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Original Research

Use of Methyl Methacrylate for Small and Large Cranial Defects: A Single Institute Experience

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ABSTRACT

Objective: Data obtained from cases wherein methyl methacrylate was used for cranioplasty are discussed along with the literature, and methods for preventing potential complications are presented.

Methods: Records of patients who had been operated for cranioplasty between 2013 and 2017 were retrospectively analyzed. Early and late results of the cases were recorded. Area measurements of cranium defects were performed through computed tomography, scanography, or direct X-ray. The steps considered for preventing known complications are explained, and the results are discussed.

Results: Cranioplasty with methyl methacrylate was administered to areas <10 cm^2 in 29 cases, areas of 10–25 cm^2 in 25 cases, and areas >25 cm^2 in 10 cases. Cranioplasty with methyl methacrylate was performed in the supratentorial area in 57 cases and in the infratentorial area in 7 cases. In 48 cases, partial cranioplasty was performed by administering methyl methacrylate along with autograft to the craniectomy defect. A subcutaneous drain was left for 2–3 days in all cases. During this period, dual antibiotherapy was administered. Symptoms of infection were not encountered in any case. No clinical symptoms associated with cranioplasty material were discovered in the late follow-up period.

Conclusion: When methyl methacrylate is applied with appropriate methods and necessary precautions are taken, it proves as an inexpensive and effective cranioplasty material that can successfully be applied in large cranial defects, which reduces the risk of infection. This inexpensive material can be applied to repair partial craniotomy flap deformities to achieve better cosmetic outcomes.

Keywords: Cranioplasty, methyl methacrylate, calvarium, cranium, cosmetic

INTRODUCTION

In cases wherein cranial defects occur after neurological surgery, cranioplasty is performed for the conservation of the brain parenchyma and for aesthetic reasons (1, 2). Although the use of autologous bone for cranioplasty is the first choice for all neurosurgeons, cranioplasty materials made from synthetic or organic preparations can also be used. Multi-part and infected bone fractures cannot be used for cranioplasty. In this case, the bone fractures are too deformed, and it would be impossible to bring them together. Cranioplasty materials are also preferred due to ease of use in these situations (1, 3-7).

Cranioplasty materials should be tissue-compatible and easy to apply. They should not be easily infected. Unfortunately, it is predicted that none of the cranioplasty materials are as capable as autologous grafts. Various studies showed that these materials may result in graft rejection, parenchymal defects, and infection in the early or late period (8-12).

Methyl methacrylate (MM) is currently one of the most frequently used cranioplasty materials. It possesses advantages such as being easily developed and taking on the desired shape. However, it also has some disadvantages as it emits heat to the environment during its application. Additionally, it can be easily infected during the postoperative period.

In this study, the early and late results and advantages and disadvantages of MM that was used in 64 patients with calvarial defects have been discussed. Additionally, the cases wherein MM was used for cranioplasty have been presented along with comparisons with literature data.

METHODS

Records of patients who had been operated for cranioplasty between 2013 and 2017 were retrospectively analyzed. Age, sex, indications for craniectomy and cranioplasty, and follow-up period were recorded. Area measurements of the cranium defect were performed through scanography or direct X-rays obtained from the PACS software (Figures 1, 2). Localizations of cranioplasty areas were recorded. Herein, the methods to prevent known complications are explained, and the results are discussed.

Surgical Method

After the primary surgical intervention was performed and the dura was covered, the cranioplasty phase started. MM was applied to the craniectomy defect and shaped. Care was taken to

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Figure 1. Multi-part craniectomy defects

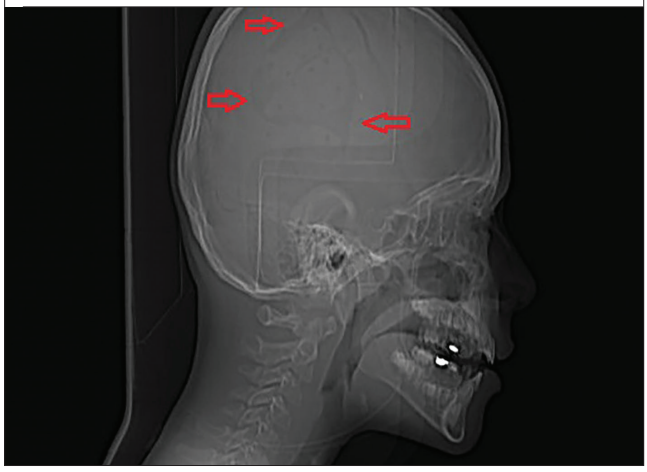
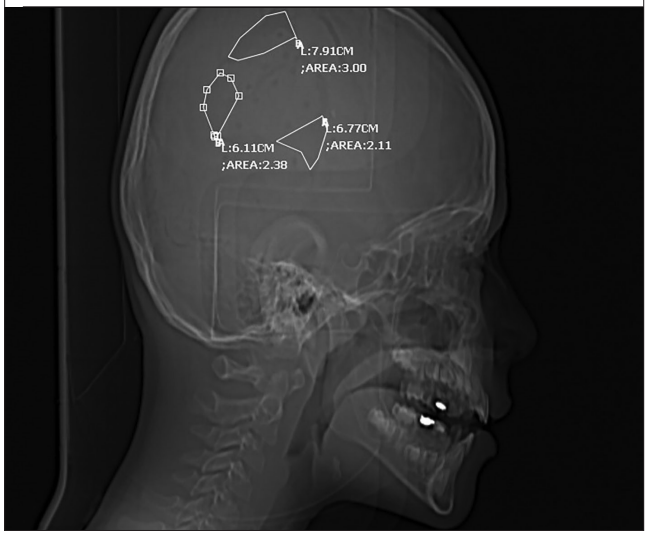


Figure 2. Measurements of cranioplasty areas



ensure that no dead spaces would remain in the epidural area under the cranioplasty material. Therefore, it did not matter if the cranioplasty material lacked uniform thickness over the entire region (Figures 3, 4). Later on, the MM was shaped, but suture holes were not opened to fix the cranioplasty flap (Figure 5). Edges were converted into a groove and were ensured to hold onto the cranium to attach the flap. The material was cooled by cold physiological saline solution and continuous spraying for approximately 10–15 minutes to ensure that the heat emitted after MM was administered would not damage the brain parenchyma. Later on, when the heat reaction was completed, a negative-pressure hemovac, minivac, or Jacksonian drain was placed on the cranioplasty flap, and the skin flap was sutured.

Informed consent was not required due to the retrospective nature of the study. Ethics committee approval was received for this study from Ahi Evran University Clinical Research Ethic Committee (Aprroval Date: 30.01.2018; Approval No: 2018-02/20).

Figure 3. Cranioplasty material applied to the dural surface and was not affected by the different thickness of the flap to prevent dead space

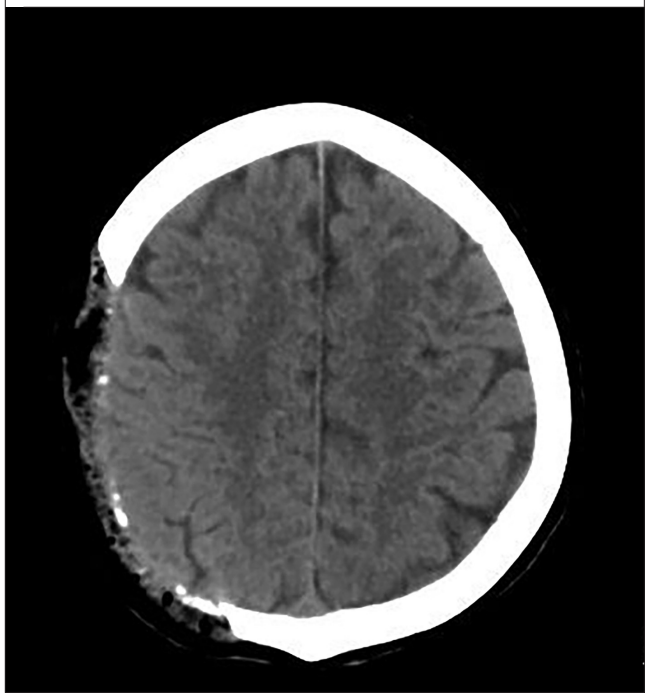
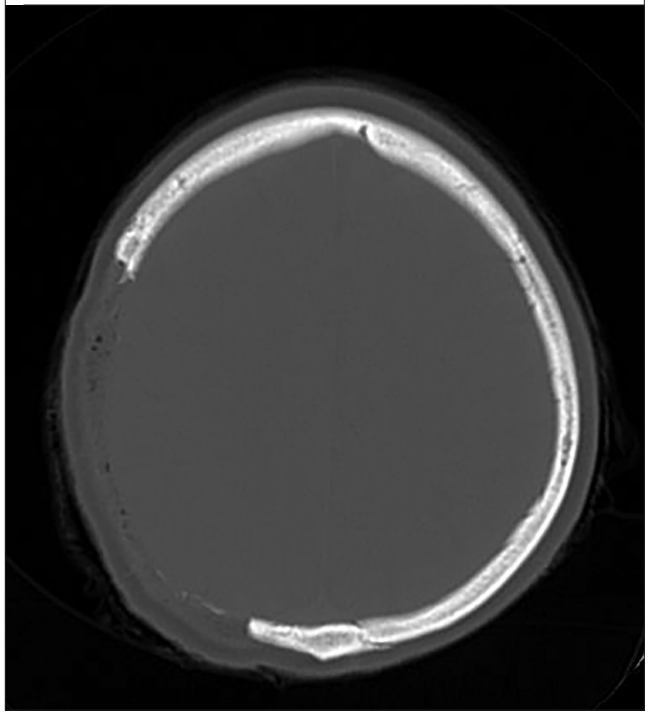


Figure 4. Postoperative 1st day of fibrous dysplasia case. Methyl methacrylate shapes do not show a density on computerized tomography



RESULTS

In total, 64 cases were evaluated in the study. The median age of the patients was 42.9 years. Overall, 52 male and 12 female patients were evaluated in the study. Craniectomy was applied

Table 1. Demographic characteristics of the cases, measurements of cranioplasty area, and late follow–up durations

Number of cases	Surgery type	Mean age (years)	Cranioplasty area (cm^2)	Mean follow–up time (months)
48	MPF	39.9	14.3	17.4
4	Decompressive craniectomy	51.7	34.6	19.5
5	Convexity/Calvarial tumor	54.8	24.2	20.5
7	Posterior fossa surgery	50.3	8.2	15.8

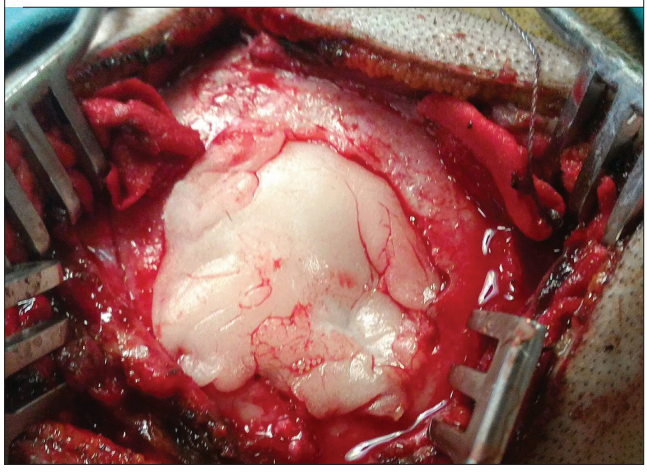
MPF: multi–part fracture

Table 2. Cranioplasty localizations and measurements of craniectomy area (*)

	<10 cm^2	10–25 cm^2	25–50 cm^2
Frontal	12	14	7
Temporal	8	5	0
Parietal	5	3	3
Occipital	4	3	0

*largest cranioplasty area was accepted for cranioplasty localization

Figure 5. Cranioplasty after suboccipital craniectomy. Edges were converted into a groove and were ensured to hold onto the cranium to fix the flap without suturization

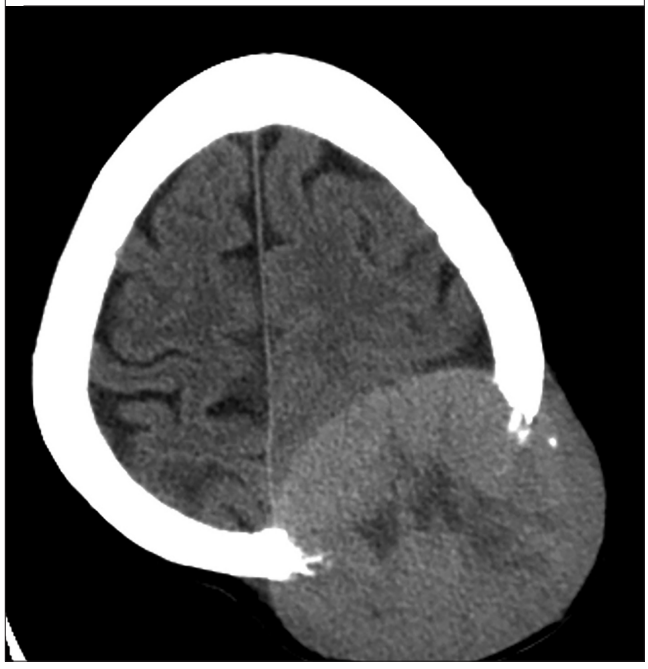


to 48 cases due to multi-part cranial fractures. Further, five cases were operated due to a convexity tumor and seven due to posterior fossa surgery; MM was used for cranioplasty. Cranioplasty was performed in four cases, on an average 85 days after decompressive surgery. Demographic analysis results of the cases are shown in Tables 1 and 2.

No findings of infection were encountered in the early or late period during the postoperative follow-up. Four cases directly died after the primary pathology in the early period during the follow-up.

One patient who had giant follicular carcinoma metastasis causing cranium defect (Figure 6) was re-operated after 15 months

Figure 6. Giant extra-axial metastasis caused large cranium defect in the left parietal region



due to recurrence of the tumor (Figure 7). Tumor invasion or destruction was not observed in the cranioplasty material used for cranioplasty in the first operation. Even though the tumor tissue was seen below and over the cranioplasty material, it did not cause macroscopic flap deformation. Because the material had hardened, microscopic examination could not be performed (Figure 8). Cranioplasty was performed in the same region again with MM (Figure 9).

DISCUSSION

There are various studies in the literature about the use of MM for cranioplasty. It has been reported that the most frequent complication was an infection, and it was encountered at rates of 3.8%–14% in different series (13, 14). It was concluded that microorganisms that are frequently seen could not grow following appropriate antibiotherapy; after MM, bioactive glass and bioactive ceramic materials used for cranioplasty were left in bacterial cultures (15).

Several risk factors have been defined regarding infection encountered following cranioplasty. Factors that have been pre-

Figure 7. Tumor tissue around cranioplasty material. The tumor could not destruct cranioplasty material but could damage other tissues

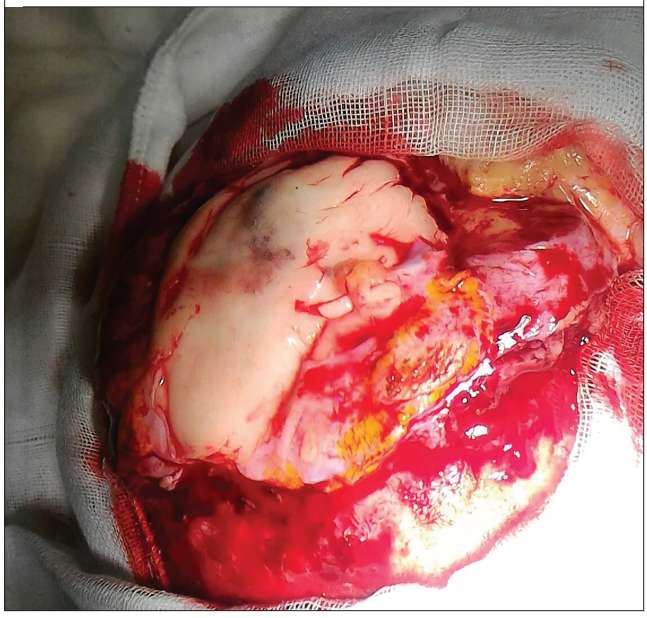
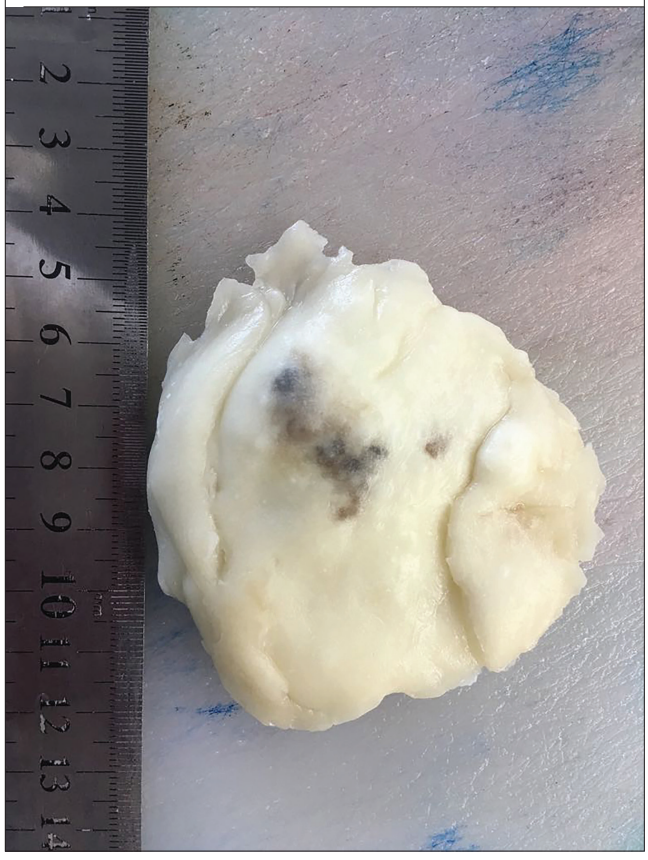


Figure 8. Tumor destruction was not observed in the cranioplasty material and did not macroscopically cause flap deformation



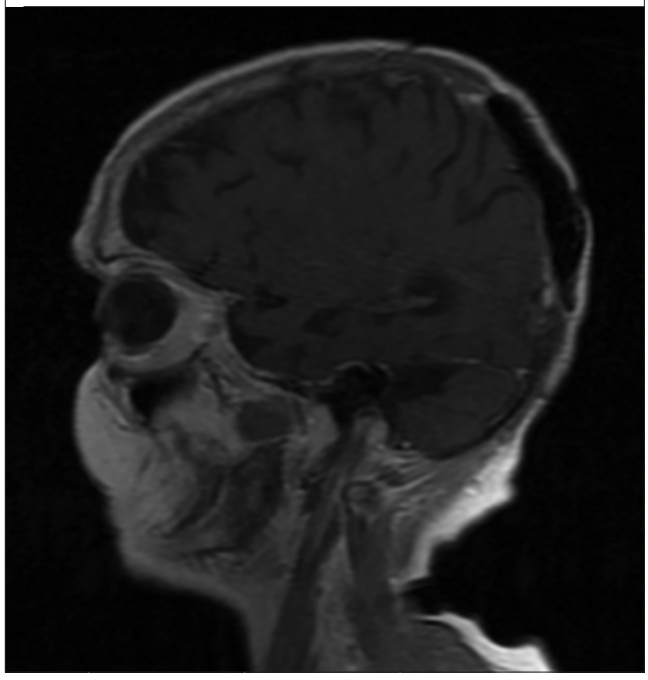
viously defined include history of cranial operations, diabetes mellitus, long operative time, old age, infection in the area to be operated, and surgical indications. Another risk factor is the placement of subcutaneous drains in the area where cranioplasty material is applied (16).

It has been known that MM causes accumulation of a significant amount of fluid under the skin after it is applied. Therefore, negative-pressure drain was left under the skin for a minimum of 2 days. The drain was removed on the 3rd day at the latest. Dual antibiotherapy comprising parenteral cefazolin and gentamicin was sustained for at least 3 days. Antibiotherapies involving three antibiotics, of which one had an anaerobic effect, was continued for 5–7 days in cranioplasty cases with a dirty wound or frontal sinus repair. The non-hemorrhagic serous fluid that filled the drainage was present since the first postoperative day. Pathogenic bacterial growth was not detected in the examinations of the liquid culture obtained from three cases.

Suboccipital craniectomy is a common procedure in posterior fossa surgery. In cases wherein craniotomy is applied, the bone is inserted in place of a flap. It may be more difficult to open the craniotomy flap on the occipital bone due to the curved structure of this area. Therefore, the use of ready-made cranioplasty materials is challenging in cases wherein suboccipital craniectomy is performed. The use of MM in this area for cranioplasty provides convenience to surgeons, and the material can be easily shaped. Hence, MM can be preferred. Furthermore, cerebrospinal fluid fistulas are often encountered after surgery in this region (17). Thus, cranioplasty application after surgery in this region will also be beneficial for protection from cerebrospinal fluid fistulas.

Figure 9. Cranioplasty material on the parietal region is shown at a sagittal section of MRI

MRI: magnetic resonance imaging



Especially following supratentorial surgeries, defects associated with craniectomy performed when craniotomy is not of adequate size, has irregular loss of bone tissue at the borders of craniotomy, and has burr-hole defects may result in noticeable cosmetic problems beneath the scalp. Even in cases wherein there are several defects, their coverage by administering MM leads to better cosmetic results. The combined use of MM during the use of autologous grafts or application of craniotomy flap in the late period for cranioplasty and in the cases of reduction of the flap in size or coverage of other bone defects leads to more favorable cosmetic outcomes.

One of the alternative materials used for cranioplasty is the porous polyethylene implant. The shaping of this material during surgery takes a long time when compared with MM. Although the desired cosmetic results may be achieved when it is applied, dead spaces between the material and brain parenchyma are probable as the material is of the same thickness all over the defect. Presence of dead spaces may lead to infection or bleeding in the form of oozing in the area (18).

It should be noted that in case wherein ready-made cranioplasty materials or MM is administered after being shaped and hardened before application on the dura, they may cause pressure on the brain parenchyma if the lower surface is thick. However, if it is prepared in a more cambered form, it may cause the formation of dead space in the epidural area. Therefore, we believe that it is more reliable to continuously wash MM with cold water immediately after it is prepared and completely solidified to protect it from the heat generated while attaching it to the cranium by making edges groove. We believe that the attachment of cranioplasty flap with auxiliary materials such as sutures or titanium plates will increase the number of foreign bodies in the region and, thus, will provoke the possibility of infection due to tissue reaction.

CONCLUSION

Methyl methacrylate is an easily applicable cranioplasty material, even in wide craniectomy defects. Its shaping after it is administered in the defect site prevents formation of a dead space. It is one of the cost-effective preparations in cases wherein autologous graft cannot be administered.

Ethics Committee Approval: Ethics Committee approval was received for this study from Ahi Evran University Clinical Research Ethics Committee (Approval Date: 30.01.2018; Approval No: 2018-02/20).

Informed Consent: Informed consent was not received due to the retrospective nature of the study.

Peer-review: Externally peer-reviewed.

Conflict of Interest: The author has no conflicts of interest to declare.

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