Significance of the simultaneous combined transcranial and endoscopic endonasal approach for prevention of postoperative CSF leak after surgery for lateral skull base meningioma

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Abstract

Lateral skull base meningiomas, particularly sphenoorbital meningiomas, sometimes extend extremely widely into adjacent structures including the paranasal sinuses. For endonasal skull base reconstruction using a vascularized nasoseptal flap for prevention of postoperative cerebrospinal fluid (CSF) leak, the simultaneous combined transcranial and endoscopic endonasal approach was applied for resection of these extensive tumors. We performed a retrospective review of four patients treated with the simultaneous combined transcranial and endoscopic endonasal approach for resection of lateral skull base meningiomas. Preoperative characteristics, tumor extent, extent of resection, complications, and postoperative outcomes were analyzed. The tumor extended into the paranasal sinus, infratemporal fossa, and pterygopalatine fossa in all patients. Extracranial extension into the cavernous sinus or superior orbital fissure was detected in two and three patients, respectively. In one patient without extension into the cavernous sinus and superior orbital fissure, gross total resection was achieved, whereas in the other three patients, subtotal resection was performed, and small residual masses of the tumor remained in the cavernous sinus or superior orbital fissure to minimize the risk of postoperative ocular nerve damage. No patients experienced postoperative CSF leak. The simultaneous combined transcranial and endoscopic endonasal approach is

useful for a subgroup of patients with lateral skull base meningiomas for prevention of postoperative CSF leak. Particularly in recurrent cases in which vascularized flaps from the transcranial side are likely unavailable due to prior tumor resection, this combined approach is worth considering depending on tumor extension into the paranasal sinus.

Keywords: combined transcranial and endoscopic endonasal approach, postoperative CSF leak, lateral skull base meningioma, nasoseptal flap

Introduction

Recently, simultaneous combination of the transcranial and endoscopic endonasal approach has been widely applied for various types of lesions located in the anterior skull base including giant pituitary adenomas, craniopharyngiomas, and sinonasal malignancies [1-3]. The main advantages of this combination for anterior skull base lesions include not only compensation for blind areas of each surgical direction but also prevention of massive postoperative hemorrhage from the residual tumor [2]. In contrast, utility of this combination for lateral skull base lesions has yet to be established.

In cases of lateral skull base meningiomas, particularly sphenoorbital meningiomas, wide extension into adjacent structures including the paranasal sinuses is sometimes observed. When the tumor extends into both the paranasal sinus and the middle fossa dura, resection of this extensive tumor significantly increases the risk of postoperative cerebrospinal fluid (CSF) leak. Based on the use of a vascularized nasoseptal flap (NSF) for reconstruction of skull base defects in cases with a high risk of postoperative CSF leak following endoscopic endonasal surgery [4, 5], we have applied the combination of the transcranial and endoscopic endonasal approach to lateral skull base meningiomas

that extend into the paranasal sinus for the purpose of aggressive surgical resection with a reduced risk of postoperative CSF leak [6].

The aim of the present study was to evaluate the utility of the simultaneous combined transcranial and endoscopic endonasal approach for lateral skull base meningiomas. We also detail the technical nuances of this combination surgery.

Materials and Methods

We conducted a retrospective review of patients who had been treated with the simultaneous combined transcranial and endoscopic endonasal approach for resection of lateral skull base meningiomas. This study was approved by the institutional review board of the University of Tsukuba Hospital.

Surgical Procedure

This combined approach involves a frontotemporal approach with a zygomatic osteotomy and an endoscopic endonasal approach. To enable simultaneous work by two surgical teams (surgeon and scrub nurse), the transcranial surgeon sat at the head end, and the endonasal surgeon stood on the right side of the patient (Fig. 1a). After induction of general anesthesia, a lumbar CSF drain was placed. The patient was placed in a supine position, with the head fixed in a Mayfield clamp with rotation of 30 degrees to the side opposite the lesion, and the neck was slightly extended. Because excessive head rotation makes endonasal surgery through the nostril difficult, the head rotation was limited to 30 degrees. This position allowed both surgeons to operate in a reasonable posture without interference. Intraoperative monitoring of the motor portion of the fifth cranial nerve was performed with the nerve integrity monitoring system.

Transcranial Approach

A frontotemporal skin incision that extended below the zygoma just anterior to the tragus was made. The skin flap was reflected anteriorly together with the superficial layer of the deep temporal fascia to avoid injury to the frontal branch of the facial nerve. After dissection of the zygomatic arch in the subperiosteal manner, the zygomatic arch was sectioned and moved downward with the temporalis muscle. The temporal muscle was then retracted inferiorly, allowing a more basal approach to the middle fossa floor. After a standard frontotemporal craniotomy was performed, the thickened hyperostotic bone around the sphenoid wing or lateral wall of the orbit was drilled out until the lateral aspect of the superior orbital fissure was reached. The meningo-orbital band was cut, and then the periosteal dura at the superior orbital fissure was cut. After identifying the cleavage plane, the dura propria of the middle cranial fossa was peeled off from the lateral wall of the cavernous sinus, so that the dura matter with the tumor could be resected. After coagulation and cutting of the middle meningeal artery, the dura propria was peeled off posteriorly along the foramen ovale and maxillary nerve. Following identification of the route of the branches of the trigeminal nerve, further drilling of the middle fossa floor including all the bone with the tumor was performed until the tumor

that extended into the infratemporal fossa and pterygopalatine fossa was largely exposed. Resection of the tumor on the medial side of the middle fossa floor or in the pterygopalatine fossa caused wide opening of the paranasal sinus that was penetrated by the extensive tumor (Fig. 2a). A tumor that extended into the infratemporal fossa and pterygopalatine fossa was mainly resected via the transcranial route. An intradural tumor was completely resected along with the tumor-involved dura matter, and the dura was repaired with a fascia lata graft (Fig. 1b, 2b). The large bone defect between the paranasal sinus and intradural space was covered with a fascia lata graft from the transcranial side (Fig. 1b, 2c).

Endoscopic Endonasal Approach

A standard endonasal approach using a rigid endoscope was performed by a neurosurgeon and otolaryngologist team. A pedicled NSF vascularized by the posterior septal branch of the sphenopalatine artery was harvested and stored in the nasopharynx. For wide exposure of the sphenoid sinus, uncinectomy, partial ethmoidectomy, and anterior sphenoidotomy were performed. In cases in which the tumor extended laterally over the vidian canal in the sphenoid sinus or the tumor extended into the maxillary sinus, the transmaxillary transpterygoid approach was employed. A tumor that extended

into the paranasal sinus was mainly resected via the endonasal route. When the tumor in the infratemporal fossa or pterygopalatine fossa tightly adhered to surrounding tissue in the blind area from the transcranial side, the tumor boundary was identified and dissected from the endonasal side. After completion of tumor resection with both approaches, the large skull base defect between the paranasal sinus and middle fossa was covered with the prepared vascularized NSF (Fig. 1b, 2d), which was fixed with fibrin glue and secured with oxidized cellulose.

Results

Patient Characteristics

Between 2016 and 2019, four patients with widely extended lateral skull base meningiomas were treated with the simultaneous combined transcranial and endoscopic endonasal approach. Patient characteristics are shown in Table 1. The mean age of the patients was 66.3 years (range, 62-70 years). Two patients were males, and two were females. Preoperative symptoms included exophthalmos in two patients and facial numbness in two patients. Three of the four patients had undergone prior transcranial tumor resection, and one patient had undergone prior endonasal tumor resection. Two of the four patients had previously received radiation therapy for the tumor. According to preoperative magnetic resonance imaging (MRI), the tumor extended into the paranasal sinus, infratemporal fossa, and pterygopalatine fossa in all patients. Extracranial extension into the cavernous sinus or superior orbital fissure was detected in two and three patients, respectively.

Postoperative Outcomes

Postoperative outcomes are summarized in Table 2. Regarding the extent of tumor resection, in one patient without extension into the cavernous sinus and superior orbital

fissure, gross total resection was achieved, whereas in the other three patients, subtotal resection was performed, and small residual masses of the tumor remained in the cavernous sinus or superior orbital fissure to minimize the risk of postoperative ocular nerve damage. Postoperative lumbar drainage was placed in three of four patients for 4–7 days. No patients experienced postoperative CSF leak after a mean follow-up of 24.4 months (range, 11.9-40.7 months). Regarding the other postoperative complications, one patient developed facial numbness that was not present preoperatively, and two patients experienced facial hypesthesia due to sacrifice of trigeminal nerve branches. Postoperative pathological diagnoses of all patients were WHO Grade I meningioma including one meningothelial meningioma and three transitional meningiomas. Three patients developed recurrences during the follow-up period; two of these patients underwent CyberKnife stereotactic radiosurgery, and one patient underwent repeat resection by an otolaryngologist for a recurrent lesion in the epipharynx 12.2 months after the combined operation.

Case Illustration

A 70-year-old man who had undergone resection for a left sphenoid wing meningioma in another hospital 3 years earlier was referred to our hospital due to findings

of growth of the residual tumor infiltrating in the middle fossa floor on follow-up MRI. Ophthalmic examination showed slight proptosis of the left eye. Gadolinium-enhanced MRI showed a large irregular homogeneously enhancing mass lesion in the sphenoid wing and orbital lateral wall that extended into the sphenoid sinus, superior orbital fissure, infratemporal fossa, and pterygopalatine fossa (Fig. 3a, b, c). Because the tumor extended into the sphenoid sinus continuously from the intradural space through the tumor-involved dura of the middle fossa, the risk of postoperative CSF leak following radical tumor resection was thought to be considerably high. After preoperative embolization using N-butyl cyanoacrylate, surgical resection via the combined simultaneous transcranial and endoscopic endonasal approach was performed. Subtotal resection was achieved in which the tumor that extended into the superior orbital fissure remained (Fig. 3d, e, f). The postoperative course was uneventful without any remarkable complications including CSF leak or ocular movement disorders; only facial numbness was present. The patient was discharged from the hospital 2 weeks postoperatively.

Discussion

Since Loyo et al. first described simultaneous combination of the transcranial and transsphenoidal approach in 1984, various combinations of the transcranial and transsphenoidal approach have been developed [7]. The combination of the transcranial (pterional or interhemispheric, or subfrontal) approach and the microscopic transsphenoidal approach was developed for giant pituitary adenomas [2, 8, 9]. The main advantages of this combination are that it avoids postoperative bleeding complications that arise from the residual tumor due to maximum tumor resection in a single stage, and the combination prevents injury to adjacent neurovascular structures by compensating for the blind area in each approach [2, 9]. In cases of a giant pituitary adenoma that extends into the lateral ventricle, the combination of the endoscopic transsphenoidal approach and the endoscopic transventricular approach has been used to mobilize and remove the tumor from the intraventricular location into the sphenoid sinus [10, 11]. In recent years, with advances in neuroendoscopic techniques, the combination of the transcranial approach and endoscopic endonasal approach has been introduced and become the established method of choice for treatment of giant pituitary adenomas [12, 13]. Thus far, the main target disease of these combination treatment strategies has been limited to anterior skull base tumors including giant pituitary adenomas, craniopharyngiomas, and sinonasal

malignancies.

A small subset of lateral skull base meningiomas, particularly sphenoorbital meningiomas, develops extremely wide extensions into adjacent structures. To achieve optimal tumor control for these extensive tumors, the importance of aggressive resection has been reported [14]. Although portions of the tumor that have extended into the cavernous sinus or superior orbital fissure are usually left behind due to the risk of cranial nerve deficits, radical resection including removal of the skull base bone that involves the tumor, dura that involves the tumor, and tumor that extends widely into the paranasal sinus, infratemporal fossa, and pterygopalatine fossa is crucial [14, 15]. When a tumor penetrates and extends into the paranasal sinus continuously from the intradural space and widely through the middle fossa, extensive drilling of the tumor-involved skull base bone along with resection of the tumor that extended into the paranasal sinus produces a large skull base defect and communication with the paranasal sinus. In addition, radical resection of the tumor-involved dura that is peeled off from the cavernous sinus lateral wall sometimes causes a dural defect that may be difficult to reconstruct to be water tight using fascia lata. In such a situation, particularly for cases in which vascularized tissue flaps using temporoparietal fascia or pericranium are unavailable due to prior surgery, the risk of postoperative CSF leak is remarkably high.

A vascularized NSF is useful for reconstructing skull base defects following endoscopic endonasal skull base tumor resection in cases with a high risk of postoperative CSF leak [4, 5]. Since the first report of successful use of an NSF for endonasal repair of CSF rhinorrhea by Hirsch in 1952 [16], various modifications have been developed for effective prevention of postoperative CSF leak. Among them, a vascularized pedicled nasoseptal mucoperiosteal flap based on the nasoseptal artery (Hadad-Bassagasteguy flap) has been used as the most reliable technique and results in a significant decrease in the incidence of postoperative CSF leak following endoscopic endonasal tumor resection [4, 5]. Because a vascularized NSF is often available for paranasal sinus wall reconstruction during resection of lateral skull base tumors as well as anterior skull base tumors, we addressed adoption of this method into surgery for lateral skull base meningiomas with extension into the paranasal sinus [6]. Thus, with respect to application of the simultaneous combined transcranial and endoscopic endonasal approach for lateral skull base meningiomas, the principal advantage is prevention of postoperative CSF leak due to endonasal skull base reconstruction using the vascularized NSF. The other advantages include avoidance of unexpected residual tumor in the blind area of the transcranial side through simultaneous observation from the endonasal side, and shortening of the operation time due to simultaneous resection of a widely extensive

tumor from different directions via two operative approaches.

Our study has some limitations. First, this was a retrospective case series. Second, this study also involved a relatively small sample size of patients who were treated with the current technique. Further investigations with a large number of patients are needed to validate the utility of this combination technique.

Conclusion

The simultaneous combined transcranial and endoscopic endonasal approach is useful for a subgroup of patients with lateral skull base tumors. Unlike anterior skull base tumors, the main advantage of this combination approach for lateral skull base tumors is prevention of postoperative CSF leak. Particularly in recurrent cases in which vascularized flaps from the transcranial side are likely unavailable due to prior tumor resection, application of this combination approach is worth considering depending on extension of the tumor into the paranasal sinus.

Figure Captions

Figure 1: Schematic diagrams.

a) Schematic diagram of the setup for combined approach. b) Schematic drawing of the reconstruction method of the large skull base defect between the paranasal sinus and middle fossa. Curved arrow shows repair of the dural defect with a fascia lata graft. Arrow shows repair of the bone defect with a fascia lata graft from the transcranial side. Arrowhead shows repair of the bone defect with a pedicled nasoseptal flap from the endonasal side.

Figure 2: Intraoperative photographs.

a) Intraoperative photograph showing the wide opening of the sphenoid sinus during tumor resection. b) Intraoperative photograph demonstrating repair of the dural defect with a fascia lata graft. c) Intraoperative photograph demonstrating repair of the large bone defect of the sphenoid sinus wall with a fascia lata graft via the transcranial route. d) Intraoperative photograph demonstrating repair of the defect of the sphenoid sinus wall with a pedicled nasoseptal flap via the endonasal route.

Figure 3: Pre- and postoperative magnetic resonance imaging.

Preoperative axial T1-weighted images with gadolinium enhancement (a, b) and a sagittal T1-weighted image with gadolinium enhancement (c) showing a large irregular homogeneously enhancing tumor in the sphenoid wing and orbital lateral wall with extension into the sphenoid sinus, superior orbital fissure, infratemporal fossa, and pterygopalatine fossa. Postoperative axial T1-weighted images with gadolinium enhancement (d, e) and sagittal T1-weighted image with gadolinium enhancement (f) showing a small residual tumor only in the superior orbital fissure. Arrows: tumor that extended into the sphenoid sinus.

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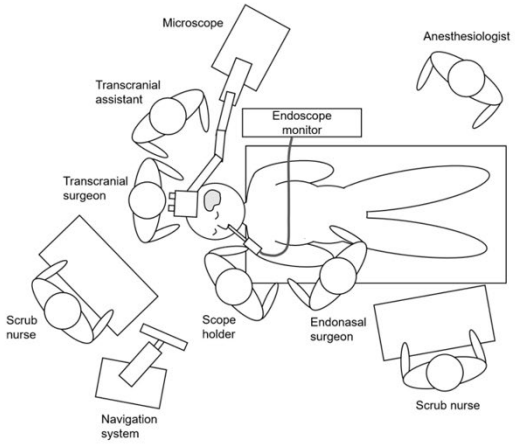
Fig. 1

a


Microscope
Anesthesiologist
Transcranial assistant
Endoscope monitor
Transcranial surgeon
Scrub nurse
Scope holder
Endonasal surgeon
Scrub nurse
Navigation system

b

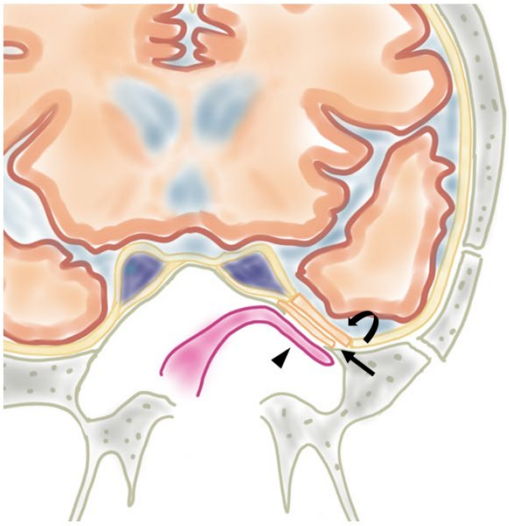


Fig. 2

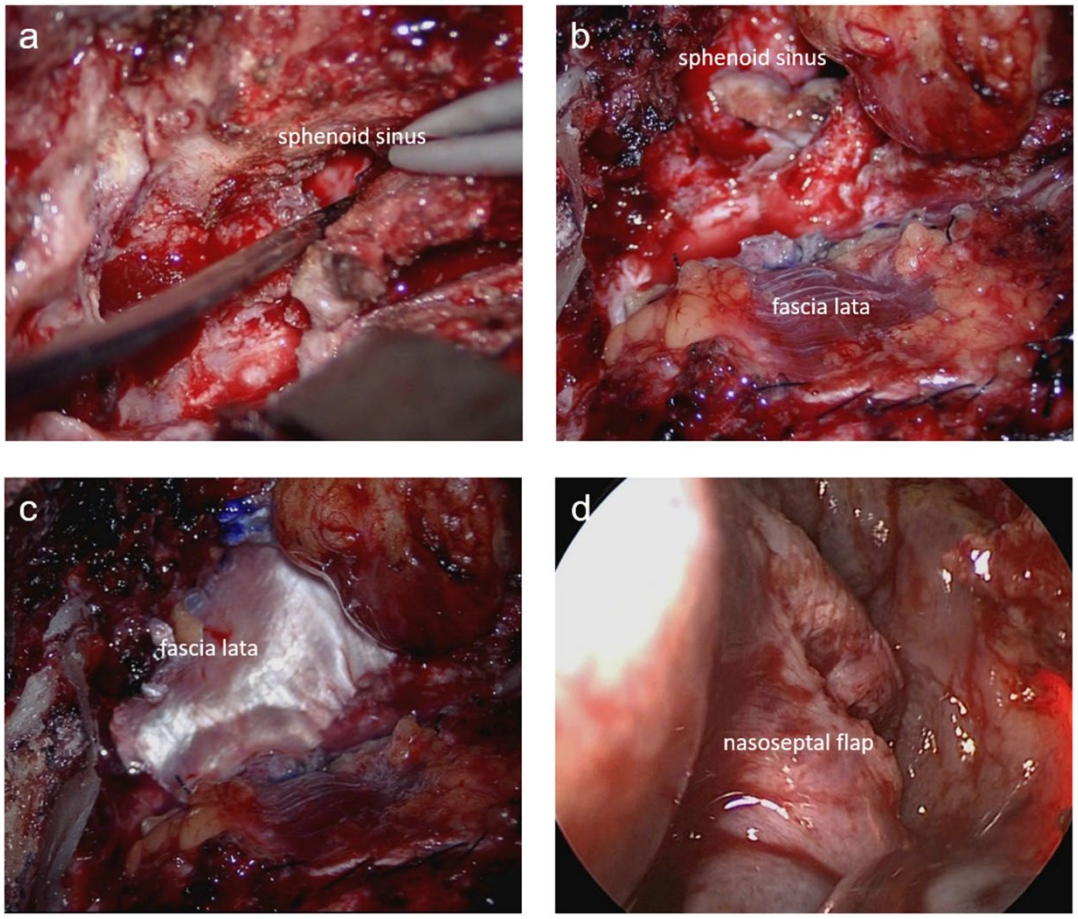

a
sphenoid sinus
b
sphenoid sinus
fascia lata
c
fascia lata
d
nasoseptal flap

Fig. 3

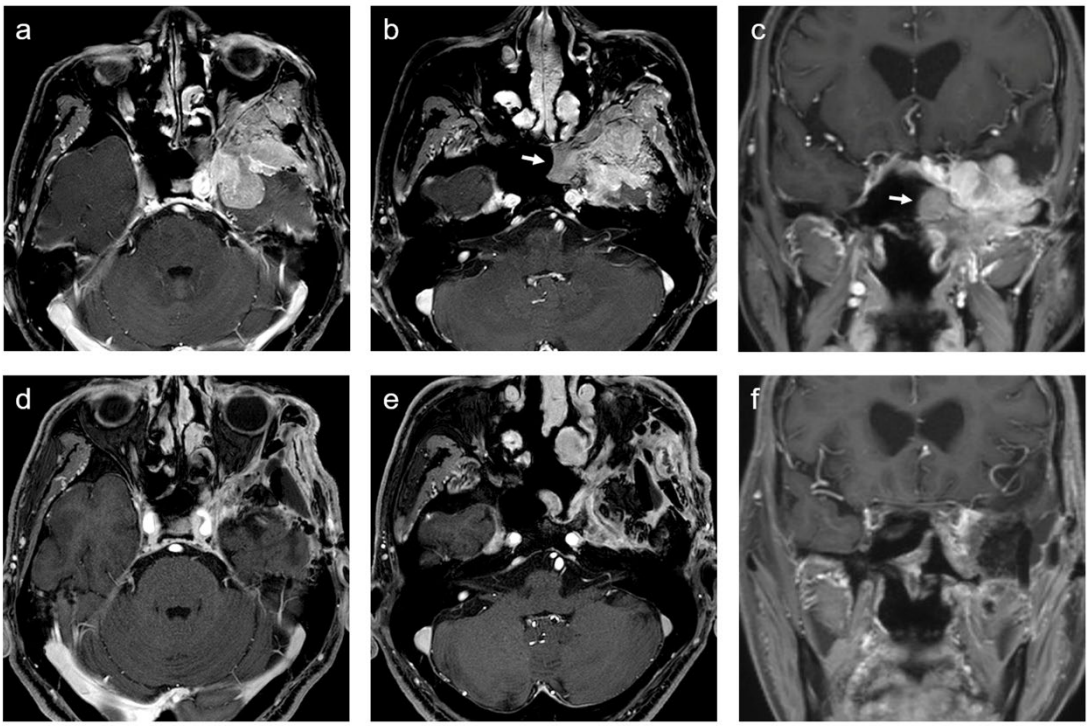


Table 1

Characteristics of the patients

Case	Age (years)	Sex	Symptoms	Prior transcranial resection	Prior endonasal resection	Prior radiation	Paranasal sinus extension	CS extension	SOF extension	PPF extension	ITF extension
1	62	M	exophthalmos	yes	no	no	sphenoid sinus	yes	yes	yes	yes
2	70	M	exophthalmos	yes	no	no	sphenoid sinus	no	yes	yes	yes
3	63	F	V2/V3 numbness	yes	yes	yes	sphenoid sinus, maxillary sinus	no	no	yes	yes
4	70	F	V2/V3 numbness	no	no	yes	ethmoid sinus, maxillary sinus	yes	yes	yes	yes

CS: cavernous sinus, SOF: superior orbital fissure, PPF: pterygopalatine fossa, ITF: infratemporal fossa.

Table 2

Operative procedures and outcomes

Case	Transcranial approach	Endonasal approach	EOR	Postoperative CSF leak	Other postoperative complication	Pathology	Recurrence	Additional treatment	Follow-up (months)
1	frontotemporal craniotomy plus zygomatic osteotomy	transsphenoidal plus transmaxillary transpterygoid	STR	none	none	meningothelial meningioma	no	none	40.7
2	frontotemporal craniotomy plus zygomatic osteotomy	transsphenoidal plus transmaxillary transpterygoid	STR	none	V2 numbness	transitional meningioma	yes	SRS	23.7
3	frontotemporal craniotomy plus zygomatic osteotomy	transsphenoidal plus transmaxillary transpterygoid	GTR	none	V2/V3 hypesthesia	transitional meningioma	yes	SRS	21.4
4	frontotemporal craniotomy plus zygomatic osteotomy	transsphenoidal plus transmaxillary transpterygoid	STR	none	V2 hypesthesia	transitional meningioma	yes	repeat resection	11.9

EOR: extent of resection, STR: subtotal resection, GTR: gross total resection, CSF: cerebrospinal fluid, SRS: stereotactic radiosurgery