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Unseparated Temporal Muscle and Duramater Cranioplasty Methods Following Decompressive Craniectomy: Technical Note

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ABSTRACT

Objective: Cranioplasty (CP) is used to repair cranial defects after decompressive craniectomy. During this procedure, the temporal muscle can contract or retract toward the base and adhere to the scalp flaps above and/or below the dura. Several complications including functional and cosmetic problems can occur following CP. This study presents the technical notes and outcomes of CP.

Methods: This retrospective observational study collect data of CP-procedures using unseparated muscle-dura technique performed at our hospital in 2019-2022. Technical note is presented regarding the lack of separation of the temporal muscles from the dura mater. A bone flap or titanium mesh was placed above the temporal muscle layer, which was still attached to the dura mater. Functional outcomes were evaluated using OHIP-14 Questionnaire to assess mastication quality.

Results: Twenty-three patients were included in this study. Initial surgeries were mostly caused by trauma (65.2%). Most patients underwent autologous bone flap CP (52.2%), during which the bone flap was stored in either the abdominal subcutaneous pocket or cryoprecipitated. Only one patient experienced mastication problems after CP ($p<0.001$). Temporal hollowing remained a problem in this technique. However, dissection of the temporalis muscle to reduce temporal hollowing can cause facial nerve injuries and masticatory problems. Due to the lack of temporal muscle manipulation, our patients had minimal mastication problems.

Conclusion: CP should be performed to improve functional and aesthetic outcomes. A CP technique with the temporal muscle unseparated from the dura mater can be selected to avoid damage to the muscle and mastication problems after surgery.

Keywords: Reconstructive surgical procedures; Decompressive craniectomy; Mastication; Treatment outcome

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Conflict of Interest
The authors have no financial conflicts of interest.

Informed Consent
This article has been get consent for publication and data analysis from each patients.

Ethics Approval
This research has been ethical approved by The Ethics Committee of the Faculty of Medicine, University of Indonesia – Cipto Mangunkusumo Hospital.

INTRODUCTION

Cranioplasty (CP) is a neurosurgical procedure to repair cranial defects after decompressive craniectomy. The aims of CP are to restore esthesis, improve cerebrospinal fluid (CSF) dynamics, and provide cerebral protection. CP is a crucial surgical intervention as it not only reinstates the skull's structural stability and protective function but also enhances neurological results and prevents the occurrence of the Syndrome of the Trephined. Nonetheless, post-surgery results are not consistently satisfactory due to various factors, including the initial decompressive procedure.[3,15]

Many articles discuss the material for CP and complications after CP. This requires careful consideration of the temporomandibular muscle, which is often contracted or retracted toward the base and adheres to the scalp flaps above and/or the dura below. This involves subtle separations that can lead to significant bleeding and increase surgery time. Other complications are intraoperative dural tear, cortical and parenchymal vascular injury, postoperative CSF leak, and surgical site infection.[1,4]

Only a few articles explore surgical techniques for CP. Majority of literature talked about separation of muscle and duramater before CP material laid over duramater. However, there is difficulty in separation of muscle-duramater and it ended as a complication. This article introduces a technical note about unseparated muscle-duramater CP with outcome of case series.

MATERIALS AND METHODS

Study design

This is descriptive observational study with retrospective study design, analyze the quality of mastication as outcome and compare it with preoperative. We collected CP procedure data with unseparated muscle-dura technique at Department of Neurosurgery, Universitas Indonesia, Dr. Cipto Mangunkusumo National General Hospital from 2019–2022. All surgery is done by the first author, so the bias could be ignored. Consecutive sampling of all patients had CP this technique included in this study. The patient who can not be interviewed excluded from this study.

Surgical technique

The patient was in a supine position on the operating table under general anesthesia, with the head turned to the contralateral side. The surgical area on the head and the abdomen was prepared and sterilized using chlorhexidin, alcohol, and betadine. An incision was made on the abdomen, following the previous scar, penetrating through the skin, subcutaneous tissue, and fatty tissue. The cranial bone was identified, and a bone sample was taken for measurement.

Next, an incision was made, following the previous scar on the head, penetrating through the skin, subcutaneous tissue, and galea. Bleeding was controlled using bipolar cautery. Subgaleal undermining was performed, and the skin flap was suspended cranially. Temporal muscle were not dissected from the duramater as in **FIGURE 1A**. The bone flap or titanium mesh were placed above the layer of temporal muscle that was still attached together with duramater as shown on **FIGURE 1B**. The defect in the cranium was identified, ensuring that there was no infection in the bone area. If the size of the bone was sufficient, CP was performed using the bone, and it was fixed using sutures or plates and screws. If not, a titanium mesh could

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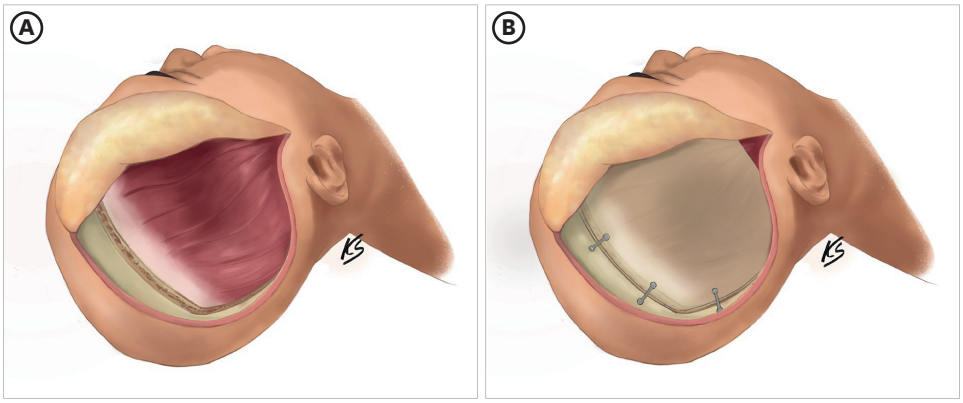

FIGURE 1. Cranioplasty technique illustration. (A) Illustration of cranioplasty technique without separating the layer of temporal muscle and duramater. The layer after opening the skin and galea flap showed the temporal muscle and dura were attached in the cranial defect. (B) The bone flap was placed in the defect above the layer of temporal muscle and duramater.

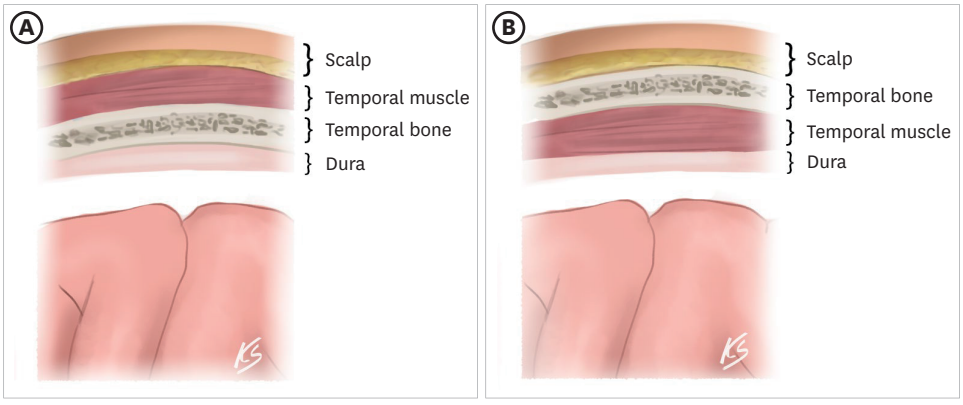

FIGURE 2. Layers of Scalp before and after cranioplasty. (A) Illustration of normal scalp, muscle, cranium, and meninges layers before decompressive craniectomy. (B) Layers of scalp until meninges after cranioplasty showed bone placed above the temporal muscle.

be placed on the defect and fixed using autodrive screws. A U-shaped incision was made on the superior mesh with a pedicle directed towards the frontal area, and then sutured onto the mesh. After active bleeding was ruled out, the surgical wound closed layer by layer. The difference of layers before craniectomy and after CP as shown in **FIGURE 2A & B**.

Outcome

Problems of mastication were asked using Oral Health Impact Profile 14 Questionnaire (OHIP-14) on **TABLE 1** before and after CP. Interview was done by phone or direct communication in the outpatient clinic to the patient or caregiver. Patients were categorized to mastication problems if there were one or more questions answered with "yes".[4] We compare the mastication quality before and after surgery in each patient, without comparing with other techniques.

Data analysis and statistic

Data were described and descriptively analyzed from Microsoft and SPSS statistics software. Patient characteristic were describe with tables or diagram. Bivariate analysis were done with χ^2 or McNemar test for categorical variable, statistically significance were achieved if $p<0.05$.

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TABLE 1. OHIP-14 for evaluate mastication quality[4]

Questionnaire
For the past 7 days, have you....
... had trouble pronouncing any words because problems with your teeth or mouth?
...felt that your sense of taste has worsened because of problems with your teeth or mouth?
...had painful aching in your mouth?
...found it uncomfortable to eat any foods because of problems with your teeth or mouth?
...been self-conscious because of your teeth or mouth?
...felt tense because of problems with your teeth or mouth?
...had to interrupt meals because of problems with your teeth or mouth?
...found it difficult to relax because of problems with your teeth or mouth?
...been a bit embarrassed because of problems with your teeth or mouth?
...been a bit irritable with other people because of problems with your teeth or mouth?
...had difficulty doing your usual jobs because of problems with your teeth or mouth?
...felt that life in general was less satisfying because of problems with your teeth or mouth?
...been totally unable to function because of problems with your teeth or mouth?
Has been your diet been unsatisfactory because of problems with your teeth of mouth?

OHIP-14: Oral Health Impact Profile 14 Questionnaire.

RESULTS

Patients' characteristic

Forty-five patients were obtained from 2018-2023 that underwent CP surgery. Patients then excluded due to uncontactable for evaluation of mastication quality and surgical outcome. Of 23 patients included, most of the patients were male (69.6%), with average ages 32.48±18.6 years old. The cause of decompressive craniectomy were mostly due to trauma in 15 patients (65.2%), followed by vascular event either malignant ischemic stroke or hemorrhagic stroke in 4 patients (17.4%), neoplasm in 3 patients (13%), and infection in 1 patient (4.3%). The mean interval time between craniectomy and CP were 241.9 days (range, 43–919 days). Most of our patients had autologous bone flap CP (52.2%), followed by implant either titanium mesh or bone cement (43.5%), and combination of autologous bone flap and titanium mesh (4.3%). The autologous bone flap CP patients had their bone stored in the subcutaneous layer of abdomen (50%) or cryopreservation in tissue banking place (50%).

Surgical technique and outcome

Surgery was done according to our technique (**FIGURE 3**) in all 45 patients. The mastication problems were only found in four patients (17.4%) after CP whereas three of them already had the problem before CP (**FIGURE 4**). Therefore, only one patient (4.3%) had CP-related mastication problems in this study. Bivariate analysis showed there was no relation between the cause of pathology (p=0.214), type of bone flap either autologous or implant (p=0.831), and interval time between craniectomy to CP (p=0.921) with the mastication problems. The comparison of mastication quality before and after CP showed statistically significance (p=0.001).

DISCUSSION

When patient recovers from primary insult after craniectomy decompressive, the cranial defect can be a problem due to cosmetic issues, loss of cranial shield or barrier and allow the atmospheric pressure to compress unprotected intracranial contents that can affect brain perfusion, and result in sensory-motor deficits, headache, dizziness, seizures, anxiety attacks, depression, mood instability, memory problem, and other clinical sign and symptoms also known as sinking skin flap syndrome.[15] Large cranial defect also can result

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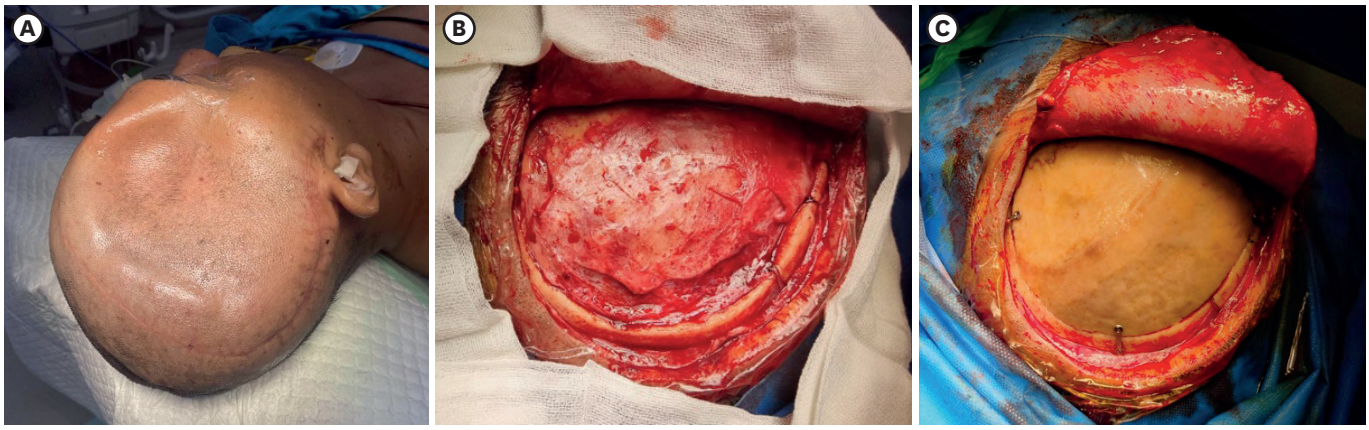

FIGURE 3. Documentation of surgical steps of cranioplasty. (A) Skin incision followed the previous surgical design. (B)Cranioplasty technique showed skin flap dissection to and suspended cranially. (C) Placement of the autologous bone flap above the layer of temporal muscle and duramater (courtesy of Department of Neurosurgery, Faculty of Medicine Universitas Indonesia, Dr. Cipto Mangunkusumo National General Hospital).

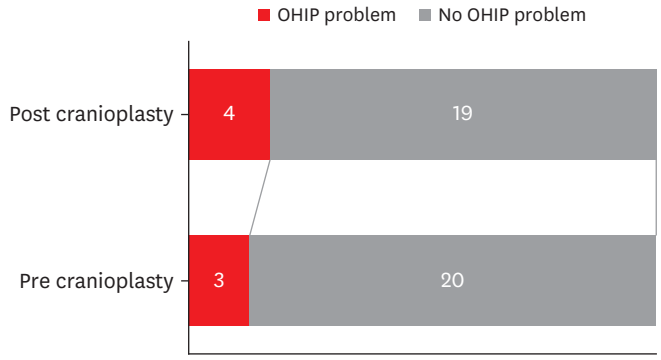

FIGURE 4. Oral health impact profile before and after cranioplasty.
OHIP: Oral Health Impact Profile.

in atrophy of brain parenchyma and the difference of gradient pressure to CSF flow causing hydrocephalus. From multivariate analysis study, subdural hemorrhage, one dilated pupil, and posttraumatic hydrocephalus were predictors with unfavorable functional outcome in patients who underwent decompressive craniectomy for traumatic brain injury.[8,1244)]

CP is the surgical reconstruction of cranial bone defects acquired as a result of trauma or surgical intervention for other pathologies. In our study, the most common causes were trauma, followed by vascular events, neoplasma, and infection. The use of CP is for protection of the brain, restoring dynamics of closed cranial cavity due to absence of overlying bone that influence the difference of atmospheric pressure and intracranial pressure (ICP).[9)] Over thousands of years, the evolution of surgical procedure of CP has been improved. The acquisition of bone biology and bone healing enabled the use of autologous bone flap, however new biocompatible synthetic materials also developed.[11)] In our study we prefer to use autologous bone flap and implant were only used if the bone were crashed, infected, or infiltrated by neoplasm. The benefits of autologous bone flap were low cost and lower risk of rejection. However, the autologous bone flap had a risk of resorption either if they were stored in a subcutaneous abdomen pocket or cryopreservation in the freezer.[5)] The cryopreservation process was done in the National Nuclear Power Organization of Indonesia freezer storage.[2)] Supplementary to autologous bone flap with implant were done due to resorption of the bone in our study.

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Several issues during CP can be related to the temporal muscle such as damaged muscle during detachment from the temporal bone on the initial surgery because of the use of monopolar coagulation can cause fiber retraction and atrophy. After the decompressive procedure, muscle is usually left lying over the exposed dura, which can lead to further scarring and muscle retraction. There may not be a clear dissection plane during CP due to this condition. Dissecting muscle can increase the risk of postoperative hematoma formation and cause masticatory difficulties and aesthetic problems due to temporal hollowing.[6] In our technique, we did not manipulate or dissect the temporal muscle to avoid those problems. Therefore, after CP in our study only one patient (4.3%) had a problem of mastication, and the rest had no complaint. Compared with other study from Gierthmuehlen et al.[4] (2022), after craniotomy 69% of the patient has no oral health impact problem, however after 3 to 15 months observation, the OHIP score increases in some patients. In our study, three (13%) had the mastication problem before CP that still occur after CP, and only one patient that develop new problem after CP.

However, the weakness in our technique was the temporal hollowing. Several studies showed technical nuances for reducing temporal hollowing such as using three-dimensional (3D) reconstruction modelling, dissecting the layers of temporal muscle and separating them anteriorly to fill the layer above the bone flap placed. However, this technique can cause facial nerve injury and restricted jaw movement.[16] Muscle reconstruction using additional temporal plate or deviation and elevation of the temporal plate without additional plate with 3D printed Titanium Mesh can improve efficacy with lower artifacts and complication rates.[17] However, the feasibility in our country and cost efficiency should be considered. Another study also suggested to put synthetic dural material deep to the temporal muscle at the time of closure following initial surgical decompressive craniectomy to ease the dissection of temporal muscle and dura mater in future CP, or open the dura mater that attaches together with the temporal muscle pedicle and repair the dura mater defect with substitute of duraplasty or other synthetic material.[6,7] The cost-effectiveness of CP using autologous bone flap was significantly lower than implants ($2,156.28±$1,144.60 vs. $35,118.60±$2,067.51).[2] The use of further synthetic material of dura and implant would add to the health care finance that sometimes could not be claimed by insurance or government insurance policy.

After CP, patients should have a better functional outcome or improvement of their activities daily living score significantly. CP can improve neuropsychological status regarding memory function, processing speed and inhibitory control, language function and visual-constructional ability. CP improved cerebral blood flow velocities that before were interrupted due to atmospheric pressure transmitted to the cranial cavity after decompressive craniectomy.[10] Neurosurgical approaches through the temporal muscle can cause significant postoperative impairment on oral health related quality of life. However, recent studies showed improvement of the symptoms over time. Studies through either quality of life questionnaire or objective parameters from magnetic resonance volumetry and electromyography activity showed improvement of symptoms after 3 months up to 15 months after surgery.[4]

CONCLUSION

Decompressive craniectomy is used to control medical-refractory ICP. However, several complications can develop from this condition. Therefore, CP should be done for functional recovery and aesthetic outcome. CP can use an autologous bone flap or implant, and the storage

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of bone flap can be placed on the subcutaneous abdomen pocket or cryoprecipitated. CP technique with unseparated temporal muscle from the duramater were good enough to avoid further damage of the muscle and mastication problems after surgery. However, the temporal hollowing is still become the problems. Further studies for better technique should be evaluated.

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