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Clinical Article

Cosmetic outcome after electrocautery versus non-electrocautery dissection of the temporalis muscle for pterional craniotomy

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Objective: Despite the usefulness of pterional craniotomy (PC), its cosmetic outcome is questionable. Electrocautery (EC) causes injuries to adjacent structures, and it could be a factor that affects the cosmetic outcome. Evaluation of cosmetic outcome is difficult because it is often determined by patient's subjective criteria. The objective of this study is to compare the cosmetic outcome after EC versus non-electrocautery (NEC) dissection of the temporalis muscle for PC by analyzing long-term follow-up data determined from both physician and patient's aspects.

Methods: Patients at follow-ups between January 2014 and April 2021 after PCs were enrolled. The keyhole (KH) site, the inferior margin of the temporal line of the frontal bone (ITL), the mid-temporal (mid-T) area, and the posterior incision line (PIL) were inspected by a physician to check the presence of depressions. Patient's cosmetic satisfaction was categorized into satisfactory, intermediate, or unsatisfactory by a survey. The presence of osteolysis was checked from the radiological images. Patients were classified into two groups; one with EC dissection and another with NEC retrograde dissection using a double-ended dissector.

Results: The incidences of depression at the mid-T area and osteolysis were higher in the EC group (p=0.001, $p<0.001$). The percentage of satisfactory cosmetic outcome was lower in the EC group (p=0.002). The presences of depression at the mid-T area and osteolysis were related with lower rate of satisfactory outcomes ($p<0.001$, $p<0.001$).

Conclusions: NEC dissection causes less destruction to adjacent structures and brings better cosmetic outcome after PC.

Keywords Cosmetic outcome, Electrocautery, Osteolysis, Pterional, Temporalis

INTRODUCTION

Pterional craniotomy (PC) is one of the most frequently performed surgical approaches in the neurosurgical field, and it has been utilized for exposing various intracranial lesions including aneurysms, vascular malformations, and tumors.[12)14)] Despite the proven efficacy and usefulness of this surgical approach, many have raised questions on its cosmetic outcome.[2)11)12)14)] Disfigured appearance in front of the hair line tends to be easily exposed on the forehead, and it often causes cosmetic complex from the patient's aspect. Undesirable cosmetic outcomes are mainly caused by bony defect, temporalis muscle atrophy and/or displacement, and other soft tissue thinning. They could be noticed early but, more frequently, months after PC due to gradual progression of atrophy and resolution of soft tissue swelling. The frequent cosmetic disfigurements are a focal depression at the keyhole (KH) site, a linear depression along the inferior margin of the temporal line of the frontal bone (ITL), and a diffuse mid-temporal (mid-T) hollow (Fig. 1).[8)12)14)]

Fig. 1. A photograph of a patient after pterional craniotomy shows a focal depression at the keyhole site (black arrow), a linear depression along the inferior margin of the temporal line of the frontal bone (white arrowheads), and a diffuse mid-temporal hollow (asterisk).

Many modifications and specific techniques have been added to the classical PC to enhance the cosmetic outcome by minimizing the anatomical destruction and maximizing the anatomical reconstruction. Myocutaneous (MC) flap, creating the temporalis muscle and scalp as one flap, minimizes the extent of surgical manipulation on the temporalis muscle and reduces the risk of facial nerve injury.[3)9)12)] Several reports introduced methods for anatomical restoration of the temporalis muscle to its original attachment site.[2)12)15)] Some authors focused on specific techniques to reconstruct the defect at the MacCarty's KH site.[8)]

Use of electrocautery (EC) for dissection could also be one of factors that affect the soft tissues including the temporalis muscle and maybe the skull by denervation, devascularization, and direct tissue injury.[4)6)11)14)] Oikawa et al. introduced a technique called retrograde dissection of the temporalis muscle without use of EC and reported good cosmetic outcomes in 100 patients, but no statistical or comparative analyses were available.[11)] Hwang et al. conducted MRI volumetric analysis on the temporalis muscle and concluded that EC does not contribute significantly to muscle atrophy, but there were no direct comparisons between the groups of EC versus non-eletrocautery (NEC) dissection for identical procedures.[4)] Moreover, the EC dissection may influence not only the temporalis muscle but also other soft tissues and even bone tissues.[4)] Such volumetric measurements of the temporalis muscle have limitations because they cannot evaluate the cosmetic disfigurement caused by displacement or change in its alignment. In addition, the cosmetic outcome is often determined by patient's subjective criteria. For instance, a gradual depression of mild to moderate degree over diffuse area may be noticed less easily than a focal and abrupt depression with loss of only small volume. Therefore, the objective numeric result does not always correlate with the cosmetic result from the patient's aspect.

This study was conducted to compare the cosmetic outcome after EC versus NEC dissection of the temporalis muscle for PC. In this study, simplified data from physician's visual inspection and results from survey

on patient's cosmetic satisfaction were used to evaluate overall cosmetic outcome instead of numeric measurements of certain specific structures, and the radiological images were also reviewed.

MATERIALS AND METHODS

Patient enrollment and data collection

Patients who visited the outpatient department (OPD) at our institute between January 2014 and April 2021 for follow-ups after PCs were candidates for this study. All of them underwent PCs performed by the primary surgeon (YS Lee). In our institute, MC flap was routinely used for exposure, and reconstruction of KH defect and reconstruction of the temporalis muscle to its original attachment site were also routinely performed for closure. The patients who did not undergo such routine procedures were all excluded. Cosmetic outcomes were evaluated at OPD by physician's visual inspection and survey on patient's cosmetic satisfaction at least six months after the surgery, and then the latest radiological images were reviewed. Naturally, the patients who were lost to regular follow-ups and those with follow-ups before six months after the surgery were all excluded. Those with not enough cognitive function or mental status to participate properly in the survey were also excluded. The KH site, the ITL, the mid-T area, and the posterior incision line (PIL) where the temporalis muscle was cut were carefully inspected, and presence of any obvious depressions was checked (Fig. 2). The cosmetic satisfactions were decided by patients, and the results were assigned to satisfactory, intermediate, or unsatisfactory. The presence of obvious osteolysis was also checked from the latest radiological images. These results were recorded precisely on the medical chart of each individual when the patients visited OPD for follow-ups. The patient's profiles, sides of lesions, operative techniques used for dissection and reconstruction, and follow-up periods were also obtained from patient's medical records. These prospectively acquired databases were reviewed retrospectively.

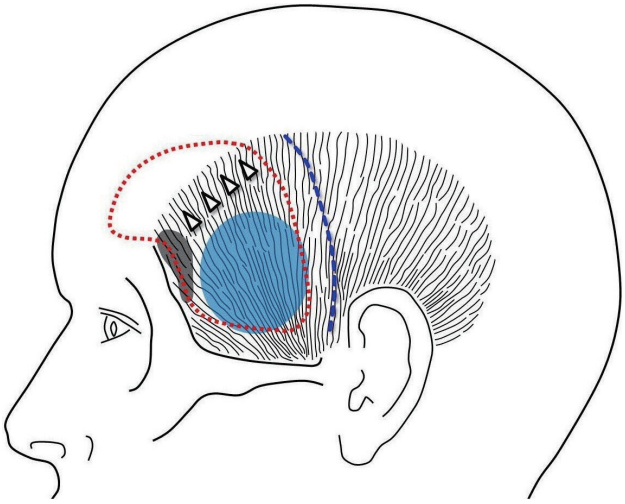

Fig. 2. The illustration indicates the locations of depression after pterional craniotomy (red dotted line), which are the keyhole site (black shaded area), the inferior margin of the temporal line of the frontal bone (white arrowheads), the mid-temporal area (blue shaded area), and the posterior incision line (blue dotted line) where the temporalis muscle is cut.

The patients were classified into two groups; one group in which EC dissection was used to peel off the temporalis muscle from the skull, and another in which NEC retrograde dissection with a double-ended dissector was used.

Surgical procedures for dissection and reconstruction of the temporalis muscle

After scalp incision, the temporalis muscle beneath the PIL was cut using EC for both groups. This step to transect the temporalis muscle was inevitable for an adequate exposure. Then, EC dissection was performed for EC group and retrograde dissection with a double-ended dissector for NEC group to peel off the temporalis muscle and the galea aponeurotica from the skull and to create an MC flap. After the intracranial procedures, the bone flap was fixed using mini-plates, titanium clamps, or burr hole covers. The KH site was repaired by temporal mesh floating technique.[8] The antero-inferior portion of the temporalis muscle was sutured over the temporal mesh. The edge of the temporalis fascia and muscle was sutured onto the original attachment site by the technique using the contourable strut plate described by Park et al. or through the mini-holes made on the temporal line of the frontal bone (Fig. 3).[2)12)]

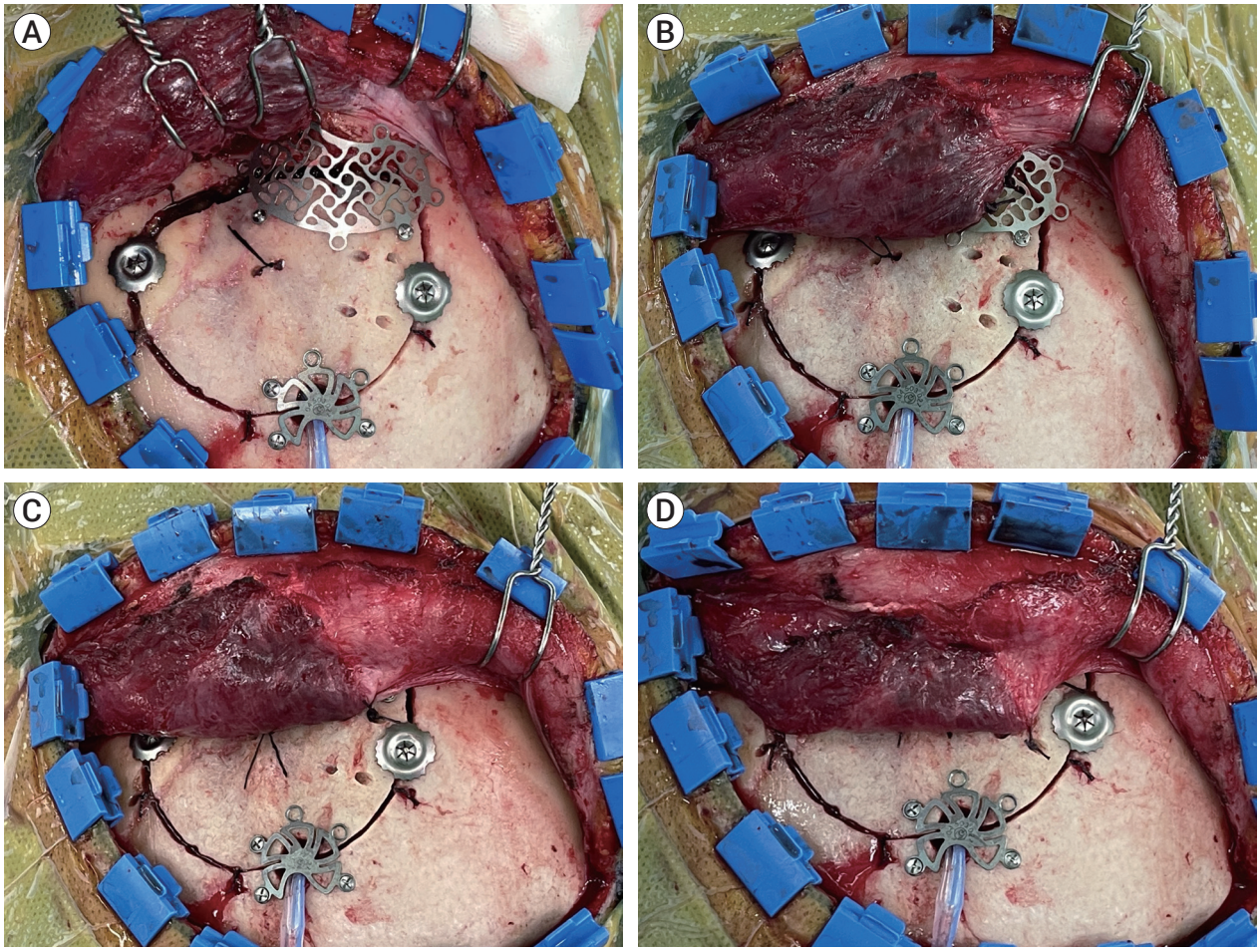

Fig. 3. Intraoperative photographs demonstrate the procedures of the temporalis reconstruction after non-electrocautery dissection of temporalis muscle. (A) After fixation of the bone flap, the keyhole site is repaired using temporal mesh floating technique. (B) The antero-inferior portion of the temporalis muscle is sutured over the temporal mesh. (C, D) The edge of the temporalis fascia and muscle is sutured onto the original attachment site through the mini-holes made on the temporal line of the frontal bone. Note that retrograde dissection using double-ended dissector leaves no remnant marks of soft tissues on the skull.

Therefore, the PIL was the site where the temporalis muscle was cut using EC for both groups. The KH site was reconstructed using the same technique for both groups, and the anatomical restoration of the temporalis muscle to its original attachment site was achieved in both groups. The only difference was whether EC or NEC was used when creating an MC flap.

Statistical analysis

Statistical analyses were performed using Statistical Package for the Social Sciences (SPSS) version 22.0 (SPSS Inc., Chicago, IL, USA). For comparison between EC and NEC groups, Pearson's *chi-square* test and Fisher's exact test were used for the categorical variables and Student's *t*-test for the continuous variables. The Cramer's V value was also computed to measure the degree of association between the categorical variables. This value is located between zero and one where being close to one indicates strong association. Probability values (*p* values) less than 0.05 were considered statistically significant.

RESULTS

Total 156 PC cases in 131 patients were enrolled in this study. Twenty-five of these patients underwent

bilateral PCs in the different sessions, and each side of the PC was counted and evaluated separately. There were 117 cases (34 males and 83 females, mean age of 58.03±10.06) in the EC group and 39 (13 males and 26 females, mean age of 63.10±7.93) in the NEC group. No statistical differences were observed in sex, age, and the side of PC between the two groups (p=0.614, p=0.274, p=0.517). There were no cases of significant post-operative hematoma that required reoperation in the both groups. No statistical differences were also observed in the incidences of depressions at the KH site, along the ITL, and at the PIL (p=0.574, p=1.000, p=0.181). However, the incidences of depression at the mid-T area and osteolysis were higher in the EC group than NEC group (25.6% versus 2.6%, 34.2% versus 5.1%), and significant differences were seen (p=0.001, $p < 0.001$). In terms of cosmetic satisfaction, the percentage of satisfactory outcome was lower in the EC group than NEC group, whereas the percentages of both intermediate and unsatisfactory outcomes were higher, and the results showed statistical significance (p=0.002) (Table 1).

Further statistical analysis on cosmetic satisfaction in association with the presence of depression at the mid-T area demonstrated that the presence of depression at the mid-T area was related with lower rate of satisfactory outcome and higher rate of intermediate and unsatisfactory outcomes, and the results showed statistical significance ($p < 0.001$). The Cramer's V value was 0.913 indicating a strong association between these two variables (Table 2). The analysis on cosmetic satisfaction in association with the presence of osteolysis demonstrated that the presence of osteolysis was also related with lower rate of satisfactory outcome and higher rate of intermediate and unsatisfactory outcomes, and the results showed statistical significance ($p < 0.001$). The Cramer's V value was 0.414 indicating a medium association (Table 3).

Table 1. Subgroup analysis between EC and NEC groups

	EC group (n=117)	NEC group (n=39)	*p* value
Sex			
Male	34 (29.1)	13 (33.3)	0.614*
Female	83 (70.9)	26 (66.7)	
Age	58.03±10.06	63.10±7.93	0.274†
Side of PC			
Right	59 (50.4)	22 (56.4)	0.517*
Left	58 (49.6)	17 (43.6)	
Depression at KH site			
(+)	3 (2.6)	0 (0.0)	0.574†
(-)	114 (97.4)	39 (100)	
Depression along ITL			
(+)	4 (3.4)	1 (2.6)	1.000†
(-)	113 (96.6)	38 (97.4)	
Depression at PIL			
(+)	47 (40.2)	11 (28.2)	0.181*
(-)	70 (59.8)	28 (71.8)	
Depression at mid-T area			
(+)	30 (25.6)	1 (2.6)	0.001†
(-)	87 (74.4)	38 (97.4)	
Osteolysis			
(+)	40 (34.2)	2 (5.1)	< 0.001†
(-)	77 (65.8)	37 (94.9)	
Cosmetic satisfaction			
Satisfactory	82 (70.1)	38 (97.4)	
Intermediate	28 (23.9)	1 (2.6)	0.002*
Unsatisfactory	7 (6.0)	0 (0.0)	

Values are presented as number (%) or mean ± SD.
*Pearson's *chi-square* test, †Student's *t*-test, ‡Fisher's exact test
EC=electrocautery dissection, NEC=non-electrocautery dissection
ITL=inferior margin of temporal line of frontal bone, KH=keyhole
mid-T=mid-temporal, PIL=posterior incision line

Table 2. Analysis on cosmetic satisfaction in association with the presence of depression at mid-T area

Cosmetic satisfaction	Depression at mid-T area		*p* value	Cramer's V
	(+)	(-)		
Satisfactory	0 (0.0)	120 (96.0)		
Intermediate	24 (77.4)	5 (4.0)	< 0.001*	0.913
Unsatisfactory	7 (22.6)	0 (0.0)		

Values are presented as number (%).
*Pearson's chi-square test
mid-T=mid-temporal

DISCUSSION

EC, or thermal cautery, is a procedure that uses heat generated from the tip of the electrode using a direct

Table 3. Analysis on cosmetic satisfaction in association with the presence of osteolysis

Cosmetic satisfaction	Osteolysis		*p* value	Cramer's V
	(+)	(-)		
Satisfactory	21 (50.0)	99 (86.8)		
Intermediate	15 (35.7)	14 (12.3)	< 0.001*	0.414
Unsatisfactory	6 (14.3)	1 (0.9)		

Values are presented as number (%).
*Pearson's chi-square test

or alternating electric current, and it is used to achieve hemostasis or to burn or destroy the target tissue. The use of cautery, or treatment by fire or heat, dates back to ancient times shortly after the discovery of fire, but when or who invented it is not known. Traditionally, it was used to remove a diseased body part, to stop bleeding, and to reduce infections. The modern surgical instrument of EC was named after William T Bovie (1882-1958), a biophysicist who developed the first commercial electrosurgical device at Harvard University and contributed to the popularization of its use. Then, Harvey Cushing (1869-1939) popularized the device in neurosurgery since he first used it in 1926.[1)10)13)]

Although EC is beneficial for a surgeon to achieve hemostasis easily and to make a clear and fast dissection, it transmits considerable thermal energy to adjacent anatomical structures, thereby causing denervation, devascularization, and direct thermal injury.[4)6)11)14)] In the current study, the incidence of depression at the mid-T area was remarkably higher in the EC (25.6%) than NEC group (2.6%), meaning EC dissection can be an important factor that results in mid-T hollow. Mid-T hollow is one of the most frequent cosmetic disfigurements after PC, and the temporalis muscle atrophy has been regarded as a main cause.[14)] Therefore, application of NEC dissection when creating an MC flap for PC can minimize the temporalis muscle atrophy. However, the incidences of depressions at the KH site and along the ITL were not significantly different in both groups. The reason could be that, for both groups, the KH site was repaired by temporal mesh floating technique and the temporalis muscle was reconstructed onto the original attachment site at the temporal line of the frontal bone. These reconstruction techniques may be highly effective to overcome the effect of EC dissection on the temporalis muscle at these sites. Of course, the incidence of depression at the PIL was not significantly different in both groups, because EC was used for both groups to cut the temporalis muscle beneath the PIL. Although 40.2% in EC group and 28.2% in NEC group showed depression at the PIL, many of them had not even noticed its existence prior to physician's inspection at OPD. Since the PIL is located behind the temporal hair line, the use of EC at this location may be acceptable. It is noteworthy that the incidence of osteolysis was considerably higher in the EC group (34.2%) than the NEC group (5.1%). The bone flap requires adequate blood supply from the periosteum for its recovery. It can be assumed that the thermal energy transmitted by EC damages both the periosteum and cortical bone which then triggers progressive osteolysis of skull bone. Therefore, based on the current study, EC has a substantial influence on not only the soft tissues including the temporalis muscle but also such a rigid structure as skull bone. According to the result from the survey on patient's cosmetic satisfaction, EC dissection has a negative influence on cosmetic outcome from the patient's aspect. Since the development of either depression at the mid-T area or osteolysis has a considerable association with cosmetic satisfaction, the prevention of these disfigurements might be important, and NEC dissection can definitely be a good feasible option.

With the advancement of modern surgical technology, the definition of successful surgical outcome has been gradually expanded and cosmetic outcome has become an important component that should not be undervalued. Disfigured appearance and facial asymmetry after PC can make the patient experience a lack of confidence, an inferiority complex, and further psychosocial problems even long after a complete recovery from the disease, and a number of neurosurgeons have been concerned with the similar issue.[5)8)12)14)] However, there exist great difficulties dealing with the matter of cosmetic outcome. First, reconstructions of bony defect and the temporalis muscle, as introduced in many articles, have immediate effects on cosmetic outcome, but progression

of cosmetic disfigurement continues for months after PC. Therefore, uncertain and inaccurate estimation of disfigurement which will gradually occur in the future is required when deciding the extent of reconstruction. Second, precise evaluation on cosmetic outcome after the surgery is not always easy because it is not determined by an objective measure and is a matter of patient's subjective satisfaction. A physician and a patient may have different opinions because they have different points of view. Third, making an additional correction when the cosmetic problem is found seems even more difficult. It is nearly nonsense to repeat a surgery for an additional reconstruction months after the initial PC when the disfigurement has become evident. A reconstruction should be completed in a timely and adequate manner at a single session. Moreover, utilization of less destructive surgical technique is important for the efficacy. Therefore, in this study, an MC flap was created using NEC dissection to minimize the destruction of adjacent structures, and further effective techniques of reconstruction were added such as temporal mesh floating technique and the temporalis muscle reconstruction onto the temporal line of the frontal bone which were already published in the previous articles.[8)12)] For reasonable and accurate evaluation of the cosmetic outcome, long-term follow-up data, at least six months after PC, from both physician and patient's aspects with simplified criteria were used in this study. In order to prevent an erroneous result affected by various factors, this study set the both group in an identical condition using the same method of reconstruction except for one variable, the use of EC. Therefore, the current study emphasizes the positive influence of NEC dissection on the cosmetic outcome after PC and also offers its reliable evidence.

CONCLUSIONS

Neurosurgeons should make utmost efforts to achieve desirable cosmetic outcome after PC. NEC dissection of the temporalis muscle brings less destruction to the adjacent structures including the temporalis muscle and skull bone, and it has a positive influence on the cosmetic outcome after PC. Less destructive surgical techniques along with timely and adequate reconstructions are required for the optimal cosmetic outcome.

Disclosure

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

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