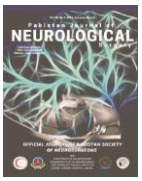

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Original Article (BRAIN)

Cranioplasty Following Decompressive Craniectomy-Analysis of Neurological Outcome and Complication Rate

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ABSTRACT

Objective: The current study aimed to review the neurological outcome and complications rate of cranioplasty after decompressive craniectomy.

Material and Methods: An observational cohort study was conducted in 76 patients of Cranioplasty after decompressive Craniectomy in the department of Neurosurgery Hayatabad Medical Complex, Peshawar. The demographic profile indicated decompressive Craniectomy, location of the cranial defect, type of bone graft, operative time in minutes, intraoperative blood loss in ml, Glasgow-Coma-Score (GCS), Glasgow-outcome-scale-extended (GOSE) while cranioplasty, associated complications were recorded and the obtained data were analyzed.

Results: The overall cranioplasty-associated complication rate of 18 (23.6%) was recorded. The seizure was the most common complication seen (6.57) percent, followed by subgaleal collection 4(5.2%), hydrocephalus 2 (2.63%), bone flap infection 2 (2.63%), empyema, subdural hematoma, intracerebral hemorrhage in 1 (1.31%) respectively. Out of these 5 (6.57%) had major complications in which redo surgery was done. Minimum Glasgow-Coma-Score (GCS) recorded was 8 at the time of cranioplasty while a maximum of 15 was recorded. Statistical analysis showed significant improvement in Glasgow-Coma-Score (GCS) after one month, three months, and six months.

Conclusion: The cranioplasty followed by decompressive craniotomy is associated with maximum complications, however, the neurological results outweigh the associated complications.

Keywords: cranioplasty, Decompressive craniectomy, outcome, complications.

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INTRODUCTION

Decompressive Craniectomy (DC) is a neurosurgical treatment that involves skull bone removal and allows enough space for the brain to expand. It is a common procedure in modern neurological practice mostly needed after

traumatic brain injury, infiltration of skull bone by tumor, middle cerebral infarction, or any other severe infection.[1,2]

Cranioplasty is a surgical procedure for repairing cranial defects, protecting the brain, and can be performed for both cosmetics and functional purposes.[3] Cranioplasty is a simple, safe, and clean procedure while the material used is controversial that involves certain complexities to this fine procedure.[4] Presently, autologous flap replacement by using the previously removed bone flap is common in practice. Other option includes the iliac crest, rib, sternum, and scapula. It is effective as there is less immune rejection and bone in growth substrate as well as revascularization, however, the risk of secondary infection increases, and bone resorption reduces the strength, thus making room for the allograft. In the present situation, there are three classes of allograft, metal, ceramic, and polymer.[5-7]

Titanium mesh is usually used as it is biocompatible with a low infection rate, costly and strong material shows no deflection in cases of traumatic stress.[8] Polymethyl methacrylate (PMMA) is commonly used having low cost, lack of thermal conduction and radiolucency, lack of incorporation, and fragmentation.[9] A good scaffolding material known as Hydroxyapatite is used in limitation due to its brittleness and low tensile strength.[10] Cranioplasty (CP) is associated with a high complication rate and a literature review on large series revealed 12% to 50%.[11-12] Several factors have a great impact on the outcome of this procedure. It includes the timing of surgery, the pre-operative status of the patients, bone draft type, underlying pathology, patient comorbidity, and surgical technique.[13]

The objective of the current study is to review the neurological outcomes and cranioplasty associated complications after decompressive craniectomy and its comparison with available literature. The result of this study will be shared with neurosurgeons in our community, so that they may be well aware of neurological outcomes and complications of this procedure.

MATERIALS AND METHODS

Study Design & Setting

An observational cohort study was conducted on 76 patients of Cranioplasty after decompressive Craniectomy in the department of Neurosurgery Hayatabad Medical Complex, Peshawar, after approval from the Hospital ethical and Research Committee from August 2017 to February 2020.

Demographic data of the patients were recorded including age, gender, indication for decompressive craniectomy, type of bone graft, location of the cranial defect, operative time in minutes, GCS (Glasgow Outcome Scale), GOSE (Extended Glasgow Outcome Scale) at time of cranioplasty, and co-morbid condition.

Inclusion criteria

All patients above 14 years or who underwent decompressive craniectomy due to acute subdural hematoma, traumatic brain injury, intracerebral bleed, infarct, tumor, and venous thrombosis were included in this study.

Exclusion criteria

Patients who were not willing to participate and had a karnofsky score of less than 40 were excluded.

Data Collection

All patients were monitored 6 months after cranioplasty and neurological outcomes were determined by GCS and GOSE at 1, 3, and 6 months and the complication rate were categorized into major and minor complications. Major complications include those patients who required secondary surgery and minor are those not required second surgery. CT scan was performed after the operation and the results

were recorded. All information was collected and analyzed by using SPSS version 25 and stored in tabulated form.

RESULTS

A total of 76 patients were included in the current study who underwent cranioplasty, of which three patients were lost to follow-up.

Gender Distribution

In the study population, both male (73.6%) and female (20.0%) patients were investigated. At the time of cranioplasty, the average age was 40.13 ± 15.96.

Location of Cranial Defect

As a result of decompressive craniectomy, the majority of patients had unilateral defects, while 4 (5.21%) had bifrontal defects. Most of the patients with unilateral defects involved the right side (50.0%). See Table 1.

Table 1: Demographic Profile and Operative Details.

Characteristics	No of Patients	Frequency
Gender		
Male	56	73.6%
Female	20	26.31%
Location of Cranial Defect		
Unilateral (right)	38	50%
Unilateral (left)	34	44.73%
Bifrontal	4	5.2%
Type of Bone Graft		
Bone flap(autologous)	28	36.84%
Titanium mesh (allograft)	40	52.6%
PMMA	8	7.89%
Intraoperative Information		
Mean operative time		121.55 ± 20.53 minutes
Mean blood loss		185.83 ± 49.34 ml.
Co-Morbid Condition		
Hypertension	47	61.8%
Diabetes Mellitus	29	38.15%
Coronary artery disease	18	23.6%

Decompressive Craniectomy

The common indication of decompressive craniectomy was acute subdural hematoma in 26 (34.2%), head injury in 23 (30.2%), intracerebral hemorrhage in 7 (9.2%), middle cerebral artery infarct in 7 (9.2%), tumor in 8 (10.52%), and venous thrombosis in 5 (6.5%) cases. See Table 2.

Table 2: Indication For Decompressive Craniectomy (DC).

Indication for DC	No. of Patients	Frequency
Severe head injury	23	30.2%
Acute subdural hematoma	26	34.2%
Intracerebral hemorrhage	7	9.2%
Middle cerebral artery infarct	7	9.2%
Tumors	8	10.52%
Venous thrombosis	5	6.5%

Type of Bone Graft

The majority of patient allograft (titanium mesh) were used 40 (52.6%), and PMMA (Polymethyl methacrylate) in 8 (7.89%) cases. While in 28 (36.84%) autografts (bone flap) were used. In almost all cases bone flap was stored in the abdomen. See Table 1.

Surgical Procedure

Mostly 38 (50%) cranioplasty was done 13 – 24 weeks after decompressive craniectomy, 25 (32.8%) cranioplasty was performed < 12 weeks of DC. And only 13 (17.1%) of patients had cranioplasty > 24 weeks of duration.

Intraoperative Information

The average operational time was 121.55 ± 20.53 minutes, with a mean blood loss of 185.83 ± 49.34 ml. The minimal GCS at the time of cranioplasty was 08, while the maximum was 15. At the time of cranioplasty, the patient's GCS was

13.08 ± 2.35; one month later, it was 13.46 ± 2.51; and six months later, it was 13.53 ± 2.44. After cranioplasty, statistical analysis revealed a substantial improvement in GCS at 1 month, 3 months, and 6 months. See Table 1.

Complications Reported

The overall associated complication rate was 18 (23.6%) including the most common seizure 5 (6.57%), followed by subgaleal collection 4 (5.2%), followed by hydrocephalus 2 (2.63%), bone flap infection 2 (2.63%), empyema, subdural hematoma, intracerebral hemorrhage in 1 (1.31%) respectively. Superficial wound infection was seen in 2 (2.63%) of cases. Out of these 5 (6.57%) had major complications in which redo surgery was done and it including hydrocephalus, bone flap infection, and subdural hemorrhage. Post-cranioplasty, associated co-morbidities such as hypertension, coronary artery disease, and diabetes mellitus increase the risk of both major and minor complications. See Table 3.

Table 3: Complication of Cranioplasty.

Complication	No. of Patients	Frequency
Subgaleal collection	4	5.2%
Hydrocephalus	2	2.63%
Seizure	5	6.57%
Bone flap infection	2	2.63%
Empyema	1	1.31%
SDH	1	1.31%
ICH	1	1.31%
Superficial infection	2	2.63%
Total	18	23.6%

DISCUSSION

Cranioplasty along with cranial trephinations is one of the earliest procedures. The first cranioplasty was done in 7000bc by using metal and gourds to repair the cranial defect. Fallopius describe the repair process by using gold plates however, Van Meekeren used the first bone graft[14.] During World War 1 and II, lots of people have cranial defects and thence the use of synthetic material has been introduced for the repair of cranial defects. It includes Methyl methacrylate, hydroxyapatite, and polyether ether ketone (PMMA) implants.[15] In the study population, both male (73.6%) and female (20.0%) patients were investigated while the mean age at the time of cranioplasty was 40.13 ± 15.96 (Mean ± SD) years. Hamandi et al. reported 85% were male and 14% were female and the majority were in the age group of 21 – 30 years.[16] This is more or less similar to our study, similarly, Lal et al. reported that 73% were male and 22% were female and our study[10] found that the average age was 38 ± 14.42. After decompressive craniectomy, the majority of patients had unilateral defects (72.73 percent), while 4 (5.21%) had bi-frontal defects. Out of unilateral defects majority were on the right side 38 (50%) side. Andrabi et al. in their study showed the common defect was unilateral (94.9%) followed by bilateral (4.2%) and bi-frontal (0.8%) cases which correspond to the current study.[17] In the current study, At the time of cranioplasty, the minimum GCS was 8 and the maximum was 12. Patients' mean GCS at the time of cranioplasty was 13.08 ± 2.35; after one month, it was 13.46 ± 2.51; and after six months, it was 13.53 ± 2.44. Statistical analysis showed significant improvement of GCS at 1, 3, and 6 months ($P < 0.05$) after cranioplasty. Rakesh Singh et al, reported assessment of GCS and GOSE preoperatively and post-operatively at the interval of 1 month, 3 months, and 6 months after surgey[18] which shows similarity to the current study findings.

Cranioplasty followed by decompressive craniectomy carries a high rate of complications. A study done by Basheer et al depicted the overall complication rate as 23% and other complications were seizure, bone flap infection subgaleal collection, subdural hematoma[19] which corresponds to our study. Another study conducted by Zain et al, shows the overall complication rate was 36% of which 10.4% had

major complications in which redo surgery was done and 26% had minor complications which include seizure, subgaleal collection, and superficial wound infection.[20]

CONCLUSION

Cranioplasty following decompressive craniectomy is associated with post-operation higher complications. However, it can be minimized by meticulous timing of surgery, good control of co-morbidities, and fine surgical technique. The neurological outcome is good and always outweighs the complication.

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Additional Information

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Ethical Review Board Approval: The study was conformed to the ethical review board requirements.
Human Subjects: Consent was obtained by all patients/participants in this study.
Conflicts of Interest:
In compliance with the ICMJE uniform disclosure form, all authors declare the following:
Financial Relationships: All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work.
Other Relationships: All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

AUTHORS CONTRIBUTIONS

Sr.#	Author's Full Name	Intellectual Contribution to Paper in Terms of:
1.	Sohail Amir	1. Study design and methodology.
2.	Mushtaq	2. Paper writing, referencing, data calculations
3.	Muhammad Ali Numan	3. Data collection and calculations
4.	Shahid Ayub	4. Analysis of data and interpretation of results etc.