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Functional and Aesthetic Evaluation Following Cranioplasty: A Prospective Study

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Abstract

Introduction: Cranioplasty is the surgical procedure to restore the calvarial form and function secondary to decompressive craniectomy. Cranioplasty is generally performed for cosmetic reasons and cerebral protection. It also has a therapeutic role in improving cerebral perfusion, cerebrospinal fluid dynamics and neurological outcomes. The present study assessed functional and esthetic outcomes following cranial reconstruction.

Materials and Method: The prospective study evaluated 23 patients (18 male and 5 female) aged between 28 to 65 years who reported to Department of Oral and Maxillofacial Surgery, Army Dental Centre (Research & Referral), Delhi who underwent cranioplasty post decompressive craniectomy. Cranioplasty was performed using autogenous calvarial bone and alloplastic material using PMMA and Titanium mesh. Functional and esthetic outcomes assessment was done one day prior to surgery and post-operatively at 6 months. Functional outcomes were evaluated on a 7-tier ordinal scale using functional independence measure. Esthetic outcomes were evaluated on a 4-tier grading scale based on skull shape and symmetry, cosmesis and scars.

Results: The present study revealed functionally, structurally and cosmetically satisfying results. Neurological status significantly improved in four patients (17%), mild improvement in eight patients (35%) and unchanged neurological status was recorded in eleven patients (48%) post cranioplasty. The skull shape and symmetry, cosmesis and scars revealed excellent improvement in 78%, 70% and 65% of patients respectively.

Conclusion: Given the impressive outcomes of the present study, it can be concluded that a significant

number of the patients had improved neurological and esthetic outcomes post cranioplasty.

Keywords: Cranioplasty, Functional independence measure, Esthetic.

Introduction

Cranioplasty is an established surgical procedure since more than two decades to correct the residual calvarial bone defect following decompressive craniectomy.[1] It is generally performed for cosmetic reasons and to provide mechanical shield against the development of the syndrome of the trephined i.e. neurological deterioration following the decompressive procedure. The defects are commonly observed in frontal, parietal, temporal and occipital bones. It can be classified as simple, compound and complex defect based on anatomical involvement and small, medium and large defect based on the surface area.[2] Reconstruction of the calvarial defect depends upon various factors like cause of defect, condition of recipient site, age and general condition of the patient, and availability of preserved bone.

Grant and Norcross in 1939 firstly described syndrome of the trephined which causes symptoms like headache, seizures and behavioural disturbance.[3,4] Neurological deficits generally occur following decompressive craniectomy, however cranioplasty is a well-established procedure to improve the cognitive and neurological behaviour of the patient. Restoration of the anatomic barrier between intracranial structures and the environment lead to reduction in cerebral compression due to atmospheric pressure and elimination of the atmospheric pressure effects which results in an increase in the cerebral blood flow, thus leading to neurologic improvement.[5]

Preserved autologous bone is the first choice of material in cranioplasty because of high resistance to infection and lower probability of extrusion, but associated with absorption rate if it is not preserved well. Alloplastic materials have an excellent contour, but have a higher risk of infection and extrusion. The most used materials are Poly Methyl Methacrylate (PMMA), Hydroxyapatite (HA) and titanium. Customized PMMA plate provides excellent match up and contour to the cranial defect which can be fabricated with help of 3D model.[6,7,8] Literature review revealed very few studies on cranioplasty patients evaluating the neurological status along with cosmetic correction. The aim of the present study is to evaluate the functional and aesthetic outcomes following calvarial reconstruction.

Materials and Methods

Clinical Data

The prospective study evaluated 23 patients (18 male and 5 female) aged between 28 to 65 years reported to Department of Oral and Maxillofacial Surgery from May 2018 to June 2019 who underwent cranioplasty post decompressive craniectomy. The study was approved by the institutional ethical committee and written informed consent was taken from all the patients and closed relatives. Descriptive data of patients were recorded. The cranioplasty was performed after evaluating the patient's medical condition and general health, history of recent seizure episode, sinking flap, drug therapy, type of the defect, size of the defect, evaluation of neurological behavior. The mean time interval between craniotomy and cranioplasty was six to nine months. All the cranioplasty was performed by the same surgical team after the neurosurgical clearance

Treatment Outcomes

Functional and esthetic outcomes assessment was done one day prior to surgery and post-operatively at 6th month. Functional outcome was evaluated on 7-tier ordinal scale using functional independence measure. Functional Independence Measure (FIM) is a basic indicator of

severity of disability that comprises of motor and cognitive items such as walking, grooming, bathing and memory. The total motor items are 13 and the cognitive items are 5. The rating scale designates major graduations in behaviour from dependence which is scored as 1 to independence for that task which is scored as 7. Therefore, total score for all 18 items range from 18 to 126. A change in the total FIM of greater than 2 points was considered as mild improvement and change up to 4 points was considered as the significant improvement.

Esthetic outcomes was evaluated on 4-tier grading scale based on skull shape and symmetry, cosmesis and scars as scale as poor (score 0), satisfactory (score 1), good (score 2) and excellent (score 3).

Statistical Analysis

The data was subjected to statistical evaluation by paired t-test for FIM using the SPSS 17.0 (SPSS, Inc, Chicago, IL). with values less than 0.05 considered statistically significant for the parameter. Changes in FIM before and after cranioplasty were compared using a paired t-test

Results

A total of 23 patients who underwent cranioplasty with complete records and completed follow-up period of 6 months were included in this study. The age of the patients ranged from 28 to 65 years with an average age of 39.91 ± 2.18 years. Twelve patients had residual calvarial defect on left side, eight patients had defect on right side and three patients had midline residual calvarial defect. Head injury was the cause for craniectomy in 14 patients, Sub arachnoid haemorrhage in 02 cases, Refractory intracranial HTN in 04 cases and brain tumor in 03 cases **(Table 1)**.

Cranioplasty was performed from 128 to 212 days with a mean time period of 172.1 ± 26.20 days after decompressive craniectomy. The area of bone graft ranged from 39 cm^2 to 154 cm^2 (mean 81.46 ±34.23 cm2). The mean duration of hospitalization following cranioplasty ranged from 5 to 8 days with an average of 6.75 ±0.97 days. Healing was satisfactory and there were no signs of infection, epidural or subdural hematoma, hydrocephalus, subcutaneous CSF collection or fistulas in all patients during follow-up monitoring.

There was statistically significant improvement in neurological status in four patients (17%), mild improvement in eight patients (35%) and unchanged neurological

status in eleven patients (48%). The preoperative FIM score ranged from 34 to 88 with a mean of 61.6 ± 3.16 and the postoperative FIM score at 6 months ranged from 38 to 92 with a mean of 63.6 ± 2.95 **(Table 2)**. Statistically significant improvement was recorded in FIM score (p=0.005) following the cranioplasty procedure. **(Table 3).** The shape, symmetry, and contour of skull showed excellent maintenance in 18 patients (78.2%), moderate improvement in 3 patients (13.04%) and mild improvement in 2 patients (8.76%). Cosmetic outcomes were judged excellent in 16 patients (70%), moderate improvement in 5 patients (21%) and mild improvement in 2 patients (8%). Scars revealed excellent improvement in excellent in 15 patients (65%), moderate improvement in 4 patients (17%) and mild improvement in 4 patients (17.5%). Esthetic outcomes are summarized in **(Table 4)** and a representative case of cranial reconstruction using autogenous bone flap is presented in **(Figures 1 to 4)**.

Figures showing representative case of cranioplasty using autogenous bone graft

Fig. 1: Pre-op photograph

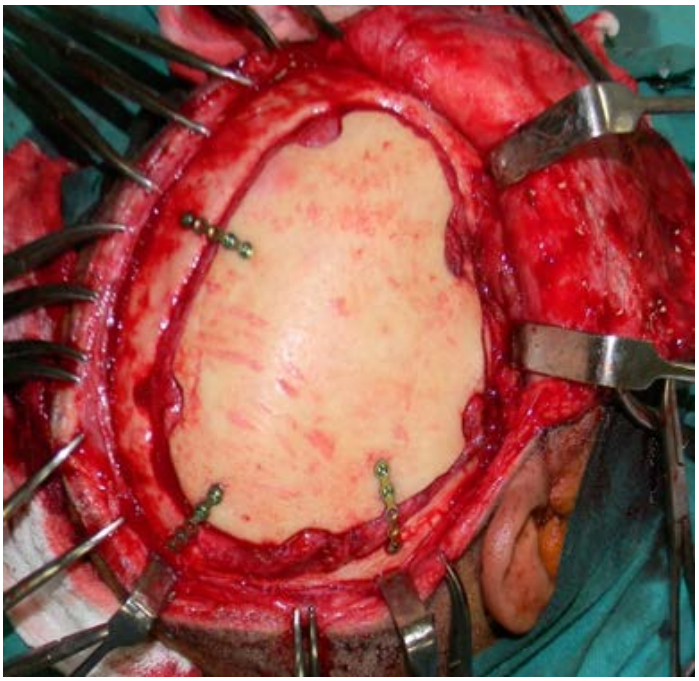

Fig.2: Cranioplasty

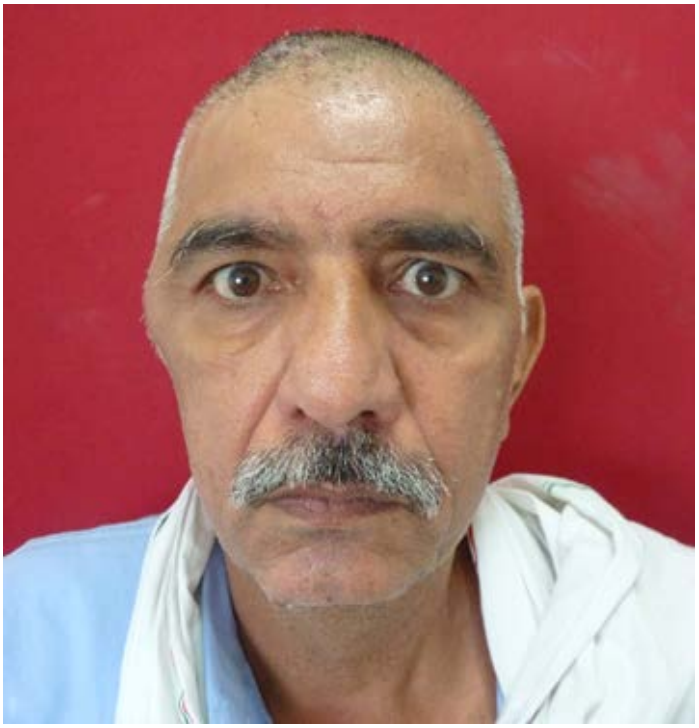

Fig 3: Post-op photograph

Fig 4: Esthetic evaluation

Table1: FIM score pre-operative and post-operative FIM scores (n= 23).

No.	Age/ Sex	Pathology	Pre op FIM score (Motor + cognitive)	Post op 06 months FIM score (Motor + cognitive)
1	31/F	Traumatic brain injury	66	68 (Mild Improvement)
2	28/M	Sub arachnoid haemorrhage	62	64 (Mild Improvement)
3	65/M	Space occupying lesion	34	38 (Significant Improvement)
4	34/M	Refractory intracranial HTN	54	54 (No improvement)
5	39/M	Traumatic brain injury	46	58 (Significant Improvement)
6	33/M	Traumatic brain injury	58	60 (Mild Improvement)
7	47/F	Sub arachnoid haemorrhage	66	66 (No Improvement)
8	45/F	Traumatic brain injury	88	88 (No Improvement)
9	38/F	Traumatic brain injury	48	56 (Significant Improvement)
10	28/M	Traumatic brain injury	46	48 (Mild Improvement)
11	49/M	Traumatic brain injury	40	42 (Mild Improvement)
12	46/M	Refractory intracranial HTN	48	50 (Mild Improvement)
13	33/M	Traumatic brain injury	56	56 (No Improvement)
14	37/F	Space occupying lesion	78	78 (No Improvement)
15	31/M	Traumatic brain injury	66	66 (No Improvement)
16	52/M	Refractory intracranial HTN	72	72 (No Improvement)
17	29/M	Traumatic brain injury	74	74 (No Improvement)
18	33/M	Traumatic brain injury	76	78 (Mild Improvement)
19	30/M	Traumatic brain injury	80	80 (No Improvement)
20	56/M	Traumatic brain injury	88	92 (Significant Improvement)
21	53/M	Traumatic brain injury	62	62 (No Improvement)
22	38/M	Refractory intracranial HTN	44	46 (Mild Improvement)
23	40/M	Space occupying lesion	66	66 (No Improvement)

Table 2: Descriptive data of the patient and FIM score

		AGE	SEX	FIM SCORE 1 DAY PRIOR TOSURGERY	FIM SCORE POSTOP AFTER 06 MONTHS
N	Valid	23	23	23	23
	Missing	0	0	0	0
Mean		39.9130	1.2174	61.6522	63.5652
Std. Error of Mean		2.18503	.08794	3.15766	2.95408
Std. Deviation		10.47904	.42174	15.14358	14.09679
Variance		109.810	.178	229.328	198.719
Range		40.00	1.00	54.00	58.00
Minimum		28.00	1.00	34.00	38.00
Maximum		68.00	2.00	88.00	92.00
Sum		918.00	28.00	1418.00	1462.00

Table 3: Paired difference pre and post op FIM score

	Paired Differences					t	df	Sig. (2-tailed)
	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1 PRE-OP FIM – POST OP FIM AFTER 06 MONTHS	-1.91304	2.92191	.60926	-3.17657	-64952	- 3.140	22	.005

Table 4: Esthetics outcomes following cranioplasty

S.No.	Shape and Symmetry (Average Score	Cosmesis (Average Score)	Scars (Average Score)
1	3	3	2
2	3	2	3
3	3	2	2
4	2	3	3
5	3	2	3
6	2	3	2
7	3	2	1
9	3	3	3
10	2	3	2
11	3	3	3
12	3	3	1
13	1	3	3
14	3	1	3
15	3	3	1
16	3	2	3
17	1	3	3
18	3	1	3
19	3	3	1
20	3	3	3
21	3	3	3
22	3	3	3
23	3	3	3

Discussion

The Main function of cranioplasty is provide a mechanical shield to the underlying brain and restore cosmesis of the patient. Pathophysiology behind the improvement in the neurological status are multifactorial. Restoration of cerebral hemodynamics as an explanation for neurological recovery after cranioplasty was proposed by Richaud et al (1985).[9] Suzuki et al (1993) investigated the cerebral blood flow with dynamic CT scanning in patients who underwent cranioplasty.[10] They suggested that an increase in the bilateral cerebral blood flow after cranioplasty might play a role in the patient's neurological improvement. Till now there are very few studies in literature which have studied neurological status of the patient, present study shown the improvement in the neurological behaviour with a long term of follow up to six months. There were two patient who developed seizure episode immediate after the surgery which was managed with injection phenytoin 300mg stat. None of the patient deteriorated after surgery or developed any symptoms of syndrome of the trephined fell outside the predetermined assessment period. All the patient were discharged after five to eight days of hospitalization and recalled after on monthly basis for the evaluation. Functional and Aesthetic evaluation was performed after sixth follow after cranioplasty and compared with the previous score.

The materials used in the reconstruction of residual cranial defect fall into 4 groups: autografts, allografts, xenografts, and alloplastic materials. ideal material should match the physical, chemical, thermal, immunological, and embryological properties of the tissue to be replaced. Autogenous bone flap harvested from craniectomy site is considered as the gold standard reconstructive material. It is readily available, cost-effective grafting material that has identical anatomical match with desirable cosmetic outcomes. Bone flap infection and resorption is the common troubling complication with an incidence rate ranging from 0 to 33%, In this study resorption of the bone was seen in one patient.[11,12] Other material like PMMA has been the most commonly used material for secondary cranial reconstruction. PMMA consists of a thermoplastic material with high biocompatibility, mechanical resistance, and gives better cosmetic results also.

Cranioplasty is a proven surgical procedure to improve the neurological behaviour and in this study with statically improvement was seen in the patients following cranioplasty, significant improvement in neurological status along with improvement in the esthetics. Dynamic Magnetic Resonance Perfusion Imaging will be helpful to study the perfusion changes in cerebral hemodynamic and to evaluate pathophysiology behind thr improvement in neurological status based on the perfusion.

Conclusion

This prospective study showed significantly impressive outcome after an adequate follow up period of 6 months. It can be concluded that most of the patients had improved neurological status, form, function and aesthetic outcome post cranioplasty. Further studies are recommended to evaluate the pathophysiology for the improvement in the score.

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