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Osteoplastic Pterional Craniotomy: Success Rate of Surgery in Patient Aspect

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ABSTRACT

AIM: To evaluate the effect of osteoplastic pterional craniotomy on temporal hollowing and its sequelae.

MATERIAL and METHODS: A total of 97 patients who underwent pterional craniotomy for an aneurysm were analyzed retrospectively. Of these 97 patients, 63 underwent surgery via the conventional pterional approach and 34 underwent surgery via the osteoplastic pterional approach. The temporal muscle volume was calculated bilaterally on CT images obtained in the sixth postoperative month. The results obtained in the conventional and osteoplastic approaches were compared.

RESULTS: Of the 97 included patients, 45 were female and 52 were male. The mean patient age was 50.37 years. In the conventional group, 31 were female and 32 were male. In the osteoplastic group, 14 were female and 20 were male. The temporal muscle volume difference between the operated and non-operated side was not statistically significant in the osteoplastic group. However, the volume was slightly lesser on the operated side than on the non-operated side in the conventional group.

CONCLUSION: The osteoplastic pterional approach is superior to the conventional approach in preserving the muscle volume and function. Patients who underwent osteoplastic craniotomy demonstrated higher levels of satisfaction with their facial appearance compared to those who underwent craniotomy using the conventional pterional approach.

KEYWORDS: Pterional approach, Temporal muscle atrophy, Intracranial aneurysm, Cosmetic result

ABBREVIATIONS: ROI: Region of interest; **CT:** Computed tomography; **VAS:** Visual analog scale; **99mTC MDP SPECT:** Technetium-99m methylene diphosphonate single photon emission computed tomography

INTRODUCTION

Pterional approach is one of the most widely used procedures in daily neurosurgical practice (4). However, it can cause temporal hollowing and several complications such as mastication issues, cosmetic issues, and pain (5). According to most surgeons, the surgical success rate is measured by the lack of recurrence and clear postoperative images. However, cosmetic results and quality of a patient's social life are also important factors.

The pterional approach has been used in several cadaveric studies (17). However, clinical studies that measure the temporal muscle volume and function following the pterional approach are limited (4).

The osteoplastic craniotomy was first described by Schlitt et al. for small frontotemporal craniotomies (13). Osteoplastic pterional approach has its own complications such as postoperative hemorrhage and infection (6). In this study, we evaluated the complication rates among the participants.

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Nowadays, cost effectiveness is an important concern. Several studies have used the plate-screw system for the cranioplasty via the pterional approach (3,7,9). However, in this study, we used silk-based sutures instead of a plate-screw system for the cranioplasty to lower surgical expenses.

MATERIAL and METHODS

The ethics committee approved the study (Date: 20.06.2023; No: 218499048).

A total of 152 patients who were admitted to the Umraniye Training and Research Hospital with a non-traumatic subarachnoid hemorrhage between December 2018 and December 2020 were retrospectively evaluated. Patients who had undergone surgery for an aneurysm and met the inclusion criteria were included in the study. Patients who had temporal artery or facial nerve disruption, in whom CT scans were not obtained in the sixth postoperative month, or who had severe comorbidities (such as resistant diabetes mellitus and hypertension) and were bedridden were excluded. Other patients who were excluded are listed in Table I. The included patients were divided into two groups: the conventional pterional approach group, where temporal muscle mobilization without bone was performed, and the osteoplastic pterional approach group, where temporal muscle mobilization with a bone flap was performed. The conventional and osteoplastic approaches are depicted in Figure 1. The temporal muscle volume was calculated on CT images obtained in the sixth postoperative month using OsiriX MD software. The regions of interest (ROI) were defined in multiple slices in the operated and non-operated sides in each patient. The temporal muscle volume was calculated bilaterally (Figure 2). Differences in the muscle volumes were used to calculate temporal muscle atrophy. Subsequently, the volumes were compared between the two approach groups using IBM SPSS (version 25.0). All the operations were performed by the same surgical team and with the same surgical factors, such as surgical equipment, surgical microscope, and operating room. Radiologic measurements were performed by two researchers separately, and the mean of the measurements was used for statistical analyses.

Table I: Exclusion Criteria

Severe comorbidities (resistant diabetes mellitus, resistant hypertension, bedriddency etc.)
Patients without a CT scan at 6 months postoperatively
Temporal artery or facial nerve disruption

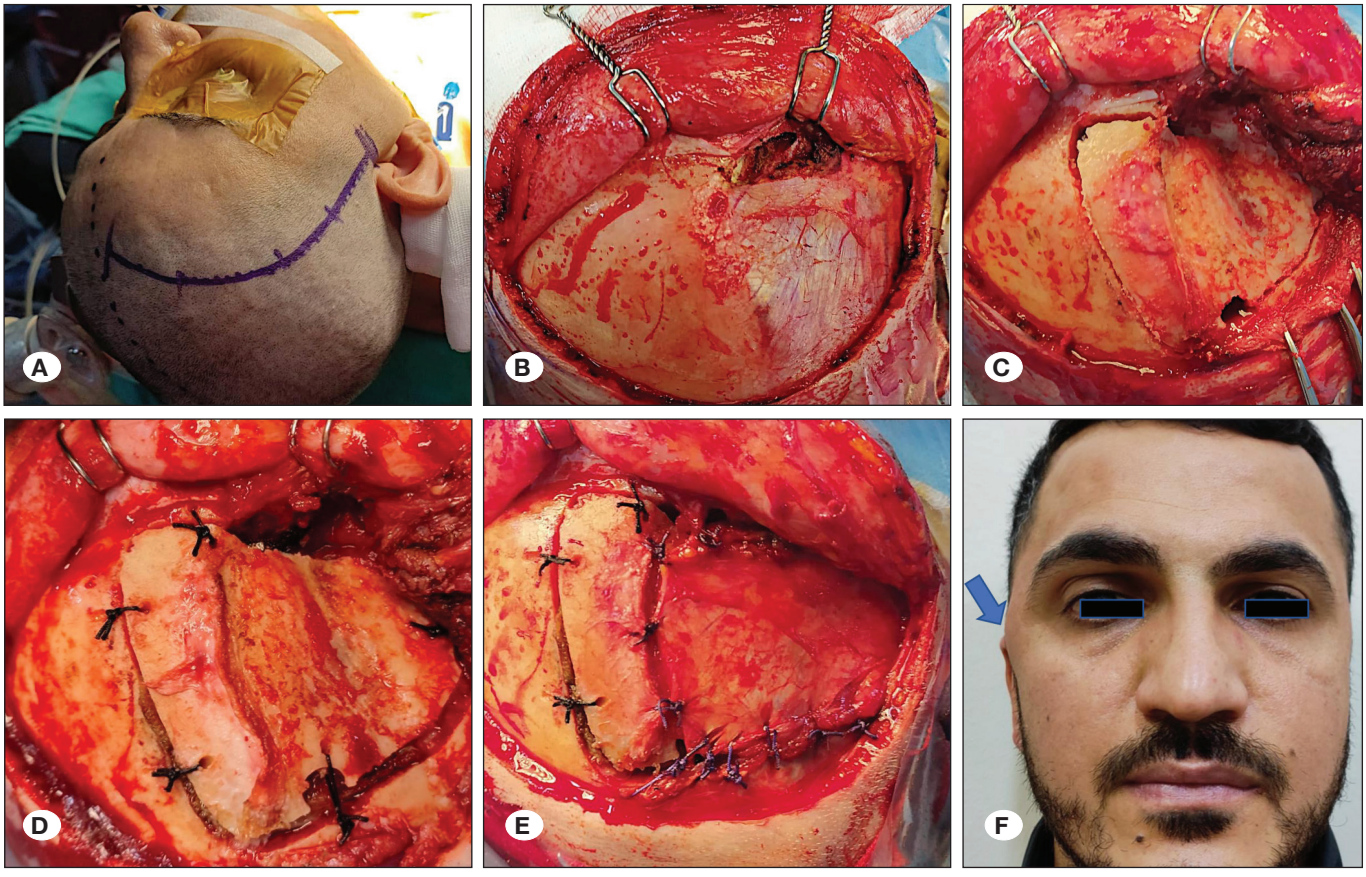

Figure 1: Conventional pterional craniotomy. **A)** Skin incision. **B)** Step before muscle dissection. **C)** Craniotomy with three burr holes. **D)** Stabilization of the bone flap after surgery using silk-based sutures. **E)** Muscle flap replacement during closure. **F)** Clinical image of a patient 6 months after surgery. Arrow head shows temporal muscle disorganization due to muscle atrophy. The patient developed issues with mastication.

Each patient's psychological status and degree of happiness were evaluated using the visual analog scale (VAS). The patients were asked about how they feel about their appearance after surgery, and they graded their response on a scale from 0 to 10 (0 indicated "I hate my appearance" and 10 indicated "I am happy with my appearance").

Surgical Procedure

We used 2 different types of cranial opening in this study in order to conventional and osteoplastic pterional opening. In conventional pterional cranitomy is shown in Figure 1. The skin incision is same in both of conventional and osteoplastic pterional craniotomy (Figure1A, Figure 2A). The underskin tissue is dissected to expose temporal muscle and interfascial opening is used to preserve facial nerve (Figure 1B). The temporal artery is preserved for blood supply. Temporal muscle is dissected from bone and small muscle cuff is left behind to suture when closing procedure (Figure 1C). 3 burr holes are opened for craniotomy (Figure 1C). Craniotomy is performed. Bone flap is sutured by silk based sutures in closing procedure (Figure 1D). Temporal muscle is sutured by small muscle cuff which is left behind (Figure 1E).

In osteoplastic pterional approach we used the same skin incision (Figure 2A). Interfascial opening is used to preserve fascial nerve and temporal artery is dissected carefully to prevent any laceration (Figure 2B). 2 burr holes are performed, 1 of them is on keyhole and other is on the nearest point to base of the cranium (Figure2C). The bone between the burr holes is removed by Kerrison rongeur to ease the breaking of bone. The bone flap is removed with temporal muscle together by breaking the bone between 2 burr holes (Figure 2D). The bone-muscle flap is replaced with silk sutures after the operation (Figure 2E).

Statistical Analysis

All statistical analyses were performed using Statistical Package for the Social Sciences (SPSS) (version 25.0; IBM Corp., Armonk, NY, USA). Descriptive data are expressed as numbers, percentages, means, and standard deviations. Quantitative comparisons between the groups were performed using the independent samples t-test. Categorical comparisons were performed using the chi-square test. The relationship between two continuous variables was analyzed using Pearson correlation analysis. The results were evaluated at 95% confidence interval, and statistical significance was set at $p<0.05$.

Figure 2: Osteoplastic pterional approach. **A)** Skin incision. **B)** Step before the craniotomy. **C)** After the craniotomy. **D)** Breaking the base of the temporal side (star indicates the bone flap along with the temporal muscle). **E)** bone-muscle flap placement during closure. **F)** Clinical image of the patient 6 months after surgery. The patient has no complaints regarding physical appearance or function, such as issues with mastication.

RESULTS

The age of the study participants ranged from 28 to 77 years, with a mean age of 50.37 ± 10.98 years. Approximately 46.4% were females and 53.6% were males. There was no statistically significant difference between the muscle volume measurements obtained by the two researchers. There was no statistically significant difference in the patient's age and sex between the two study groups (p>0.05) (Table II).

In the conventional pterional approach, the mean muscle volume difference ratio of the surgical and non-surgical sides was 31.88 ± 22.46. This was statistically significantly higher than the mean (8.15 ± 8.83) in the osteoplastic pterional approach (t=7.392, p<0.001) (Table II).

Patients who underwent surgery via the conventional pterional approach had a statistically significantly lower satisfaction level with their external appearance than patients who underwent surgery via the osteoplastic pterional approach (mean ± SD, 4.44 ± 1.76 vs. 6.79 ± 1.57) (t=6.512, p<0.001) (Table II).

In both the approaches, the mean muscle volume in women was statistically significantly lower than that in men (conventional pterional, 7.96 ± 4.48 vs. 12.11 ± 4.71, t=3.588, p=0.001; osteoplastic pterional, 10.21 ± 2.79 vs. male=15.09 ± 3.15, t=4.660, p<0.001) (Table III).

There was no statistically significant difference in the ratio of muscle volume difference between the operated and non-operated sides and the satisfaction with the external appearance based on sex between the two study groups (p>0.05) (Table III).

There was a statistically significant negative correlation (r=–0.248, p=0.014) between muscle volume and age in both groups. Additionally, there was a statistically significant positive correlation (r=0.335, p=0.001) between age and satisfaction with external appearance (Table IV).

In all patients (r=–0.605, p<0.001) and patients in the conventional approach group (r=–0.520, p<0.001) there was a statistically significant negative correlation in the volume difference ratio between the operated and non-operated sides (Table IV).

There was no statistically significant correlation between the patients age and level of satisfaction with the external appearance (p>0.05) (Table IV).

None of the patients in the osteoplastic group developed postoperative hemorrhage. Three patients in the conventional group developed postoperative hemorrhage; of these patients, two developed epidural hemorrhage and one developed subdural hemorrhage.

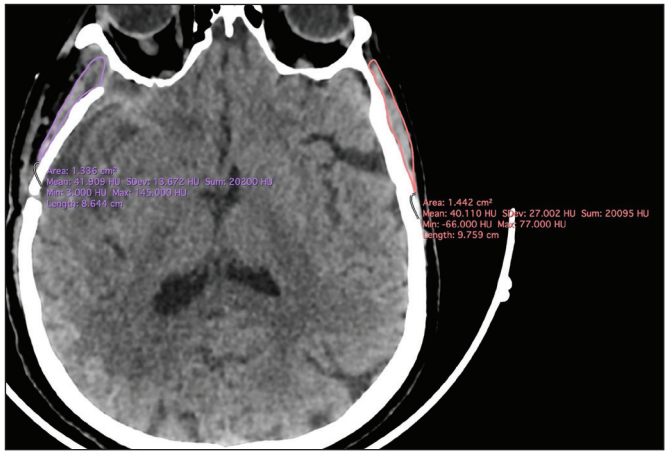

Figure 3: Temporal muscle volume calculation using OsiriX MD. Details are included in the materials and methods section.

Table II: Patient Characteristics (n=97)

		All (n=97)	Conventional Pterional Approach (n=63)	Osteoplastic Pterional Approach (n=34)		
Variables	**Category**	**n (%)**	**n (%)**	**n (%)**	**χ2/t**	**p-value**
Gender	Female	45 (46.4)	31 (49.2)	14 (41.2)	0.295[a]	0.587
	Male	52 (53.6)	32 (50.8)	20 (58.8)		
Age	**Mean (SD)**	50.37 (10.98)	50.52 (10.78)	50.09 (11.50)	0.186[b]	0.853
Localization side	Right	62 (63.9)	40 (63.5)	22 (64.7)	0.000[a]	1.000
	Left	35 (36.1)	23 (36.5)	12 (35.3)		
Surgical side muscle volume	**Mean (SD)**	11.12 (4.84)	10.07 (5.02)	13.08 (3.84)	**3.051[b]**	**0.003***
Non-surgical side muscle volume	**Mean (SD)**	15.29 (6.87)	15.88 (7.99)	14.19 (3.90)	1.401[b]	0.164
Difference in muscle volume of the surgical and non-surgical side	**Mean (SD)**	23.56 (21.95)	31.88 (22.46)	8.15 (8.83)	**7.392[b]**	**<0.001***
VAS	**Mean (SD)**	4.44 (1.76)	4.44 (1.76)	6.79 (1.57)	**6.512[b]**	**<0.001***

= *p<0.05, a(χ2)=Chi-Square Test, b(t)=Independent Samples t Test,* ***SD: *Standard Deviation*

Table III: Patient Characteristics by Gender (n=97)

		All (n=97)	Conventional Pterional Approach (n=63)	Osteoplastic Pterional Approach (n=34)		
Variables	**Gender**	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**	**t**	**p-value**
Surgical side muscle volume	Female	8.65 (4.13)	7.96 (4.48)	10.21 (2.79)	1.730	0.091
	Male	13.26 (4.40)	12.11 (4.71)	15.09 (3.15)	**2.733**	**0.009***
	t	**5.287**	**3.588**	**4.660**		
	p	**<0.001***	**0.001***	**<0.00***		
Difference in muscle volume of the surgical and non-surgical side	Female	24.60 (22.52)	31.05 (23.94)	10.30 (8.65)	**4.250**	**<0.001***
	Male	22.67 (21.63)	32.68 (21.28)	6.65 (8.85)	**6.122**	**<0.001***
	t	0.430	0.285	1.194		
	p	0.668	0.777	0.241		
VAS	Female	5.07 (2.11)	4.23 (1.84)	6.93 (1.38)	**4.897**	**<0.001***
	Male	5.44 (1.95)	4.66 (1.68)	6.70 (1.72)	**4.233**	**<0.001***
	t	0.909	0.971	0.412		
	p	0.366	0.335	0.683		

***:** *p<0.05,* ***t:** Independent Samples Test,* ***SD:** Standard deviation,* ***VAS:** Visual analogue scale.*

Table IV: The Correlation Between Age and Satisfaction of Facial Appearence Level and Muscle Volume Measurements

		All (n=97)		Conventional Pterional Approach (n=63)		Osteoplastic Pterional Approach (n=34)	
Variables	**Test**	**Age**	**VAS**	**Age**	**VAS**	**Age**	**VAS**
Surgical side muscle volume	r	**-0.248**	**0.335**	-0.243	0.226	-0.289	0.181
	p	**0.014***	**0.001***	0.055	0.075	0.098	0.306
Difference in muscle volume of the surgical and non-surgical side	r	0.194	**-0.605**	0.238	**-0.520**	0.209	-0.184
	p	0.057	**<0.001***	0.061	**<0.001***	0.236	0.298
VAS	r	-0.046	-	0.226	-	0.177	-
	p	0.657	-	0.075	-	0.316	-

***:** *p<0.05,* ***r:** Pearson Correlation.*

DISCUSSION

This study showed that the osteoplastic pterional approach is better than the conventional pterional approach for preserving muscle volume. The pterional approach is used commonly in daily neurosurgical practice. It is used in aneurysm-related and neurooncological surgeries, as well as in emergency conditions such as epidural and subdural hemorrhages (4). According to a neurosurgeon, surgical success rate may be related with aneurysmal clipping, tumor resection rate, or saving the life of a patient. However, the cosmetic results and facial appearance following surgery are important to the patient. Temporal hollowing is criticized in the field of plastic and reconstructive surgery; however, studies on temporal hollowing are limited in the field of neurosurgery (15,16). If the appropriate approach is followed, the patient will not require a secondary surgery to reconstruct the impaired facial symmetry.

Studies on temporal hollowing have been mostly based on measuring the muscle thickness on CT images (6,7). Furthermore, the flap viability has been assessed using 99mTC MDP SPECT, which has shown that osteoplastic flaps have approximately three times the metabolic activity of free flaps at the flap center and almost twice the activity at the flap border (14).

In this study, the muscle volume was calculated using OsiriX MD instead of only measuring the muscle thickness.

Although the exact cause of temporal hollowing remains unknown, some studies indicate that the interfascial opening and preservation of the temporal artery prevent temporal hollowing (2,10). In this study, patients in whom the temporal artery or facial nerve was disrupted were excluded. Thus, future studies are required to assess how preservation of the temporal artery and facial nerve affect our study results.

Postoperative hemorrhage, especially epidural hemorrhage, can occur after osteoplastic pterional craniotomy (6). In our study, only three patients (3.09%) developed postoperative hemorrhage; however, they had all undergone surgery via the conventional pterional approach. None of the patients in the osteoplastic group developed postoperative hemorrhage. At our center, the hemovac drain system is used in every case and strict hemostasis is achieved at the end of the surgery to prevent postoperative hemorrhage.

When performing additional postoperative surgeries, the osteoplastic pterional approach is reportedly superior to the conventional approach. In a recent study involving 202 patients, the frequency of infection was the same in both groups; furthermore, free flaps were removed more often. Additionally, the osteoplastic technique was associated with better healing than the conventional approach (12). In another study, 24 (17%) patients who underwent conventional craniotomy developed infections; however, there were no infections in the osteoplastic cohort (1).

In our study, the patients were more satisfied with their facial appearance in the osteoplastic group than in the conventional group. In a recent study that assessed patient satisfaction, patients who underwent temporal augmentation surgery, which protects the temporal muscle thickness, were more satisfied than those who underwent non-augmented pterional craniotomy (7). In another recent study, the osteoplastic approach produced better cosmetic results than the conventional approach in terms of achieving a symmetrical temporal is muscle; additionally, the osteoplastic approach was associated with better mouth opening (14).

In most previous studies, a screw-plate system has been used during closure (7,11,15). In this study, we used silk-based sutures during closure in all the study patients. There were no suture-related complications in the conventional or osteoplastic group. In a recent study, the use of silk-based sutures for closure eliminated the costs incurred by free bone flaps for cranial fixation and reduced the possibility of bone flap subsidence as it is anchored, in its entirety, to the overlying skin (8).

Patients with hypertension, diabetes mellitus, and other severe comorbidities were excluded from this study to achieve clear analyses and results. The presence of comorbidities are reportedly related with temporal hollowing (7). Bone-to-bone ossification and temporal hollowing in patients with severe comorbidities should be investigated in future studies.

Our study has some limitations, such as the small number of patients included and lack of information regarding the procedure's cost effectiveness. Future studies are required to assess the cost effectiveness of the cranioplasty techniques.

CONCLUSION

Our study results indicate that the osteoplastic pterional approach is superior to the conventional pterional approach in preserving muscle volume and function. Patients who underwent osteoplastic craniotomy demonstrated higher levels of satisfaction with their facial appearance compared to those who underwent craniotomy using the conventional pterional approach.

AUTHORSHIP CONTRIBUTION

Study conception and design: EV, AG

Data collection: FA, SOA

Analysis and interpretation of results: FA, AFR

Draft manuscript preparation: FA, MUE

Critical revision of the article: MUE, CKY, AG

Other (study supervision, fundings, materials, etc...): CKY, AG, EV, AG, MRO

All authors (EV, FA, MUE, AFR, SOA, AG , MRO, CKY) reviewed the results and approved the final version of the manuscript.

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