable repair could not always be achieved, occasionally resulting in fatal outcomes.

Notably, recurrent postoperative CSF leaks were associated with a markedly increased risk of fungal meningitis, with three patients developing Candida albicans meningitis. This high incidence of fungal meningitis may be attributable to prolonged CSF leaks, multiple failed repair attempts, repeated exposure to broad-spectrum antibiotics, and impaired host defenses. Except for the patient described above who ultimately died of severe fungal infection, the remaining two patients recovered following treatment with Amphotericin B and Fluconazole.

The TPFF represents an effective reconstructive option for recurrent cerebrospinal fluid leaks. The modified temporoparietal temporalis myofascial flap (TPTMFF) incorporates deeper fascial and pericranial layers together with a strip of contralateral temporalis muscle at the distal tip of the flap,

thereby providing increased tissue volume and structural support for resistant CSF leaks[21]. Compared with the TPFF and TPTMFF, the TMF can provide even stronger structural support owing to its substantial muscle mass while avoiding sacrifice of the contralateral temporalis muscle.

Potential complications of TMF reconstruction include injury to the frontal branch of the facial nerve, V2, and Vidian nerve during flap harvesting and transpterygoid transposition. Careful microsurgical dissection and detailed understanding of the regional anatomy are essential to minimize these complications. Despite its increased surgical invasiveness and associated morbidity, TMF reconstruction may serve as a valuable salvage option for patients with complex and recalcitrant recurrent CSF leaks after failed prior repairs, helping to prevent serious and potentially fatal complications.

In conclusion, the pedicled TMF is a reliable and effective salvage reconstructive technique for managing recalcitrant postoperative CSF leaks following EEEA for PAs, particularly when conventional vascularized intranasal flaps are unavailable.

Declarations

Conflict of interest

The authors declare that they have no conflict of interest.

Ethical approval

All procedures performed in studies involving human participants were in accordance with the ethical standards of the Ethics Committee of Beijing Tiantan Hospital and with the 1964 Helsinki

Declarations
and its later amendments or comparable ethical standards.

Funding

This study was supported by Capital’s Funds for Health Improvement and Research (2026-2-20411).

Author Contribution

C.L. and Z.L. conceived and designed the study. Z.L., Z.X., J.B., C.L., H.Z., L.C., S.C., and D.N. acquired the data. Z.L. drafted the manuscript. S.G. and Y.Z. supervised the study and critically revised the manuscript. All authors reviewed and approved the final manuscript.

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Figures

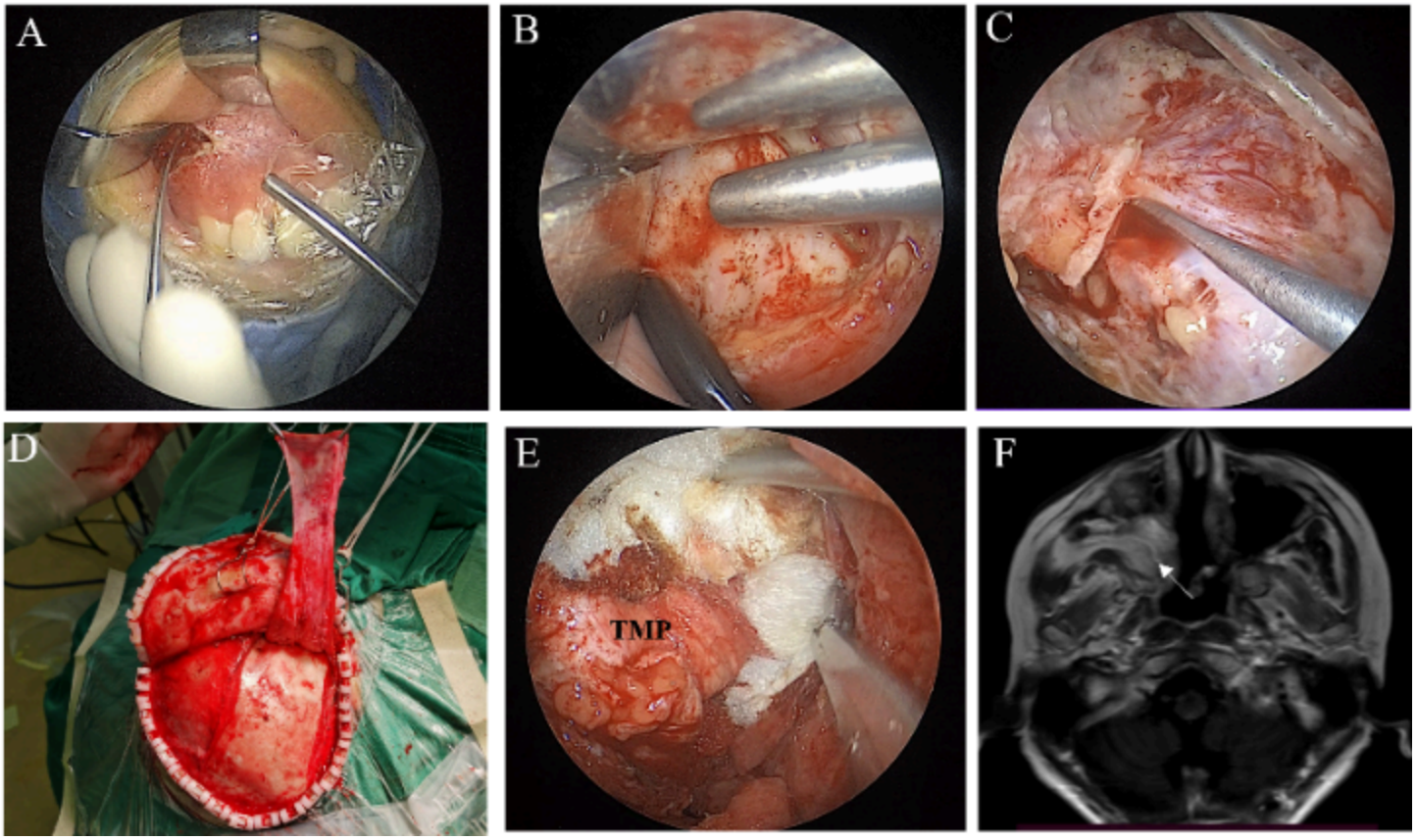


Figure 1

Pedicled TMF reconstruction. A, Gingivobuccal incision B, Exposure of the anterior maxillary wall through subperiosteal dissection C, Exposure of the pterygopalatine and infratemporal fossae following removal of the posterior and lateral walls of the maxillary sinus

D, Harvesting of the pedicled temporalis muscle flap E, Transposition of the pedicled TMF through the EETTA corridor into the nasal cavity F, Axial MRI showing the pedicled TMF (white arrow)

TMF=temporalis muscle flap, EETTA=endoscopic transnasal transmaxillary transpterygoid approach

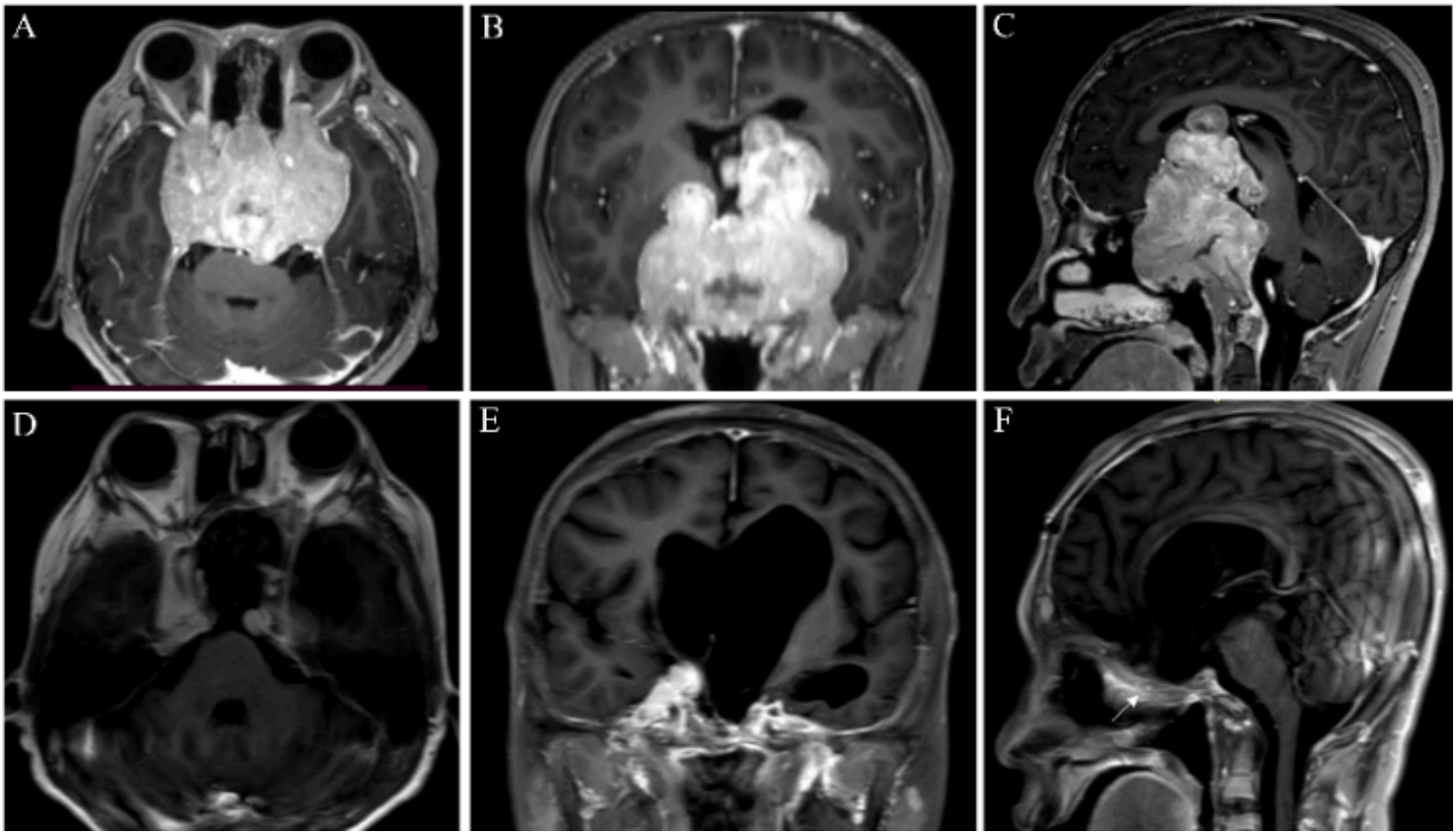


Figure 2

Case 1. TMF reconstruction for postoperative CSF leak following EEEA resection of a giant recurrent pituitary adenoma. A-C, Preoperative MRI before the last tumor resection demonstrated a giant recurrent pituitary adenoma encasing both internal carotid arteries (Knosp grade 4), with marked suprasellar extension causing compression and distortion of the floor of the third ventricle. D-F, Four-year postoperative MRI demonstrated stable residual tumor in the right cavernous sinus and enhancement of the pedicled TMF (white arrow)

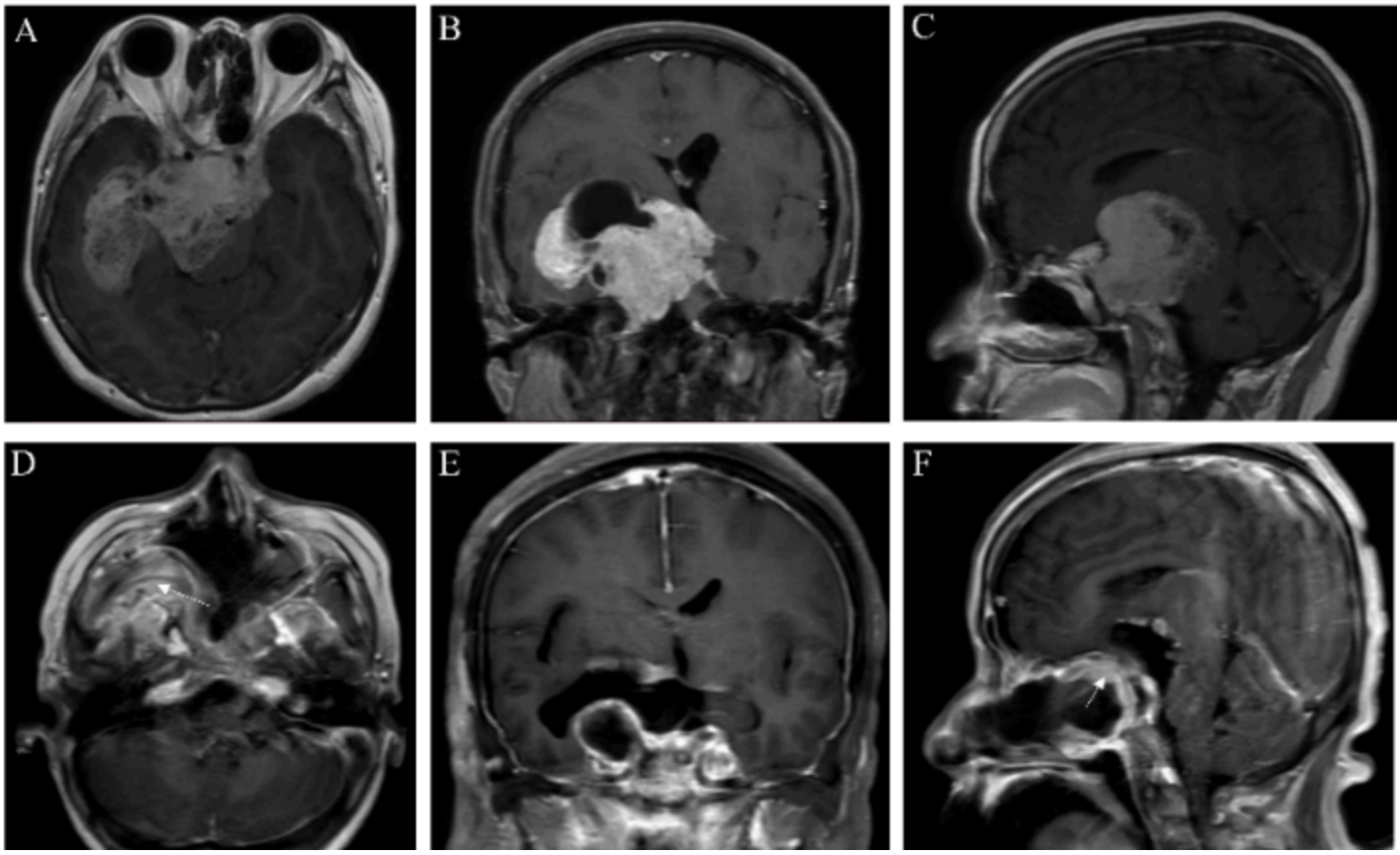


Figure 3

Case 2. TMF reconstruction for postoperative CSF leak following EEEA resection of a giant recurrent pituitary adenoma. A-C, Preoperative MRI before the last tumor resection demonstrated a giant recurrent pituitary adenoma with extensive suprasellar and right lateral extension and bilateral cavernous sinus invasion (Knosp grade 4), causing compression and distortion of the floor of the third ventricle. D-F, Three-month postoperative MRI demonstrated gross-total resection of the tumor and enhancement of the pedicled TMF (white arrow)

TMF=temporalis muscle flap, CSF, cerebrospinal fluid, EEEA, extended endoscopic endonasal approach