—Case Reports—

Second Free Flap Surgery for Skull Base Tumors: Case Report and Literature Review

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Tumors of the skull base, such as meningiomas, tend to recur. With progress in free vascularized flap surgery, an increasing number of studies are investigating skull base reconstruction with free flaps after tumor removal. In this report, we discuss the results of second free flap surgery after skull base reconstructive surgery. We retrospectively analyzed data from patients treated at our center during the period from 2013 through 2017. All four patients identified had skull base anaplastic meningioma and had undergone radiotherapy. In all cases, the flap and donor blood vessel were sourced from sites that differed from those used in the previous surgeries. No complications developed, such as cerebrospinal fluid leakage, meningitis, wound infection, wound hemorrhage, or flap necrosis. Because the first flap was found to be unviable, it was difficult to preserve and was removed. Essential points in preventing complications are anchoring at the appropriate site, pinprick testing of the created flap, and use of multilayered countermeasures to prevent cerebrospinal fluid leakage. (J Nippon Med Sch 2019; 86: 248–253)

Key words: meningioma, skull base, free flap, cerebrospinal fluid, reconstruction surgery

Introduction

Numerous studies[1–5] have described skull base tumors invading the paranasal sinuses. Recurrence of such tumors is common[4,5], and radiation therapy or additional surgery is often required. Prevention of cerebrospinal fluid (CSF) leakage and meningitis is important[2,6,7] during skull base tumor removal, because skull base surgeries require removal of the dura and release of the paranasal sinuses. One method[2,6,8] to prevent these complications is the use of a free flap for reconstruction of the skin, dura, and supporting tissue after tumor removal. The temporal, facial, or cervical artery is often used as a donor vessel for the flap[9]. However, the tumor often recurs after reconstructive surgery, and surgical treatment in such cases is difficult[2,4,10,11].

In the head and neck region, free flap reconstructive surgery is often performed to remove the tumor[7,9,12–14]. Repeated reconstructive surgery that uses a new flap for tumor recurrence after free flap reconstructive surgery is referred to as second free flap surgery[10,11,15–18]. The purpose of the second flap is broadly classified into two types: (1) when initial (i.e., previous) tumor removal uses a free flap to close the wound and creates another free flap during a reoperation for the recurrent tumor, and (2) when using a free flap to close a wound with an initial (previous) surgical operation and then rebuilding the free flap after necrosis. These previously reported definitions were used in this study. To our knowledge, no previous study has described the use of second flaps for repairing skull base surgery. We therefore present our experience with second free flap surgery for skull base tumors.

Materials and Methods

From January 2013 through December 2017, 17, 44 surgeries (712 brain tumors) were performed at our center, among which eight were reconstructive surgeries using

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Table 1 Patient characteristics

	Age/ sex	Interval from first surgery (year)	No. of procedures	Radiotherapy regimen	Interval from radiation to second flap (year)	Pathology	WHO grade	Ki 67 (%)
1	50s/ Male	19	6	Conventional (50 Gy), cyber	5	Meningioma	II	15%
2	60s/ Male	14	9	γ-knife	8	Meningioma	I-II	20%
3	60s/ Male	12	5	Conventional (50 Gy), X, cyber	4	Meningioma	III	10-40%
4	40s/ Male	0.8	2	Conventional (spine 44 Gy), γ-knife	0.2	Meningioma	III	60%

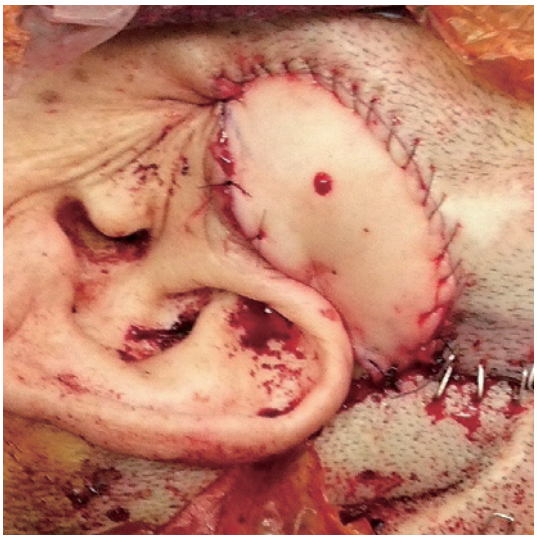

Fig. 1 Postoperative image of a skin flap around the left ear, which was formed to enable monitoring with pinprick testing.

vascular anastomosis. We ultimately included four of the secondary free flap cases (**Table 1**) in this study. We examined patient records and extracted data on age, sex, Ki 67, duration of treatment, number of previous surgeries, and interval from final radiotherapy. We also collected data on presence of potential complications, such as meningitis, CSF leakage, wound infection, and suture failure.

Basic Procedure

For the second flap surgery, we decided to remove the earlier flap, to resect the tumor-infiltrated flap and prevent prolonged wound healing. Flap removal was possible because the flap was originally an extractable tissue. Before wound closure, we washed the wound with 500 cc of normal saline to prevent infection. The dura was sutured with fibrin glue and gel foam and closed with free thigh fascia or rectal fascia, to prevent CSF leakage. Infusion of artificial CSF was performed to check for leakage. We used a free muscle flap that was sufficient to completely close the dead space and cover the dura. Skin was then transplanted to the nasal cavity or scalp. The skin flap was formed to enable monitoring by means of pinprick testing (**Fig. 1**). A new donor vessel was prepared for vascular anastomosis, and a microvascular anastomotic coupling device was used for venous anastomosis[19]. The free flap was sutured and fixed (anchoring) at the deepest part of the wound, to prevent the flap from moving from the proper position. Ipsilateral vessels closest to the wound were selected as donor vessels. We did not use the same donor vessel used in the previous surgery. When the temporal artery and vein were selected in the previous surgery, we first searched and dissected the proximal side. When these vessels were unusable, we dissected the facial artery, and then the thyroid artery and vein if the facial artery and vein were unusable. Spinal drainage was maintained for at least 3 days. During flap selection, new, previously unexplored sites were selected.

Results

All four cases were skull base meningiomas in adult males (**Table 2**), all of whom underwent radiation therapy. The follow-up period after the last second flap surgery was 26 to 51 months. After the final second flap surgery, no complications developed, including flap blood flow failure, CSF leakage, wound infection, and meningitis.

Report of Cases

Case 1

A man in his 50s presented with olfactory meningioma diagnosed after development of epilepsy, in 1997. Six reoperations, including ventricle-peritoneal shunt, had been performed during the period from 1997 through 2016, and the patient had bilateral visual dysfunction. Two years previously, reconstructive surgery using a femoral fascial and forearm flap had been performed at another

Table 2 Surgical complications and long-term outcomes

	Preoperative flap	Final flap	Donor vessel	Infection	CSF leak	Long-term outcome	Other complications	Follow-up period (month)
1	rt femoral fascia lt forearm flap	lt anterolateral thigh rt femoral fascia	Facial	-	-	Sudden death (6 months post-op)		32
2	lt thigh muscle flap	rt thigh muscle flap	Facial	-	-	No change		45
3	lt thigh muscle flap	rectus abdominis	Sup-T hyroid	-	-	cyber knife	Hypotension Venous thrombosis	51
4	rectus abdominis femoral fascia	rt anterolateral thigh lt femoral fascia	Facial	-	-	Death (disseminated spinal tumor)		26

CSF, cerebrospinal fluid; Lt, left; op, operation; rt, right.

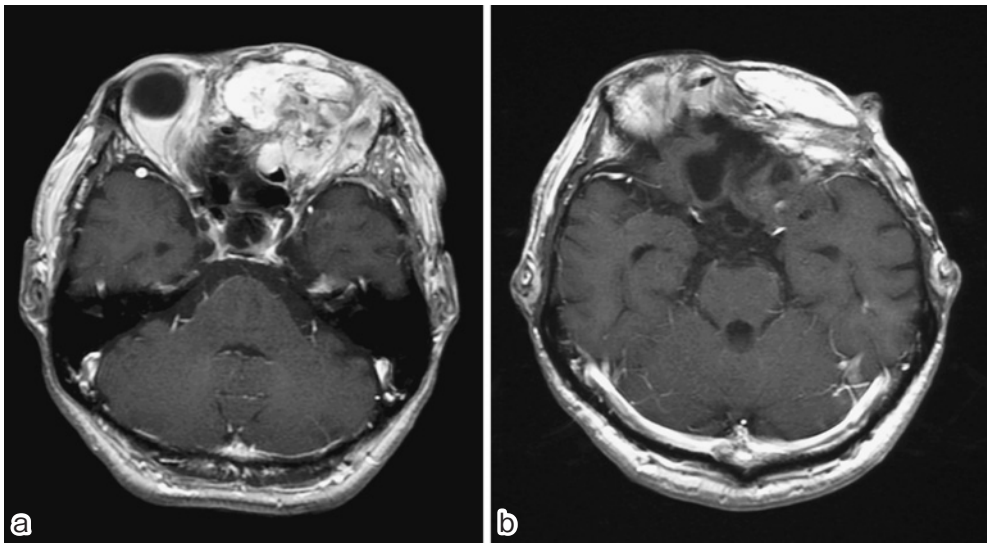

Fig. 2 a. Preoperative contrast-enhanced T1-weighted magnetic resonance image from Case 1 shows a strongly enhanced recurrent meningioma. The tumor occupies the left middle fossa, ethmoid sinus, left orbit, pituitary fossa, and maxillary sinus. Carotid arteries are encased by the tumor.
b. Postoperative contrast-enhanced T1-weighted magnetic resonance image from Case 1 on day 12 showed no enhancement and a vascularized muscle flap covering the anterior fossa, frontal sinus, and ethmoid sinus.

hospital, but the tumor recurred and invaded the frontal and ethmoid sinuses (**Fig. 2a**). In our department, we reconstructed the skull base with an anterolateral thigh flap after radical resection of the tumor. MRI on the day after surgery showed no residual tumor (**Fig. 2b**). Postoperative course was uneventful. Unfortunately, he was found dead at 6 months after surgery, and the cause of death was not determined.

Case 2

A man in his 60s presented with middle fossa meningioma diagnosed after he developed an eye movement disorder in 2002. Eight reoperations were performed during the period from 2002 to 2015. Two years previously, reconstructive surgery using a femoral fascial flap and thigh muscle flap was performed at another hospital; however, the tumor recurred and invaded the maxillary and ethmoid sinuses (**Fig. 3a**). In our department, we reconstructed the skull base by using a free thigh muscle flap taken from the contralateral side after resection of the tumor. However, an MRI on day 1 postoperatively showed residual tumor, and a reoperation was performed. The anastomosed vessels were preserved, and the ligature fixed to the deepest part was cut. The flap was moved outward, and the tumor inside the nasal cavity was carefully resected. The free flap was then sutured to the skin and re-closed (**Fig. 3b**). His postoperative course was uneventful, without development of meningitis, CSF leak, or flap failure.

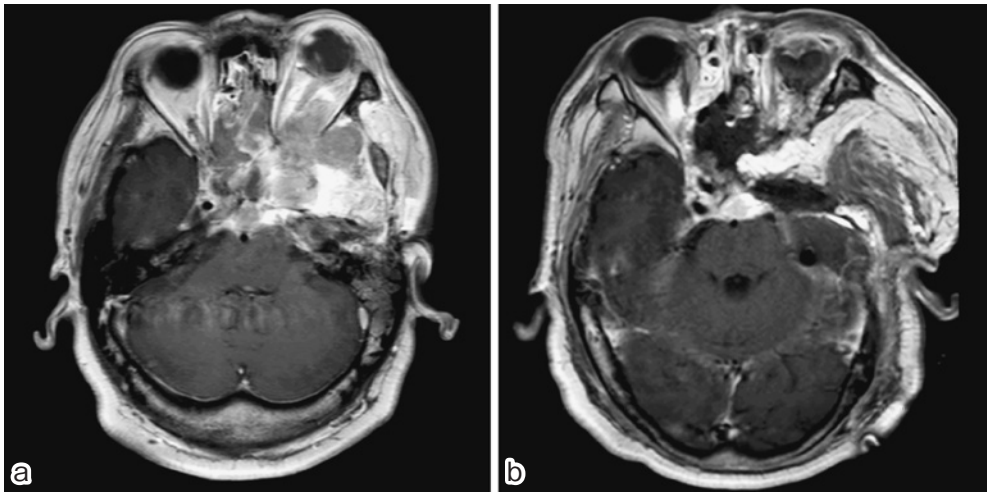

Fig. 3 a. Preoperative contrast-enhanced T1-weighted magnetic resonance image from Case 2 shows a strongly enhanced recurrent meningioma. The tumor occupies the left middle fossa, ethmoid sinus, left orbit, pituitary fossa, and maxillary sinus. Bilateral carotid arteries are encased by the tumor.
b. Postoperative axial contrast-enhanced T1-weighted magnetic resonance image from Case 2 on day 8 shows the enhanced middle fossa tumor removed and the vascularized muscle flap covering the middle fossa, ethmoid sinus, and maxillary sinus. Residual tumors can be seen at the front of the brain stem.

Case 3

A man in his 60s presented with middle fossa meningioma diagnosed after temporary aphasia, in 2002, and first surgical removal was performed. Four reoperations were performed during the period from 2002 through 2013. The patient underwent radiotherapy for tumor recurrence in the infratemporal fossa. One year previously, reconstructive surgery using a thigh muscle flap was performed at another hospital, but the tumor recurred and invaded the middle fossa. Ki67 was 14.9%. In our department, we reconstructed the skull base with a rectus abdominis flap taken from the ipsilateral side after radical resection of the tumor. The postoperative course was uneventful.

Case 4

A man in his 40s presented with intraorbital meningioma extending into the anterior fossa, which was diagnosed after development of frontal edema in 2013. Initial operations using a rectus abdominis muscle flap had been performed at other hospitals, and the pathological diagnosis was anaplastic meningioma (World Health Organization Grade III). However, follow-up MRI (**Fig. 4a**) revealed tumor recurrence in the ethmoid sinuses and spinal dissemination. In our department, we reconstructed the skull base with a free thigh muscle flap after radical resection of the tumor. Postoperative course was uneventful, with no CSF leak or flap failure (**Fig. 4b**). However, spinal cord invasion was observed, and the patient underwent radiation therapy (44 Gy) and partial removal. He died of respiratory dysfunction caused by a cervical tumor.

Discussion

We investigated surgical complications of second free flap skull base tumor surgery. In the head and neck region, the success rate of initial surgery using a free flap exceeds 95%[12,17,20,21]. However, very few studies have reported the success rate of second free flap surgery in this region[10,17,18,21,22]. Furthermore, to our knowledge no study has reported outcomes of this surgery for skull base tumors. Characteristic complications of surgery for skull base tumors, such as CSF leakage and meningitis, have not been reported for surgeries at other sites[3,6]. Therefore, the surgical results for other regions are not relevant. In the four present cases, measures to prevent complications included washing of the surgical field with a substantial volume of saline, use of multilayered CSF leakage prevention technique, postoperative spinal drainage, anchoring of the free flap, and formation of skin flaps that could be evaluated for blood flow by pinprick testing. All four patients underwent preoperative radiotherapy, but none of the abovementioned complications developed.

Regarding reconstructive surgery using a free flap lim-

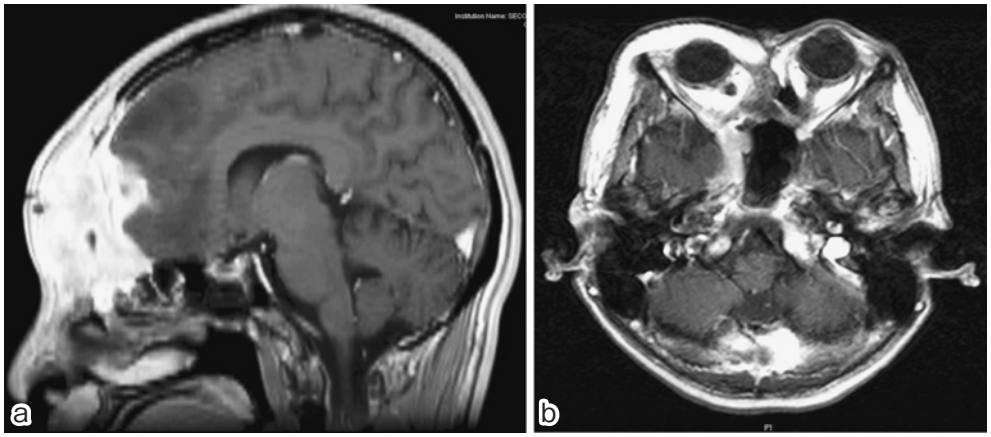

Fig. 4 a. Follow-up contrast-enhanced T1-weighted magnetic resonance image from Case 4 shows an enhancing recurrent meningioma. The tumor occupies the right anterior fossa, bilateral ethmoid sinus, right orbit, and frontal sinus.
b. At 9 months postoperatively, an axial contrast-enhanced T1-weighted magnetic resonance image from Case 4 shows no residual tumor.

ited to the skull base, Chepeha et al.[23] reported 20 cases of reconstructive surgery that used a vascularized fascial forearm flap to treat skull base tumors. Severe postoperative complications such as meningitis and subdural hematoma developed in seven patients, and venous occlusion was noted in three patients. However, the number of patients who underwent a second free flap procedure was not disclosed[23]. Very few studies[10,17,22] have reported second flap surgeries for head and neck lesions. Ross et al.[17] described their experience with second flap surgery for 123 head and neck lesions and reported a failure rate of 10%. The failure rate of second flap surgery is higher than that of initial free flap surgery. In their study[17], among patients with flap failure after the first operation, the rate of complications was significantly higher ($P < .05$) for a second flap. The most common cause of flap failure was venous rather than arterial anastomosis. Ross and colleagues reported[17] patients who underwent third and fourth free flap operations and observed that third flaps tended to fail when the second surgery had failed.

In addition to meningioma, skull base lesions requiring free flap reconstruction include squamous cell carcinoma in the sinus tract, skull base sarcoma, and severe head injury. Malignant meningioma had been diagnosed in previous surgery in all four of the present patients requiring a second flap. We attribute this to the frequency of recurrence and the characteristics of patients at our hospital. Unfortunately, because our hospital performs few skull base surgeries using free flaps for diseases other than the meningioma, we were unable to include such cases in this study. A previous study reported that a second flap is required as a cause of initial flap necrosis, even in the absence of tumor recurrence. However, this was not confirmed in the present study.

Conflict of Interest: The authors declare no conflicts of interest.

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