Cranioplasty: Complications Observed In Dhaka Medical College And Hospital

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Abstract—Background: Cranioplasty is a secondary surgical procedure performed to restore a defect on the cranial vault among the surviving patients are obligated to undergo a second procedure after a previous decompressive craniectomy made for severe traumatic brain injury (TBI). Apparently, it may resemble an easy and routine surgical procedure, cranioplasty has a rate of complications 31% to 41% of cases[21], but we have 37% complications. The most frequently reported complications are infections, autologous bone flap resorption, and hematomas. But sometimes, wound dehiscence, seizures, hygroma, sinking flap syndrome and poor cosmesis may develop.

Objective: Complications of cranial reconstruction and factors affecting the success are not well described in literature and remain under reported. In this study, the complications would suggest the measures to improve the care of these patients and to reduce further complications. Minor complications (31%) can be solved conservatively but major complications (06%) may need revision surgery with or without removal of the cranioplasty flap. Aim of cranioplasty is to restore vault defect created by previously performed decompressive craniectomy thereby, *i)* Protect the brain – prevent vulnerable brain damage*, ii)* Cosmetic purposes of head *and iii)* Accelerate and improve neurological and cognitive recovery including headache, dementia, speech etc.

Methods: Data were collected on the variables like age, sex, pattern of head injury, aetiology of DC, time interval between decompressive craniectomy and cranioplasty, materials used for skull reconstruction, infection and complications related to cranioplasty. The neurological status was evaluated 1 day before, & on 7th POD, at 3 months and 6 months after cranioplasty with Glasgow Outcome Scale (GOS).

Results: Complications were analyzed by two forms. Minor complications in which the problems were solved conservatively in 31% cases and major complications were observed in 6% of cases where surgical intervention and removal of cranioplasty flap was done in 4% cases.

Conclusion: Though cranioplasty has a lot of complications, even though it has to be done for maintaining good neurological outcome, economically productive, socially, financially and psychologically aesthetic life.

Keywords- Cranioplasty, CPL, Complications, Bone resorption, BFR, Infection, Seizure, Haemorrhage.

I. INTRODUCTION

Cranioplasty is a secondary surgical procedure performed to restore a defect on the cranial vault after a previous operation made with the removal of skull bone flap. This commonly happens when a decompressive craniectomy is needed for brain contusion and edema due to traumatic injury, ischemic or hemorrhagic stroke, after the removal of cranio-dural tumors, or even after the correction of skull malformations. In many patients with severe neurological conditions, decompressive craniectomy is a lifesaving procedure, but then it requires in survivors the bone flap replacement or its reconstruction with cranioplasty.Cranial reconstruction is important for several motives: it can provide protection to the underlying brain, may improve neurological function by recovering cerebrospinal fluid (CSF) dynamics and cerebral blood flow, and it can restore cosmetically the cranial contour. Recent studies have shown that cranioplasty may improve the patient's psychological status, social performance, and neurocognitive functioning[22, 23, 24, 25]. There are different kinds of cranioplasties, but most involve

lifting the scalp and restoring the contour of the skull with the original skull piece or a custom contoured graft made from material such as Conventional cranioplasty methods involve peeling back all five layers of the scalp to place the bone remnant or custom implant in the proper cranial location. For peri-cranial on-lay cranioplasty, a newer technique, the surgeon pulls back the three uppermost layers of the scalp and inserts the bone or implant in between the third and fourth layers (John Hopkins). Several parameters such as the initial underlying pathology, type of bone graft, timing of surgery, patient comorbidity, and the technical aspects of the cranioplasty technique have been associated with the occurrence of complications which ultimately affect neurological output. CPL is a risky surgical procedure, since at least one-third of cranial reconstructions are burdened by complications[1, 2]. Several factors may influence the appearing of complications: time lapse between bone decompression and cranial reconstruction, materials used for CPL, age and conditions of patients, the experience of the surgeon on cranial reconstruction[3, 4]. The most frequent CPL complications reported in the literature are: infections, bone resorption, wound dehiscence, hemorrhage on or under the prostheses, seizures, hygromas[4, 5, 6, 8, 10]. Although uncommonly mentioned[1, 12], also poor cosmetic result must be recorded among possible CPL complications. The factors that contribute to periprocedural complications, including patients' demographic information, comorbidities, surgical procedure, and underlying disease, need to be thoroughly evaluated. Recent evidence in the literature emphasizes patient-specific factors over surgery-specific factors as major predictors of cranioplasty. complications[10, 11]. It is also becoming evident that surgical treatment for cranioplasty complications is associated with additional surgical procedures[1, 10].

II. MATERIALS AND METHODS

Data were collected in the following clinical ground-age, sex, pattern of head injury, aetiology of DC, time interval between decompressive craniectomy and cranioplasty, materials used for skull reconstruction, infection and complications related to cranioplasty The neurological status was evaluated 1 day before, & on 7th POD, at 3 months and 6 months after cranioplasty with Glasgow Outcome Scale (GOS). Complication follow up status was defined as i) Normal- when there was no problem in wound healing and any other complications. ii) Minor complications- when conservative treatment and minor local procedure was employed for wound problem. iii) Major complications- when revision surgery or implant removal was required. GOS of 1-3 was considered as unfavourable (dead/ dependent/others) and GOS of 4-5 as favourable (independent).

III. RESULTS

All these data (table 01) came from a study of acute TBI where decompressive craniectomy (DC) was done in 602 cases in Dhaka medical college hospital from 2015 to 2018. That study outcome table is the starting of this study[26].

Table 01: Post-operative GOS Score of Patients with DC (N=602)[26]

Sl. No	GOS		On 10th POD		Following 1 Month	
			No of patients (N)	%	No of patients (N)	%
1	Good out come	**5:** Good recovery: Resumption of normal life despite minor deficits	126	20.9	169	28.1
2		**4:** Moderate disability: Disabled but independent; can work in sheltered setting	139	23.1	138	22.9
3	Poor out come	**3:** Severe disability: Conscious but disabled; dependent on other for daily support	137	22.8	108	17.9
4		**2:** Persistent vegetable state: Minimal responsiveness	66	10.9	35	5.9
5	Expired	**1:** Death	134	22.3	152	25.2

Table 02: Distribution of total study population (N=602)

Parameters	Number of Patients	Percentage
Received cranioplasty	360	60%
Death	152	25.2%
Missing Cranioplasty	90	14.8%

Among the total 602 DC patients 25.2% (152) died in the hospital. Remaining patients 60% (360) attended for a second reconstructive surgical procedure called received cranioplasty group. Another 14.8% (90) patients did not attend to our centre designated as missing cranioplasty in the table 02 some of whom got reconstruction somewhere else and some may have expired subsequently.

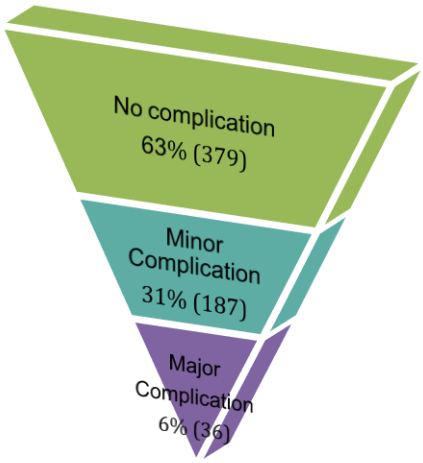


Fig. 01: Effects of Cranioplasty (N=360)

Figure 01 shows pattern of complications (n=360). Majority of our patients (63%) (379) did not develop any complication. Thirty one percent (31%) (187) patients developed minor complications which were managed conservatively and another 6% (36) patients developed major complication which were managed by revision surgical intervention with removal of cranioplasty flap.

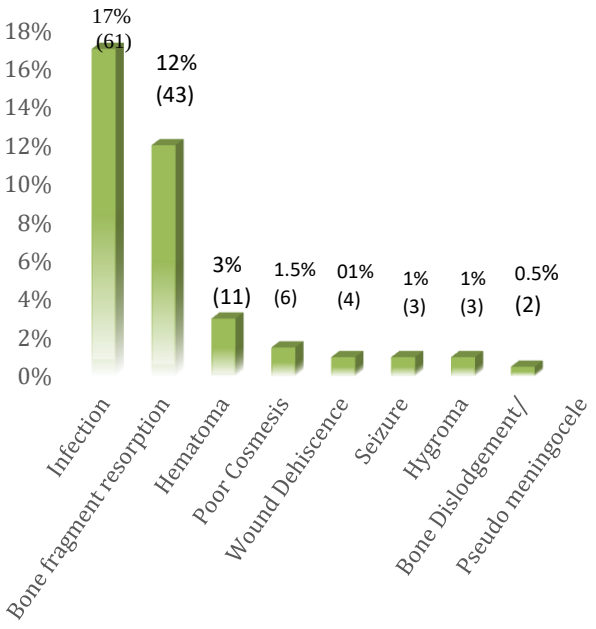


Fig 02: Distribution of All Complications (N=360)

Figure 02 shows list of all documented complications. Here, infection and bone fragment resorption are the two main complications counting 17% (61) and 12% (43) respectively constituting 29% out of total complicated 37% cases. Remaining are hematoma formation, poor cosmesis, seizure, hygroma and wound dehiscence developed in 3%,1.5%, 1%,1%, and 1% respectively.

Table 03: Materials Used for Cranioplasty (N=360)

Parameters	Number of Patients	Percentage
Autologous Bone (Subcutaneous Pocket)	72	20%
Cryo-preservative (Freezing at -35° C to -80°C)	79	22%
Synthetic (acrylic)	209	58%

In table 03, it is shown that autologous bone flap was used for cranioplasty in 42% (151) and synthetic material was used in the remaining 58% (209) cases. Hydroxyapatite bone cements mainly and polymethyl methacrylate (PMMA) bone mass were used as synthetic material in cranioplasty.

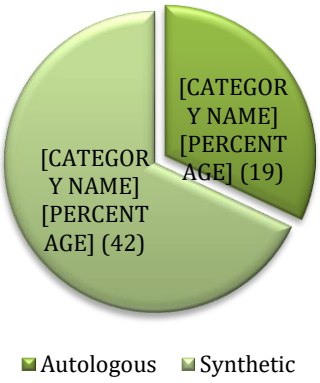


Fig 03: Infection Rate among Cranioplasty (N= 61)

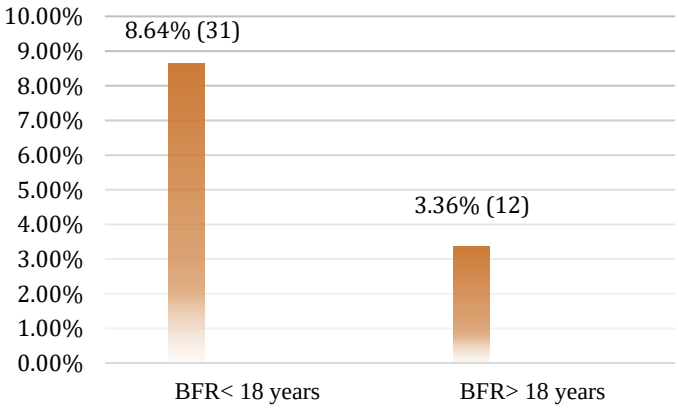


Fig 04: Distribution of Bone Fragment Resorption (BFR) (N=360)

Thirty two percent (~19) cases got infected where autologous material was used for cranioplasty rather that is 68% (~42) in synthetic group which may be due to proper sterilization and autologous bone flap did not produce any graft versus host reaction (Figure 03). In figure 04, bone resorption was 8.64% in patients < 18 years of age and that was 3.36% in adults.

Table 04: Distribution of Major Complications (N=360)

Parameters	Number of Patients	Percentage
Infection	14	4%
BFR	7	2%

2% cases of BFR and among infected cases, 2% needed removal of bone flap (table 04).

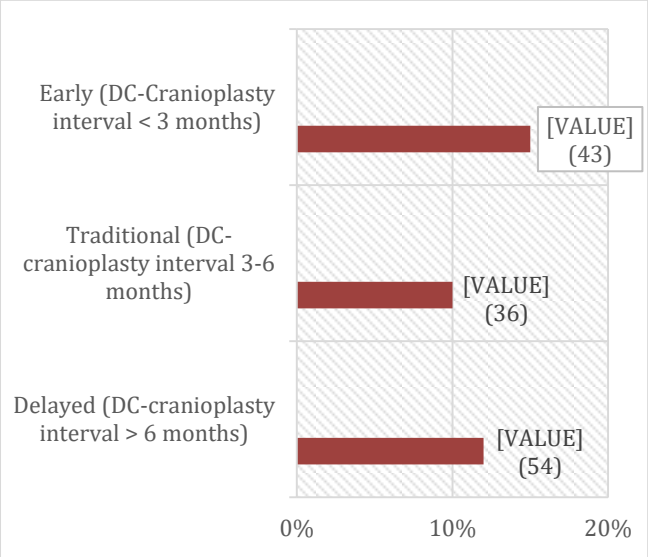


Fig 05: Infection Rate in Relation to DC-Cranioplasty Interval (N= 360)

Figure 05 shows early cranioplasty (<3 months) has more chance of infection (15%) than traditional (10%) and delayed (12%) cases.

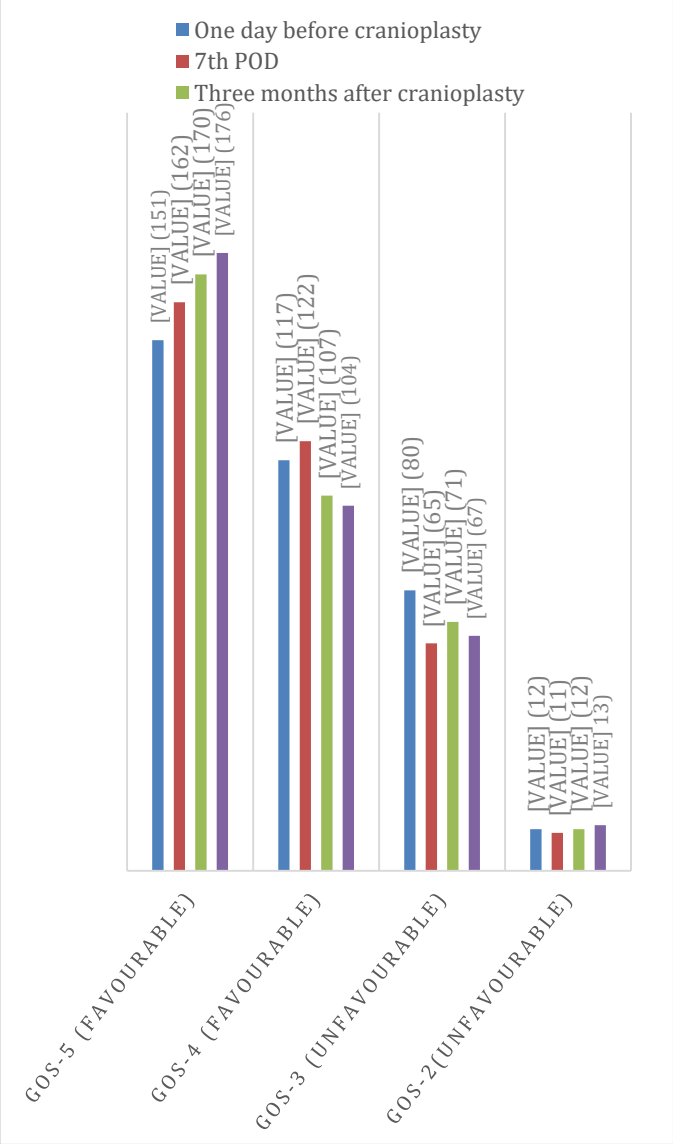
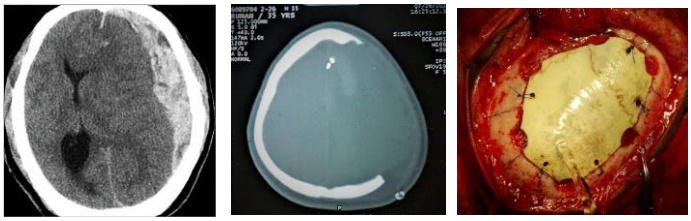


Fig 06: GOS Before and After Cranioplasty (N=360)

In figure 06, Good recovery (GOS-5) was observed as 42% before cranioplasty and 47% and 49% after 3 months and 6 months of cranioplasty respectively. But in poor group, no significant difference was found.

IV. DISCUSSION

Infections are represented by localized pain, tenderness, swelling and redness over the implants. Diagnosis of infection was done by routine laboratory tests, C-reactive protein, wound discharge with culture and sensitivity test and apply appropriate antibiotic. In our study 17% patients developed complication both minor and major.



a b c

Figure 07: Natural history of a cranioplasty, a) Lt ASDH with midline shift, b) post DC state, c) Cranioplasty by autologous bone flap (per operative).

Infection:

The most frequent complication reported is infection. Infection due to cranioplasty >26% cases[4, 9], in contrast very low rate even 0.8% when clean neurosurgical procedure was done[3]. In our study, infection rate is 17%. Infections are usually related to some relevant factors like- timing of surgery, the material used, pre-existing infection. Recently it has been shown that early cranioplasty has a higher risk (42% vs 13%) of infection than those done delayed.

Figure 08: Post cranioplasty wound infection

Another factor supposed to be involved in the risk of infection is the material used for cranial reconstruction. There is no strong evidence that allograft and synthetic materials may predispose more than the autologous bone to develop infection[11,15]. But in our study, allogenic graft has more rate of infection (68%) than autologous (32%) bone graft. Autologous graft shows lower risk of infection probably due to poor general health status of the patient, long hospital-stay, immuno-compromisation by traumatic injury, reoperation, bacterial colonization.

The use of subcutaneous drain after cranioplasty, concomitant procedure like CSF diversion, prolong surgical time, multiplicity of head lesions associated with sinus/ skull base injury with leakage, older age, lack of pre and post-operative antibiotic therapy[9, 10, 16]. In our study 4% patients developed major complications where 2% bone fragment needed to be replaced by another surgery.

Bone Fragment Resorption (BFR):

In case of cranial reconstruction, autologous bone is commonly considered the most biocompatible material, and its use has been advocated instead of allograft prosthesis[17]. We usually preserve the bone flap after craniectomy either in subcutaneous fat in the abdominal wall or with adequate sterile rapping in freezer (-35°c to -80°c) till the time for reoperation. Unfortunately, complications like general resorption is as frequent as 21%[13, 15]. While the risk rate for autologous bone resorption in adults has been estimated in 3-12% of cases[8], this rate may rise up to 50% of cases for pediatric patients[14, 18, 19]. Younger age, bone flap fragmentation, and shunt-dependent hydrocephalus have been reported as risk factors for bone resorption that is radiologically and clinically evident after 3 months from cranioplasty. It has been observed that bone flaps coming from a cranial decompression due to trauma are more prone (8.5% vs 1.8%) to resorption than non-traumatic cases. Also, the size of the flap may negatively influence bone replantation i.e. larger the flap more the resorption. Finally, factors involved in BFR are- traumatic or non-traumatic bone flap, storage method, length of flap storage, size of the flap, site of preservation in the abdominal wall and age of the patient. In our study, BFR was 12% mostly in younger patients having bone flap in the abdominal wall (8.64%). All cases were traumatic. These less percentages may be due to lack of repeated CT evaluation. Bone flap is devitalized, not in contact with vessels or nutrition, soft tissue or scar tissues are not adequately removed from edge.

Hematoma:

Hematoma under the cranioplasty flap is 1.8 - 12.24%[1, 2, 5, 7]. However, not all the postoperative hematomas require surgical evacuation as atrophic or post-traumatic brain gives space for development of residual space hematoma. Causes of this hematoma are- surgical manipulation of soft tissue (muscle, subcutaneous tissue etc.), inadequate hemostasis, dural/cerebral compression by bone flap, blood loss from the edges of the raw skull defect, sometimes anti-coagulant or anti platelet therapy continued and chemically anemia and finally negative suction drainage system, if used[1, 6]. In our study, 3% patients developed post-cranioplasty intracranial hematoma. All these cases were treated conservatively, i.e. no surgical intervention was needed.

Poor cosmetic result:

In literature this complication is rarely mentioned due to thick soft tissue covering and subsequent hair. Cosmetic result should be subjective and based on degree of satisfaction expressed by the patient i.e. when patient is in good neurological condition, young with socially active life think about aesthetic aspect

but when the patient is neurologically unfit, they do not bother regarding aesthetic aspect.

In literature poor cosmetic result have been recorded from 1.5 to 8.7% of cranioplasty cases[1, 7, 12]. In our series, it is only 1.5% (6) all of which are minor complications. Causes of these poor cosmetic results may be due to irregular modelling of acrylic resin, resorption of autologous flap, malposition of the prosthesis, implant dislodgement and finally surgeon's skill. Custom made prosthesis can give better cosmetic result than any other.

Wound Dehiscence:

Mostly caused by use of allogenic prosthesis implant like steel mesh, metal prosthetic plate that cause corrosive effect over the skin or autologous bone due to dislodgement of implant. A debilitated physical condition, saprophytic skin infection, long hospital stay, lack of good care of the surgical wound causing wound dehiscence. wound dehiscence occurs following cranioplasty is > 4%[20]. But in our study, it is about 1%.

Seizures:

In some series, seizure is reported but some doesn't as they consider seizure as pre-existing event[6]. Seizure in trauma are of three types- (i) Immediate- when appearing within 24 hours after insult/surgery/trauma (12.5% of cases), (ii) Early- when appearing within 7 days from trauma/surgery (3.12% of cases) and (iii) Delayed- the most frequent, when appearing after 7 days (over 40% of cases)[9]. Majority of patients develop delayed seizure due to gliosis, residual hemosiderin following tumor, stroke etc. Seizure following craniectomy are usually "early" in onset triggered by the surgical manipulation of the brain during cranial reconstruction increasing the epileptogenic susceptibility and altering CSF dynamics- all these causing ischemic or edematous alterations of brain with axonal injury[9]. In our study, 1% cases developed seizure all of which were early in onset and managed accordingly.

Hygromas:

Hygromas developed following cranial reconstruction represent around 2.2%[7]. Following cranioplasty big space sometimes remain below the bone flap filled up with water or CSF. Subsequent radiology shows big collection sometimes with mid line shift in immediate post-operative period that can be treated conservatively with radiological follow-up. In our series only 1% patients developed subdural hygroma and were treated conservatively

V. CONCLUSION

Aim of cranioplasty is to restore vault defect and thereby to protect the brain from external injuries, aesthetic purpose of the head, improve CSF dynamics and restore the normal ICP relationship with the skull and thereby accelerate and improve cognitive function and overall neurological recovery.

1. Cranioplasty is considered as an easy surgical procedure but surgery by an unskilled surgeon may lead to high rate of complications and poor cosmetic reconstruction.
2. Complication is more frequent in case of alloplastic material than by autologous bone.
3. Cranioplasty restore the contour of the cranium and thereby improves cognitive and neurological functions little bit and no gross improvement was observed.

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