

Outcome of Cranioplasty, The Factors that Predict Prognosis and Morbidity

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ABSTRACT

Background: Raised intracranial pressure (ICP) is a common development from several diseases affecting the cranial vault, especially intracranial mass lesions. Decompressive craniectomy is commonly used to decrease intracranial pressure. In this article we discuss the outcome of reconstruction of skull bone and the factors that predict the prognosis and morbidity.

Objective: To determine the outcome of cranioplasty procedures from our experience of single large tertiary care center.

Study Design: The type of study is a retrospective cross-sectional review. **Settings:** Civil Hospital Karachi, Pakistan.

Duration: Four years starting from January 2018 to December 2021. **Methods:** The type of study is a retrospective cross-sectional review, where we took data from four years starting from January 2015 to December 2018. We only included primary autologous cranioplasties, and excluded the non-primary cases, minor cranioplasties, and craniosynostoses related surgeries. Various demographics and clinical parameters were analyzed, including complications, time intervals and other important findings. **Results:** We included a total of 106 patients in our study population, the mean age was found to be 42.5 ± 16 years, there were n= 65 (61.32%) males and n= 41 (38.67%) were females. Stroke was found to be the most common cause requiring decompression, accounting for 54% of the cases, while trauma was in second place with 35% cases respectively. The mean duration between decompression and cranioplasty was found to be 180 ± 285 days. A total of n= 41 (38.67%) patients of autologous cranioplasty were found to have complications which lead to the removal of the implanted graft in n= 20 (18.86%) of the patients. Patients younger than 30 years of had a significantly increased risk of developing bone flap resorption having a p value of 0.03. A short time interval between decompression and cranioplasty, of between 0 and 3 months and from 3 to 6 months was associated with bone flap resorption having p value of 0.07 and 0.04. We found a significant relationship between smoking and bone flap resorption having a p value of 0.003. **Conclusion:** Cranioplasty removal was found to be associated with cigarette smoking and younger age of patients <45 years.

Keywords: Autograft, Bone resorption, Cranioplasty, Decompression.

INTRODUCTION

Raised intracranial pressure (ICP) is a common development from several diseases affecting the cranial vault, especially intracranial mass lesions.^{1,2,3} There are various methods to counteract the raised intracranial pressures, one such method is a surgical

procedure that decompresses the pressure on the brain, called as decompressive craniectomy.⁴ Neurosurgeons make appropriate room for the pressure to disperse by removing part of the bone of the skull, often the removed bone is stored for reimplantation later. The procedure of reimplantation is called cranioplasty. During the

procedure either the bone flap is used, or an artificial implant is utilized to fill in the gap created to decompress the cranial cavity. Success is dependent upon restoration of the original contour of the cranium, return of the intracranial pressure to normal, adequate protection for the contents of the cranial vault and improvement in clinical outcome for the patient.^{5,6}

There are some complications associated with this procedure as well such as, infection, hemorrhage and resorption of the bone graft, manifested as weakening and a loose flap, resulting in nonunion which is considered the most significant complication.^{7,8} Neurosurgeons will have to remove this nonunion flap and place a new implant in its place. Further exacerbating the patient condition and incurring additional resource and financial costs. Furthermore, the more the times the patient goes under the knife the higher the rates of complications. The prevalence of this failure of bone graft is reported between 1.4 to 32% in the literature, with the rates of infection being reported to be between 4.6% to 16.4% respectively.⁹

Hence our aim of this current study is to determine the outcome of cranioplasty procedures from our experience of single large tertiary care center in Dubai. The results of our study will help neurosurgeons in Dubai make better decisions about patient care when performing cranioplasties.

METHODS

The type of study is a retrospective cross-sectional review, where we took data from three years starting from January 2018 to December 2021 and followed the initially enrolled patients till December 2021, from a single large tertiary care hospital in Karachi.

The study was approved by the ethics committee, consent was not required as only deidentified data was used for our review. We looked at all the cases of cranioplasties performed at our institute and selected n= 106 cases from a total of n= 156 cases performed at our institute during this time.

We only included primary autologous cranioplasties, and excluded the non-primary cases, minor cranioplasties, and craniosynostoses related surgeries. An increase in ICP of more than 20 mm of Hg of patients having trauma was considered as raised, and these patients were considered as candidates for decompression. Other conditions such as stroke and neoplasia also warrants cranioplasty and we decided to perform the procedure based on the clinical examination, radiographic findings, and surgeons decision during the procedure. The aim for surgeons was to keep the intracranial pressure at less than 20 mm of Hg and to maintain a cerebral perfusion pressure of more than 60 mm of Hg, we also implanted a

pressure monitoring device for all the patients whose Glasgow Coma Scale (GCS) score was calculated to be less than 8. Various demographics and clinical parameters were analyzed, including complications, time intervals and other important findings. The patients were followed until death, removal of bone flap or loss to follow up. All the data was analyzed using SPSS version 22.0 for Windows. Chi square and Fisher's exact test were used to analyze the categorical variables, and continuous variables were assessed with ANOVA. A p value of less than 0.05 was considered to have statistical significance.

RESULTS

We included a total of 106 patients in our study population, the mean age was found to be 42.5 ± 16 years, there were n= 65 (61.32%) males and n= 41 (38.67%) were females. Stroke was found to be the most common cause requiring decompression, accounting for 54% of the cases, while trauma was in second place with 35% cases respectively. For detailed values please see table 1.

Table 1: Patient demographics for cases with bone flap resorption and no bone flap resorption (n= 106 cases)

Variables		Cases with no bone flap resorption clinically (n= 96)	Bone flap resorption cases clinically (n= 10)	P value
Gender	Male	58 (60.41%)	7 (70%)	0.04
	Female	38 (39.58%)	3 (30%)	
Age in years	Less than 30 years	18 (18.75%)	5 (50%)	0.02
	30 to 50 years	41 (42.70%)	3 (30%)	
	More than 50 years	37 (38.54%)	2 (30%)	
Mean size of bone flap in cm [®]		92.4 ± 40	109 ± 33.5	0.09
Diagnosis	Trauma	34 (35.41%)	6 (60%)	0.41
	Stroke	52 (54.16%)		
	Intracerebral hemorrhage	8 (8.33%)	0	
	Subarachnoid hemorrhage	31 (32.29%)	2 (20%)	
	Cerebral ischemia	13 (13.54%)	1 (10%)	
	Benign Tumor	4 (4.16%)	0	
	Neoplasia	2 (2.08%)	0	
	Infection	3 (3.125%)	1 (10%)	
	Others	1 (1.04%)	0	
Time interval between decompression & cranioplasty	0 to 3 months	28 (29.16%)	4 (40%)	0.03
	3 to 6 months	28 (29.16%)	4 (40%)	
	Greater than 6 months	40 (41.66%)	2 (20%)	

The mean duration between decompression and cranioplasty was found to be 180 ± 285 days. A total of n= 41 (38.67%) patients of autologous cranioplasty were

found to have complications which lead to the removal of the implanted graft in n= 20 (18.86%) of the patients. The postoperative complications are given in table 2.

Table 2: Post-operative complications requiring bone flap removal

Complication encountered	Patients (n= 106)	Bone Flap Removed (n= 20)
No complications	65 (61.32%)	0
Superficial surgical site infection	1 (0.94%)	0
Exposure of implant	1 (0.94%)	0
Hydrocephalus	1 (0.94%)	0
Implant migration	2 (1.88%)	1 (5%)
Cosmetically poor	3 (2.83%)	1 (5%)
Leakage of CSF	4 (3.77%)	0
Hematoma/seroma	9 (8.49%)	1 (5%)
Deep Surgical site infection	10 (9.43%)	10 (50%)
Bone flap resorption	10 (9.43%)	8 (40%)

To calculate the predictors of cranioplasty removal we calculated the odds ratio and 95% confidence intervals. We found that when the patients age at the time of the cranioplasty procedure is less than 45 years, the OR is 2.29 and CI is between 1.07 and 4.89 having a p value of 0.03. 9.43% of the cases had bone flap resorption detected clinically, and the mean interval was 530 days \pm 400 days. Patients younger than 30 years of had a significantly increased risk of developing bone flap resorption as compared to those patients above 50 years of age having a p value of 0.03. While gender did not have any significance p value of 0.12. A short time interval between decompression and cranioplasty, of between 0 and 3 months and from 3 to 6 months was associated with bone flap resorption having p value of 0.07 and 0.04, the size of bone defect was not found to be a significant predictor. Etiologies of stroke and trauma also did not have any statistically significant effect on the development of bone flap resorption. We found a significant relationship between smoking and bone flap resorption having a p value of 0.003.

DISCUSSION

The crux of our results was that young age was found to be a risk factor that is associated with bone flap resorption and cranioplasty removal. The initial etiology requiring decompression and the time interval between decompression and cranioplasty did not affect the risk of cranioplasty removal and bone flap resorption. Scientists have reported that smoking and lack of proper oxygenation can lead to incidence of BFR.¹⁰

Similar results were found in our study, hence neurosurgeons should advise the patients to quit smoking all together to prevent these complications. Not just in the field of neurosurgery other surgical sciences also report poor outcomes of smoker when they undergo a surgical procedure. Whilst pre-operative abstinence shows improved outcomes.^{11,12,13} Young age has been associated with bone flap resorption.^{14,15,16}

This could be explained by the fact that cranial growth does involve some natural resorption and an injury and intervention at this time can exacerbate the resorption complication. The primary mechanism of bone flap resorption mimics avascular necrosis as compared to direct resorption through osteoclasts. However, there is still debate on this topic as there is no associated rise in calcium levels during BFR.^{17,18}

In our study we did not find any associated between diabetes and bone flap resorption, however it is well known that diabetes tends to increase the overall complication rate of surgical procedures.^{19,20,21,22} We did not find any associated between increase intracranial pressures and bone flap survival. However, there is an inherent bias as only those cases whose chances of survival are high would be selected for the procedure. The overall complication rate of our study was 38.67% and cranioplasty removal rate 18.86%, which are consistent with similar studies.^{23,24,25}

CONCLUSION

Cranioplasty removal was found to be associated with cigarette smoking and younger age of patients <45 years.

LIMITATIONS

The only limitation to our study was the small sample size and that the study was conducted in a single center.

SUGGESTIONS / RECOMMENDATIONS

As the sample size of the study is small we recommend to further continue the study also we found close relation between cigarette smoking patient and bone flap resorption in the patient who smokes.

CONFLICT OF INTEREST / DISCLOSURE

None.

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