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Outcome of cranioplasty after decompressive craniectomy: Algorithm based study

Cranioplasty is the next major surgical procedure that the patient undergoes following the decompressive craniectomy for severe traumatic brain injury (TBI). This study was designed with the objective to evaluate the outcome of our institutional algorithm-based protocol in the management of cranioplasty.

This is aretrospective analytical study conducted in National Institute of Neurological and Allied sciences, Bansbari Kathmandu among 40 patients who underwent cranioplasty during a period of 5 years. Variables viz. postoperative CT changes, cranioplasty site infection and change in the modified Rankin scale following the cranioplasty were analyzed.

Among 40 patients who underwent the cranioplasty, 82.5% were male and 17.5% were female. The age of the patients ranged from 4 to 72 years with mean of 29.5±13.13. Interval between primary decompression and cranioplasty ranged from 3 to 78 weeks. Algorithm based preoperative planning was done before cranioplasty. Previous abdominal bone flap preservation site infection was significantly associated (p value 0.048) with cranioplasty site infection. There was no deterioration in the MRS score.

The proper evaluation of the preoperative CT scan and the combined adjunctive procedure with cranioplasty in the selected patients helps to decrease the post cranioplasty related complications.

Keywords: TBI, Decompressive craniectomy, Autologous, Acrylic, Cranioplasty, CSF diversion

Decompressive craniectomy is the established method of treatment for the brain swelling following the traumatic brain injury.[1,2] The decompressive craniectomy is often timesfollowed by the cranioplasty, which is done either for the cosmetic reason or to prevent the trephination syndrome. Though the cranioplasty seems to be the short and straight forward procedure, it is also not devoid of various complications and morbidity ranging from 12% to 50% in different series.[3-8] The various factors that have been taken into consideration for cranioplasty are timing, presence or absence of infection and the hydrocephalous.[3,5]The functional outcome of the patients following the Traumatic brain injury (TBI) mostly depends on the primary insult.

However, the certain literatures have good reviews on the neurological improvement of the patients following the cranioplasty.[9,10]Mortality following cranioplasty is 0 to 3.16 %. in different series.[11,12]Therefore, this research was designed with the objective to evaluate the outcome of our institutional algorithm-based protocol in the management of cranioplasty.

Methodology

Study design : Retrospective analytical study
Sample Size : 40 patients
Sampling Technique : Non-probability consecutive
Duration : 5 years
Inclusion Criteria : All patients who underwent cranioplasty within last 5 years
Exclusion Criteria : Cranioplasty after craniectomy for brain swelling following surgery like tumors, malignant MCA infarction, AVM, aneurysms.
Variables under study Dependent variables:
Post cranioplasty CT scan changes
Cranioplasty site infection
Change in Modified Rankin Scale (MRS)

Independent variables:

Age, gender, cause for decompressive craniectomy, duration between decompressive craniectomy and cranioplasty, type of cranioplasty, side of decompressive craniectomy, cranioplasty technique, preoperative CT scan, need of lumbar drain, Thecoperioneal (TP) shunt or Ventriculoperioneal (VP) shunt

Data collection and Analysis

All patients who underwent cranioplasty were enrolled in the study. Patients details, findings, complications and MRS were collected from patient's files. Proforma was used for data entries. Analysis was done using SPSS 20. Frequencies, percentages were calculated for demographic data. Chi square/ Fisher exact test as per needed was used to evaluated the significance of association with the outcome variables.

Algorithm based pre cranioplasty planning

CT scan was obtained on the morning of the operative day. All patients were evaluated as per the cranioplasty algorithm (Figure 1). Those patients who had hydrocephalous underwent CSF diversion procedure. The presence or absence of the fullness of brain was determined just after the intubation. In case of fullness of brain, the lumber drain was kept to drain the CSF to lax the brain before commencing the cranioplasty.

Operative technique

After opening the skin and galea, the bone edges on the decompression site was made visible by dissecting the soft tissue and the attached dura by pen-field dissector. The temporalis muscle was dissected off the dura and reflected.

Autologous cranioplasty

The preserved bone flap in the subcutaneous layer in the abdomen wasretrieved and washed with betadine and hydrogen peroxide using the separate operative instruments. After closing the abdominal incision wound was dressed and surgeon re-scrubbed for cranioplasty.

Acrylic cranioplasty

The acrylic bone cement was prepared after making the operative field ready for cranioplasty. The edges of the bone cement were fashioned to accommodate the defect. Multiple holes were made in the acrylic flap and cranial bone with drill or matchstick. Central hitch was applied and flap anchored to cranial defect with 2-0 Vicryl. Temporalis muscle repositioned over the flap and closure of skin done after placing romovac drain.

Results

There were total 40 patients who underwent cranioplasty over the study duration of 5 years. Among which 33 (82.5%) were male and 7 (17.5%) were female with male to female ration of 4.7. Mean age of patient was 29.5 (SD 13.13) years, and ranged between 4 to 72 years. Decompression was bifrontal in 16 patients (40%) followed by 14 in left (35%) and 10 in right side (25%) (Table 1). Out of 40 patients, 22 patients underwent autologous cranioplasty, 17 acrylic and 1 underwent titanium cranioplasty. Mean duration of cranioplasty following the primary decompressive craniectomy was 11.88(SD13.88) weeks which ranged between 3-78 weeks. Moreover, 22 patients (55%) underwent cranioplasty after 6 weeks and 18 patients (45%)within 6 weeks.

Side	Frequency	Percent
Bifrontal	16	40
Left	14	35
Right	10	25

Table 1: Side of decompressive craniectomy

Out of 40 patients, 14 patients (35%) had abdominal bone storage site infection after primary decompressive craniectomy (Table 2).CT scan performed before cranioplasty showed evidence of hydrocephalus in 4 (10%) and fullness in 9 (22.5%) of patients (Table 3). Of

4 patients who had hydrocephalus, 3 patients underwent cranioplasty with lumbo-peritoneal shunt in the same sitting; whereas, 1patient underwent VP shunt few days prior to cranioplasty (Table 4). Of 9 patients who had fullness, 8 of them underwent cranioplasty with intraoperative CSF drainage via lumber drainfor reducing the brain swelling while 1 patient had minimal fullness. Twenty eight patients underwent cranioplasty without any adjunctive procedures (Table 5).

Abdominal site infection	Frequency	Percent
No	26	65
Yes	14	35

Table 2: Frequency of abdominal bone storage site infection

Pre Cranioplasty-CT	Frequency	Percent
NO Hydrocephalus/Fullness	27	67.5
Hydrocephalus	4	10
Fullness	9	22.5

Table 3: Pre - cranioplasty CT findings

Operative procedure	Frequency	Percent
Cranioplasty	28	70
Cranioplasty+LD	8	20
Cranioplasty + TP	3	7.5
VP shunt followed by Cranioplasty	1	2.5
Total	40	100.0

Table 4: Frequency of patients in different operative technique

Of the entire patient who underwent cranioplasty, 2 had epidural collection and 1 had small contusion which were managed conservatively. Thirty seven patients (92.5%) patients had no changes in the post cranioplasty CT scan (Table 5).

Post cranioplasty CT	Frequency	Percent
No change	37	92.5
Epidural collection	2	5
Contusion	1	2.5

Table 5: Post-cranioplasty CT changes

There was total 5% cranioplasty site infection (Table 6). Previous history of abdominal site infection increases the odds of cranioplasty site infection (OR 0.316; CI 0.198 to 0.5040). However, other confounding variables didn't show significant association with the cranioplasty site infection (Table 7).

Cranioplasty site wound infection	Frequency	Percent
No	38	95
Yes	2	5

Table 6: Frequency of cranioplasty site wound infection

Variables	Categories	Wound Infection		P value
		No	Yes	
Age (Years)	<20	6	0	0.765
	20-29	17	1	
	30-39	5	1	
	40-49	8	0	
	50-59	1	0	
	70-79	1	0	
Gender	Male	31	2	0.677
	Female	7	0	
Duration following decompressive craniectomy	<6wks	18	0	0.189
	>6wks	20	2	
Side of Decompressive craniectomy	Right	10	1	0.70
	Left	13	1	
	Bifrontal	15	1	
Abdominal site infection	No	26	0	0.048
	Yes	12	2	
Type of Cranioplasty	Autologous	22	0	0.241
	Acrylic	15	2	
	Titanium	1	0	
Procedure performed	Cranioplasty	27	1	0.734
	Cranioplasty+LD	7	1	
	Cranioplasty + TP	3	0	
	VP shunt followed by Cranioplasty	1	0	
Pre cranioplasty CT	No HCP/fullness	26	0	0.602
	Hydrocephalus	4	1	
	Craniectomy site fullness	8	1	

Table 7: Wound Infection at different variables

None of the patients died following cranioplasty in our series. There was no deterioration of MRS in any of the patients who underwent cranioplasty. 35 patients (87.5%) had no change in MRS, 3 patients (7.5%) had 1 score improvement and 2 patients (5%) had 2 score improvement in the MRS (Table 8). Cranioplasty performed with this institutional protocol had no association with MRS difference.

MRS improvement	Frequency	Percent
0	35	87.5
1	3	7.5
2	2	5
Total	40	100.0

Table 8: MRS improvement

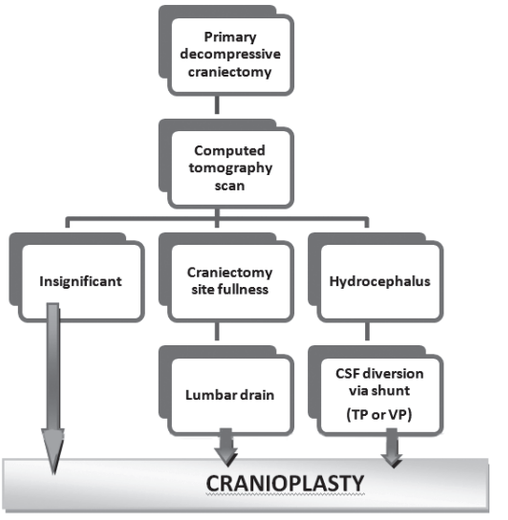

Figure 1: Algorithm for cranioplasty following primary decompressive craniectomy

Discussion

Cranioplasty is the next major surgical procedure that the patient undergoes following the decompressive craniectomy for traumatic brain injury. Person of any age group and sex can sustain traumatic brain injury; however, the males in adult age group are more susceptible to the trauma as these population are more involved in the outdoor activities and road traffic accident is also more common in these population.[13,14] Similar to this study, male patients occupied about 82.5% of the patients for cranioplasty. In our hospital, following decompressive craniectomy, bone flap is preserved in the abdominal cavity in contrast to other centers where it is preserved in the freeze. However, the abdominal bone flap preservation site infection was about 36% which is more than reported in the literature. There was no difference in infection rate in the literature depending on the site of preservation i.e. freeze or the subcutaneous area.[15] Post-cranioplasty site infection was seen in 5% of the patients which is slightly lower than that been reported by Huyang YH et al.[16]and slightly higher than reported by Roka. Y.[17] The timing of the cranioplasty following the craniectomy has been the topic of debate. The overall complication rate including the infection was not significant between early and late cranioplasty in different studies.[18-20]In contrast, Bauchmann et al. published a paper in favor of early cranioplasty and also stressed that delayed cranioplasty doesn't decreases the infection rate or the need of the CSF diversion procedure.[3]

In our study, 70% of our patients did not required any adjunct (lumbar drain, TP shunt or VP shunt) with cranioplasty, 20% required lumbar drain placement due to fullness of brain during the procedure while 7.5% patients underwent TP-shunt and 2.5% required VP-shunt before cranioplasty due to hydrocephalous. In the study done by Huyang YH et al, 20% of the patients who had hydrocephalous in the pre-cranioplasty CT scan underwent CSF shunting procedure.[16] Similarly, 12.8% of the patients who had hydrocephalous in our series also underwent CSF diversion procedure before cranioplasty. Gooch MR et al. has reported 1.6% of post-cranioplasty epidural hematoma and subdural hematoma each in their paper.[20] Similarly, 2 patients (5%) had epidural collection and 1 patient (2.5%) had underlying contusion in our series which all were managed conservatively. Various papers and the case report have shown that timing of cranioplasty not only alters the complication rates but also influences in the neurological outcome.[21,22] The mechanism for the improvement in the neurological outcome following cranioplasty is basically undermined. The believed pathophysiological basis for this has been stated that cranioplasty has got influence over the blood flow regulation, cerebrovascular reserve capacity and cerebral glucose metabolism. Few clinical literatures have demonstrated the relationship between the optimal timing of cranioplasty and the functional outcome recently.[12,18,19] Liang et al.[12] and Bender et al.[19] found that early cranioplasty is not only safe but can improve the patient's neurological outcome and also the prognosis. In our study also, there was no mortality. 3 patients (7.5%) had 1 score improvement and 2 patients (5%) had 2 points improvement in MRS following cranioplasty. However, it was not statistically significant and none of the other confounding variables had been found to be associated with this change in MRS.

Conclusion

The proper evaluation of the preoperative CT scan and algorithm based combined adjunctive procedure for cranioplasty in the post decompressive craniectomy patients helps to decrease the post cranioplasty related complications. In our study, few numbers of patients had slight improvement in the MRS score. Large prospective trial will be required to propose the definitive recommendation.

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