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Benefit of a Modified Muscle Pedunculated Pterional Craniotomy

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Abstract

The ugliness of face disproportion resulting from temporal muscle atrophy or facial nerve dysfunction is a major lasting sequela of pterional craniotomy. Now, two authors have presented promising methods to overcome the risk of facial disproportion by forming a pedunculated bone flap with the temporal muscle, however, their methods are somewhat complex and the efficacies of their methods have not been yet supported with predominance statistically yet. We modified the conventional method and developed an effective, easy alternative procedure to create a pedunculated bone flap, then evaluated the efficacy of it statistically. The following key modifications were applied: Make a curved line incision in the skin as usual and then cut the pericranium and temporal muscle along the skin incision. Dissect the subfascial space while elevating the temporal fascia, keeping it attached to the overlying scalp. Beneath the temporal muscle, create three small working spaces for an opening burr hole and a tunnel for bone cutting by dissecting a small portion of the temporal muscle from the bone surface. Remove the bone flap with the attached temporal muscle (pedunculated bone flap) and then inferoposteriorly reflect this flap. This procedure provides a wide operative field for the pterional approach. Records of 24 patients subjected to this method and 107 control patients in our centers were retrospectively reviewed. We assessed temporal muscle atrophy at two years following craniotomy by comparing the thickness of the temporal muscle of the operative side with its counterpart using CT or MRI imaging. Facial nerve dysfunction was also assessed in these patients. The ratio of the temporal muscle thickness of the operative side to its counterpart was 0.83 (median 0.84±0.12) in the new method group and 0.74 (median 0.75±0.18) in the control group. The temporal muscle atrophy rate was significantly reduced in the new method group ($p=0.03$). Facial nerve function was normal in all patients. The modified muscle pedunculated pterional craniotomy method developed herein is simple and easy in addition to providing a wide field for the pterional approach. The method prevents the future facial disproportion, which is supported by the statistical analysis.

Keywords

Temproral Muscle Atrophy, Pterional Craniotomy, Facial Nerve Injury, Pedunculated Bone Flap, Temporal Muscle Thickness

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1. Introduction

The pterional approach via pterional craniotomy is used to address many neurosurgical interventions. In the conventional strategy for pterional craniotomy, neurosurgeons create a scalp flap, keeping the temporal muscle attached by dissection between temporal muscle and the skull bone. This method is simple however, may cause atrophy of the temporal muscle and bone flap. [1, 2] Such atrophy can lead to the disproportion of the face of the patient or hollowing of the overlying skin over the enlarged pits and osteotomy line, which distresses the patient persistently. This muscle or bone flap atrophy results from injury of the temporal muscle, deep temporal artery and nerve when the temporal muscle is dissected from the skull bone. [3] Two authors have presented promising methods to overcome the risk of facial disproportion by forming a pedunculated bone flap with the

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temporal muscle. [4, 5] However, there are two remaining issues to address. The first issue is that efficacies of their methods for overcoming facial disproportion have not been yet supported with predominance statistically. They only expressed in their literature that no patients experienced paresis and all patients were pleased with the cosmetic result, with no statistical analysis.

The other issue is that their methods are somewhat complex. Forming scalp flap in Hayashi's method is based on Yaşargil's interfascial dissection method to preserve the frontal branch of the facial nerve. [4] However, dissecting the interfascial space can potentially injure the frontal branch of the facial nerve because the facial nerve may run through the interfascial space instead of through the subgaleal space, where this nerve is more commonly found. [6, 7] To avoid facial nerve injury, the fine manipulation of the scalpel is required (Figure 1). Matsumoto's method involves subfascial dissection for securer reservation of facial nerve. [3] However in this method, neurosurgeons have to overcome the cumbersome step to create two pieces of bone flap, pedunculated and free bone flap by using Gigli saw.

We modified the conventional method and developed an effective, easy alternative procedure to create a pedunculated bone flap. We evaluated the efficacy of the modified pedunculated craniotomy procedure to prevent facial disproportion compared with the previous conventional craniotomy.

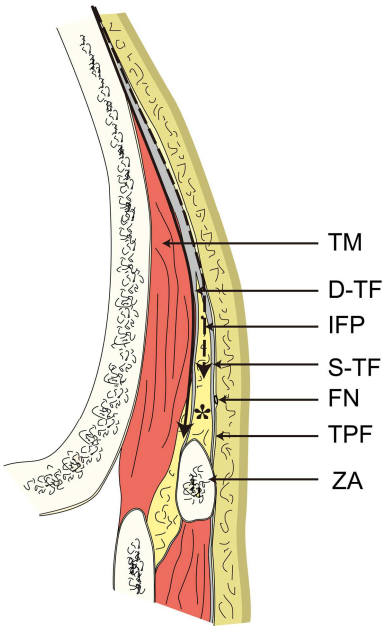

Figure 1. Schematic description of the dissection layer. A coronal section of the temporal muscle anatomy is shown. The broken line indicates the dissection between the deep and superficial fascia layers of the temporalis muscle (conventional procedure: interfascial layer dissection (*)). TPF, temporoparietal fascia; TM, temporal muscle; IFP, intermediate fat pad; D-TF, deep temporal fascia; S-DTF, superficial temporal fascia; FN, facial nerve; ZA, zygomatic arch; *, interfascial space.

2. Patients

We performed the modified method on 51 patients admitted to our center from 2005 to 2015. To retrospectively review these data, 24 of these patients were assessed for temporal muscle atrophy and facial nerve dysfunction at 2 year following craniotomy. The remaining 27 patients were excluded because of a lack of data. As a control, we assessed 107 patients who underwent conventional pterional craniotomy and fulfilled the same criteria. We measured the thickness of the temporal muscle right over the pterion using CT or MRI and calculated the ratio of the thickness on the operative side to its counterpart. All medical records were reviewed for demographic data, side of surgery, time interval between surgery and radiographic follow-up. A paired Student's t-test was used to compare the newly modified craniotomy group with the control conventional group. Differences were considered statistically significant at a p value <0.05.

3. Operative Technique

A curved line skin incision is made as usual. Next, the pericranium and temporal muscle are cut along the skin incision. The skin incision begins anterior to the tragus at the middle of the zygomatic arch, extends vertically upward to the middle of the inferior temporal line, and then extends horizontally across the midline behind the hairline. This technique can minimize the damage to the temporal muscle because the incision line is nearly parallel to the muscle fibers.

Next, the periosteum is detached from the frontal bone. The subfascial layer is dissected while elevating the temporal fascia (both superficial and deep), keeping the scalp attached (Figure 2a). This procedure does not require fine manipulation because the deep temporal fascia and temporal muscle are roughly connected, and there is no major artery or nerve in the vicinity. Then, the tight adhesion at the temporal line is detached from the skull bone and the fascia-attached scalp flap is inferiorly reflected. Three small working spaces are made by separating a small portion of muscle fiber from the bone surface using a raspatory and opening burr holes at the posterior insertion of the zygomatic arch (Key hole) at the lower limit of the skin incision on the temporal bone (Temporal hole) and at a point on the estimated cutting line on the superior temporal line (Superior temporal hole) (Figure 2b). After the three burr holes are made, a cutting burr is used to open the fronto-temporal bone along a curved line between each burr hole. The cutting line between the Key hole and the Superior temporal hole should be curved in an antero-superior direction to the midline of the orbital rim to prepare for subfrontal observation. To cut the temporal bone covered by the temporal muscle, a narrow cutting area is exposed on the

temporal bone surface along the estimated craniotomy line. For this purpose, a subperiosteal tunnel is made beneath the temporal muscle between the Key hole and the Temporal hole (Figure 2b). Care should be taken to dissect the temporal muscle in a subperiosteal direction from the bone to prevent injury to the deep temporal artery and nerve. Then, using a cutting burr, the bone is cut as far as the muscle can be elevated using a raspatory. A small cutting burr is used to make a thin line down the minor wing of the sphenoid bone, and then the bone is fractured along this line. At this step, the bone flap can be moved freely with the muscle peduncle (pedunculated bone flap). The pedunculated bone flap is inferoposteriorly reflected. This procedure provides a wide view of the pterion (Figure 2c). When a cranial window is closed, the bone flap is placed on the window and fixed with titanium screws. The incision line is sutured on the temporal fascia. Finally, the scalp and frontal periosteum are sutured together layer by layer.

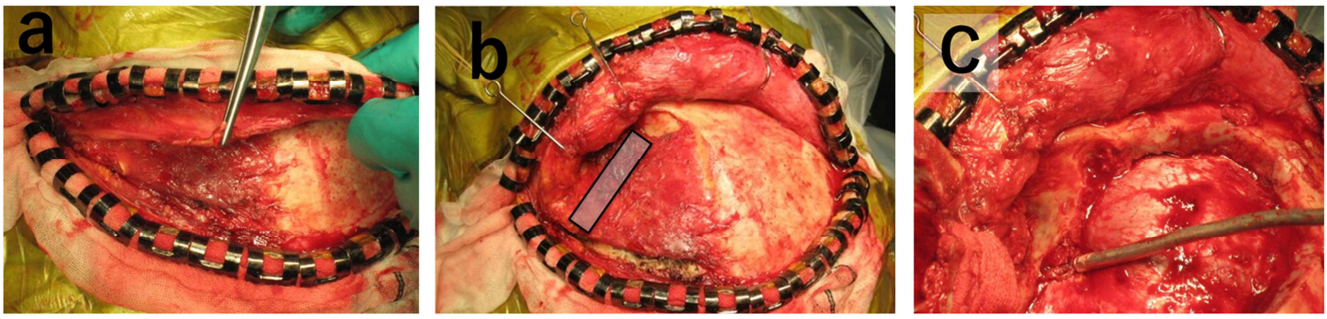

Figure 2. Operative procedure. (a) Dissection of the subfascial space. Following the skin incision, both the superficial and deep temporal fascia beneath the skin incision line were incised, and the subfascial space was dissected after elevating the temporal fascia using forceps. (b) Exposure of the temporal muscle. Both the superficial and deep layers of the temporal fascia were attached to the skin, and the temporal muscle was attached to the temporal bone. The black shadow indicates the cutting area of the temporal bone surface and the estimated craniotomy line covered with temporal muscle. To expose the narrow cutting area of temporal bone surface, a subperiosteal tunnel was generated beneath the temporal muscle between the Key and Temporal holes. (c) The pedunculated bone flap was moved backwards, and the bone flap was covered with gauze. The pterion was widely exposed.

4. Results

Among the 24 patients subjected to this new method of craniotomy, the mean thickness of temporal muscle on the operative side and its counterpart are 5.98 mm (median 5.53±2.77) and 7.20 mm (median 7.12±3.01), respectively, generating a ratio of 0.83 (0.84 ± 0.12). In contrast, among the 107 control patients, the thickness of the preceding parts was 4.84 mm (median 4.72±1.79) and 6.52 mm (median 6.24±1.75), respectively, generating a ratio of 0.74 (0.75 ± 0.18).

The difference in the ratio of the temporal muscle thickness between the two groups was statistically significant (p=0.03). The results and the remaining variables of age and gender are summarized in Tables 1 and 2. Facial nerve function was normal in all patients.

Table 1. Summary of Demographic Data.

Characteristic	Study Group	Control Group	p value
Number of patients	21	107	
Gender M. F	1.0:1.18	1.0:1.68	
Mean age	58.5 (median 60.5±13.1)	58.8 (median 61.0±12.8)	0.91
Mean interval follow-up (month)	43.8 (median 60.5±13.1)	41.1 (median 25.5±108.8)	0.92

Table 2. Summary of Results between both Groups.

	Study Group (n=24)	Control Group (n=107)	p value
Mean temporal muscle thickness of operated side (mm)	5.98 (median 5.53±2.77)	4.85 (median 4.72±1.79)	0.01
Mean temporal muscle thickness of unoperated side (mm)	7.21 (median 7.12±3.01)	6.53 (median 6.24±1.75)	0.15
Mean ratio of temporal muscle thickness of operated side to unoperated side	0.83 (median 0.84±0.12)	0.74 (median 0.75±0.18)	0.03

5. Discussion

The simple technique presented here statistically showed the predominant evidence of risk aversion for facial disproportion caused by the temporal muscle atrophy. Forming a temporal muscle pedunculated bone flap, which keeps the temporal muscle attached to the temporal bone instead of dissecting it from the bone, did not induce temporal muscle atrophy.

Temporal atrophy leads to facial disproportion and is the primary sequela following pterional craniotomy. Several authors have presented methods to prevent cosmetic deformities after pterional craniotomy using a free bone flap. [8] Horimoto et al reported a pterional approach using subfascial temporalis dissection; however, this procedure

required temporal muscle dissection from the bone. [9] Dissection between the temporal muscle and the temporal bone causes atrophy in long-term observations as a result of denervation, loss of blood supply, or muscle fiber injury. Creating temporal muscle pedunculated (keeping temporal muscle attached) bone flap will overcome the risk of temporal muscle atrophy. In the procedure to create pedunculated bone flap presented herein, only two or three small spaces and a short line segment of the temporal muscle are required for dissection from temporal bone for osteotomy. Therefore, denervation, loss of blood supply, and muscle fiber injury are avoided in this new procedure. A sufficient blood supply for the pedunculated bone flap prevents future bone atrophy, and proper positioning of the temporal muscle maintains proper muscle tension at the cranioplasty step in this method. Indeed, none of the patients who underwent the new procedure suffered from bone atrophy (data not shown). This new procedure greatly reduces the risk of cosmetic deformity after surgery. Moreover, the patients are provided another advantage to prevent trismus, which is also a sequela of conventional craniotomy. None of the patients who underwent the new craniotomy procedure suffered from trismus (data not shown). There are two authors presented the pedunculated bone flap methods. [10] These methods are promising, but require neurosurgeons a fine manipulation for interfascial dissection, or complex manipulation to create two pieces of bone flap. In our method, dissecting between the temporal muscle and the deep temporal fascia with starting from the craniotomy line is easy to perform because the temporal muscle and deep temporal fascia are roughly connected. Dissection is easy with blunt forceps or scissors, without losing the space for dissection.

The step requiring the closest attention is the cutting of the temporal bone under the temporal muscle. An artery or nerve may be present. To avoid injuring either of these structures, the muscle should be retrogradely dissected under the periosteum along the craniotomy line, and the muscle should be protected using an appropriate tool when bone cutting.

6. Conclusion

Pterional craniotomy with pedunculated bone flap statistically reduced the risk for facial disproportion caused by the temporal muscle atrophy when compared with the conventional method with free bone flap. Moreover, the modified method present herein is easier and safer than the previously reported method of pedunculated craniotomy.

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