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# Cranioplasty following decompressive craniectomy in traumatic brain injury: Experience at Level - I apex trauma centre

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**Abstract:** Complications after cranioplasty following decompressive craniectomy are often underreported. A review of the complications helps to suggest measures to improve the care of these patients. We provide a review of all complications of cranioplasty with autologous or synthetic materials in this article. All patients who had undergone cranioplasty following decompressive craniectomy at JPN Apex trauma centre, AIIMS from Jan 2008 till 2010 April were included in the study. Demographic data, indications for craniectomy, materials used, methods of autologous bone storage and all perioperative complications were recorded. Total 114 patients were studied. Mean duration between decompressive craniectomy and cranioplasty was 207.6 ± 28.2 days (Mean ± SD) with a range of 50 to 840 days . The overall postoperative complication rate was 23% (26/114) of which 16 patients (14 %) had to undergo reoperation after cranioplasty. Bone flap infection was the commonest accounting for 10 (62.5 %) of the reoperations. Even though considered as simple procedure, cranioplasty is associated with significant complications requiring reoperation. There was no correlation of complications or need for reoperation with type of materials, storage of the bone or timing of surgery. A seemingly smaller neurosurgical operation requires good surgical approach to minimize morbidity associated with cranioplasty.

**Keywords:** Cranioplasty; decompressive craniectomy; severe head injury

## INTRODUCTION

Decompressive craniectomy is a potentially lifesaving procedure for cases of refractory intracranial hypertension. Decompressive craniectomy is performed commonly in the setting of severe head injury, large-vessel infarct and less frequently in the settings of aneurysmal subarachnoid hemorrhage, intraoperative brain swelling, and encephalitis. Its efficacy is controversial and currently being investigated with respect to survival and quality of life in multicenter, prospective, randomized trials in the setting of traumatic brain injury and middle cerebral artery infarction[1,2] .

Patients who survive following decompressive craniectomy will require reconstructive cranial surgery. Much of the modern literature regarding cranioplasty following decompressive craniectomy is based on case series that emphasize the technical aspects of the procedure[3,4,5,6,7]. There are relatively few present day clinical series describing the clinical outcomes and perioperative complications of cranioplasties. Complications after cranial reconstruction, often viewed as a straightforward neurosurgical procedure, may very well be underreported. A review of the complications would suggest measures to improve the care of these patients.

There are lot of controversies regarding the methods of storing the bone flap prior to reconstruction, various materials used and the timing of surgical intervention, or other specific modifications to either the craniectomy or cranioplasty procedure, which may influence the cranioplasty. This study was undertaken to review the complications, timing of surgery, methods of storage of the bone and use of synthetic materials in deciding the outcome following cranioplasty.

Aims and objectives were to provide a complete review of all perioperative complications, defined as any potentially adverse event within 30 days of surgery, as well as identify any risk factors that may be associated with the need for reoperation after a primary cranioplasty. We also studied various methods of storage of the autologous bone, various materials used and timing of surgery in deciding the outcome of the cranioplasty including fusion.

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## METHODOLOGY

We analyzed all the patients who had undergone cranioplasty following decompressive craniectomy for severe head injury in JPN Apex trauma centre, AIIMS from January 2008 till 2010 April. The data collected from the computerized data system and patients were prospectively followed up through OPD and by phone till July 2010.

Abstracted data included age at time of cranioplasty (years), sex (male or female), medical co morbidities (hypertension, diabetes, and tobacco use), indications for craniectomy (trauma, stroke, infection, and intraoperative swelling), laterality of craniectomy (bilateral, unilateral, or bifrontal), time between craniectomy and cranioplasty (days), type of prosthesis if used (titanium, methylmethacrylate,), storage of bone flap if used (subcutaneous or tissue bank), operative time (minutes), identification of intraoperative CSF leak (yes or no), estimated blood loss (ml), intraoperative fluid administration (ml)and length of stay after cranioplasty (days). We recorded Glasgow Coma scale at the time of head injury and at the time of cranioplasty.

Complications were classified into intraoperative, early postoperative and late complications. Early complications were defined as those which occurred within 7 days after surgery and late as after 7 days of surgery. The indications for reoperations were recorded separately. Patients were classified as having no complication, any complication, and complication requiring reoperation.

Patients were prospectively followed up and underwent Computed tomography and Lateral Skull X ray 3 months after cranioplasty. Cosmetic appearance and fusion were evaluated.

Specifically, our 3 outcomes of interest were complications after cranioplasty, need for reoperation after cranioplasty and fusion during follow up. All patient and surgery related factors were assessed as risk factors for these 3 outcomes of interest via bivariate analysis. Chi square test was used to test the significance and P-Value less than 0.05 was considered significant. Statistical analysis was performed using SPSS 13 for Windows.

## RESULTS

There were 129 patients who underwent cranioplasty during the study period, out of which 15 were lost to follow up immediately after surgery. Remaining 114 patients were included in the study. Even from this population, some variables could not be reliably extracted from the medical records of few patients. The baseline patient characteristics and perioperative factors are shown in Table 1. Indication for decompressive craniectomy was trauma in all patients. Mean age at the time of cranioplasty was 26.12 ± 10.2 (mean ± SD) and majority (86 %) were males. Majority had unilateral defect (90%) while 5 patients (4.3 %) had bifrontal defect as a result of bifrontal decompressive craniectomy. Patients had a mean GCS of 8.1 ± 3.1at the time of decompressive craniectomy and 14.1± 0.6 at the time of cranioplasty.

Mean duration between decompressive craniectomy and cranioplasty was 207.6 ± 28.2 days. Majority of repairs (102 patients - 89.5%) used autologous bone; 84 of these patients (82.3 %) had their bone kept in subcutaneous pocket in the abdominal wall while remaining 18(17.6%) patients had their bone kept in tissue bank. Or the remaining 14 patients, twelve patients (8.8%) underwent methymethacrylate cranioplasty, while two had titanium mesh implant.

**Table 1:** Demographic and operative details

| Characteristic | No. of Patients (%) |
|---|---|
| **No. of patients** | 114 |
| Male | 98 (86) |
| Female | 16 (14) |
| **Type** | |
| Unilateral | 103(90.45) |
| Bifrontal | 5 (4.3) |
| Bilateral | 6 (5.2) |
| **Cranioplasty** | |
| Mean age (yrs) | 26.12 ± 10.2 |
| GCS at Decompressive craniectomy | 8.1 ± 3.1 |
| GCS at Decompressive craniectomy | 14.1± 0.6 |
| Mean no. of days between craniectomy & cranioplasty | 207.6 ± 28.2 |
| **Type of prosthesis** | |
| ***Autologous*** | 102 (89.5) |
| Sub cutaneous pocket | 84 (82.3) |
| Tissue bank | 18 (17.6) |
| Titanium | 2 (1.7) |
| Methylmethacrylate | 10 (7.1) |
| Mean operation time (min) | 143 ± 28 |
| Mean estimated blood loss (ml) | 211 ± 48 |
| Mean intraop intravenous fluids (ml) | 1810 ± 284 |
| Mean length of stay (days) | 1.45 ± 0.8 |

## COMPLICATIONS

Perioperative and post operative complications are summarized in Table 2. Twenty six patients (22.8 %) had complications of which 15 (57.6%) had early and 11 (42.3%) had late complications. Wound complications accounted for ten patients: 6 had wound infection and 4 had wound dehiscence. All ten patients had to undergo reoperation and cranioplasty had to be done with synthetic materials subsequently.

Post operative hematoma was also a significant complication following cranioplasty. Out of these 6 patients 2 had significant extradural hematoma which required surgical evacuation. Of the 3 patients who had subdural hemorrhage 2 were managed conservatively while one patient had to be operated. One patient developed parietal contusion and was managed conservatively.

Two patients had generalized tonic clonic seizure immediate post operative period while one had late onset seizure. Four patients had medical complications in the form of hospital acquired pneumonia and deep venous thrombosis.

We also studied long term outcome in the form of fusion. Out of 64 patients who had a follow up of 3 or more months, 37 patients had good fusion of the bone with rest of cranial vault, while 27 did not show fusion.

## COMPLICATIONS REQUIRING REOPERATION

Sixteen patients had to be reoperated because of complications. Most common indication for re operation was wound complications accounting for 10 patients. Six of them had wound infection while 4 had wound dehiscence. Intracranial hemorrhage accounted for three cases while sunken bone and bone resorption accounted for two and one cases respectively. After statistical analysis, no factors including type of prosthesis, laterality or type of craniectomy defect, time to cranioplasty was not significantly associated with need for reoperation (Table 3).

**Table 2:** Complications in patients undergoing cranioplasty

| | No. of Patients (%) | | |
|---|---|---|---|
| **Complication** | **Early (≤7 days postop)** | **Late (>7 days postop)** | **No. Requiring Reoperation** |
| Wound | 3(2.6) | 7 (6.1) | 10 |
| Infection | 2 (1.7) | 4 (3.5) | 6 |
| Dehiscence | 1 (0.87) | 3 (2.6) | 4 |
| Hematoma | 6(5.2) | 0 | 3 |
| Epidural | 2(1.7) | 0 | 2 |
| Subdural | 3 (2.6) | 0 | 1 |
| Parietal contusion | 1 (0.87) | 0 | 0 |
| Bone resorption | 0 | 1 (0.87) | 1 |
| Sunken bone plate | 0 | 2 (1.7) | 2 |
| Seizure | 2 (1.7) | 1 | 0 |
| Deep vein thrombosis | 2(1.7) | 0 | 0 |
| Pneumonitis | 2(1.7) | 0 | 0 |
| Total | 15 (13.1) | 11 (9.6 ) | 16/26 (61.5) |

## TYPES OF PROSTHESIS USED

Autologous bone was used for cranioplasty in most of the patients (89.5 %). Out of these 82 % of the cases bone was kept in subcutaneous plane in the abdomen while 18 % of the patients we used bone flap which was kept in tissue bank. Other materials used were methyl methacrylate in 10 patients and titanium mesh in 2 patients. On comparing autologous bone with synthetic materials used there was no significant difference in complication rates, (Table 4) or need for reoperation.

**Table 3:** Complications requiring reoperations

| | No. of Patients (%) | |
|---|---|---|
| **Characteristic** | **No Reoperation** | **Reoperation** |
| No. of patients | 98(86) | 16 (14) |
| Laterality of cranioplasty | | |
| Unilateral | 89 (86.5) | 14 (13.5) |
| Bifrontal | 4 (80) | 1 (20) |
| Bilateral | 5 (83.3) | 1 (16.7) |
| Type of prosthesis | | |
| Autologous bone | 88 (86.6) | 14(13.3) |
| Synthetic materials | 10(83.33) | 2(16.7) |
| No. of days btwn craniectomy & cranioplasty(Days) | 219 ± 24 | 243 ± 32 |

**Table 4:** Type of prosthesis used

| | No of patients (%) | |
|---|---|---|
| | **Autologous bone** | **Synthetic Material** |
| Total | 102 | 2 |
| Mean Estimated blood loss (ml) | 216 ±44 | 196±38 |
| Mean Operative time (min) | 154±32 | 132±26 |
| Complications | 22 (21.5%) | 4(33.33%) |
| Wound complications | 8 (7.8%) | 2(16.67%) |
| Intracranial Hemorrhage | 5 (4.9%) | 1(8.4%) |
| Seizure | 2 | |
| DVT | 2 | 0 |
| Pneumonitis | 2 | 0 |
| Re operations | 14 | 2 |

We also compared the complication rates, need for reoperation and fusion rates in cases in which we used autologous bone kept in abdominal subcutaneous plane with the ones kept in tissue bank. There was no statistical difference between the two groups in all the three outcomes.(Table 5). However, in groups where bone kept in tissue bank was used, the operation time and mean estimated blood loss was significantly less compared to those with bone kept in abdominal wall.

## TIME FOR CRANIOPLASTY

We grouped patients in to three groups with regard to time to cranioplasty from decompressive craniectomy as less than 12 weeks, 12-24 weeks and more than 24 weeks. Even though the differences were not statistically significant, patients who underwent cranioplasty after 24 weeks had more complications compared to other two groups (odds ratio of 1.51 and 1.94 for complications and reoperations respectively) (Table 6).

## DISCUSSION

Recent reports have suggested that the cranioplasty may help optimize neurological recovery, both physiologically and/or clinically in patients of decompressive craniectomy[8,9,10,11]. No specific materials or methods have been proven superior to another. As almost all patients surviving a decompressive craniectomy will require cranioplasty, the complications of this second operative intervention should be acknowledged. Most reports in the literature regarding cranioplasty have focused on technical aspects of the procedure and have not emphasized overall surgical complications.

**Table 5:** Storage of autologous bone

| | No of patients (%) | | |
|---|---|---|---|
| | **Sub cutaneous plane in abdominal wall** | **Tissue bank** | **P Value** |
| Total | 84 | 18 | |
| Mean Estimated blood loss (ml) | 224 ±44 | 190±38 | 0.007 |
| Mean Operative time (min) | 152±32 | 116±26 | 0.035 |
| Complications | 8(21.4%) | 4(22.22%) | |
| Wound complications | 7(8.3%) | 1(5.5 %) | |
| Intracranial Hemorrhage | 4(4.7%) | 1(5.5%) | |
| Re operations | 12(14.3%) | 2(11.1%) | |

**Table 6:** Data regarding time between craniectomy and craniotomy and ensuing complications

| | | **Complications Requiring** | | **Complications Reoperation** | |
|---|---|---|---|---|---|
| No. of weeks between Craniectomy and Cranioplasty | No.of Patient | No.(%) | OR | No.(%) | OR |
| 0–12 weeks | 20 | 4(20) | 0.81 | 2 (10) | 0.63 |
| 12–24 weeks | 46 | 9(19) | 0.72 | 5 (11) | 0.63 |
| >24 weeks | 48 | 13(27.08) | 1.51 | 9(18.75) | 1.94 |

### Complications Following Cranioplasty

Our series showed very high rate of complications with 26 out of 114 (62.5 %) patients having some complications. Of those patients who had complications 16 (62.5 %) required reoperation. Such complications included infection, bone resorption, wound dehiscence, sunken bone flap and hematoma.

Our complication rate was slightly less as compared to other reported case series as in Gooch et al[12] ,who had complication rate of 33%. They had a reoperation rate of 26% compared to 14% in our series.

Considering the straight forward nature and simplicity of procedure rate of complications and reoperation are high. All patients who had infection ultimately required reoperation. In all of them autologous bone had to be removed and a second surgery had to be done using synthetic materials.

In our series we did not find any difference in complication rate or reoperation rate with regard to age, sex, type of decompressive craniectomy, type of prosthesis used and method of storage of autologous bone. We found an increased rate of complications in patients who undergone cranioplasty after 24 weeks of decompressive craniectomy suggesting that cranioplasty should be done as soon as patient is fit for surgery following decompressive craniectomy.

There is always been controversy regarding the method of storage of the bone whether to keep it in the subcutaneous pocket or to keep in tissue bank[13,14,15,16]. We couldn't find in any study comparing these two groups in current literature. Most surgeons prefer subcutaneous pocket because majority are of the opinion that keeping bone in subcutaneous pocket will ensure viability of bone which will result in better fusion and less infection rate. But this adds to morbidity of procedure by prolonging the operation time and blood loss which is very much important factor in prognosis especially during decompressive craniectomy. Also patient discomfort and wound complications including infection, haematoma and seroma are important factors discouraging keeping bone in subcutaneous pocket.

We compared both groups (subcutaneous pocket vs tissue bank) and found that there is no statistical difference with regards to complication rate, need for reoperation or fusion. There was a significant difference in operation time and blood loss between two groups. Morbidity of abdominal wound and patient discomfort was an additional complication in patients who had bone kept in subcutaneous pocket. Although we had significantly lesser no of patients who had their bone kept in tissue bank morbidity of abdominal wound and patient discomfort was so significant to suggest that there is no advantage of keeping the bone in subcutaneous pocket. Synthetic materials don't have any benefit over autologous bone as both groups had no statistically significant difference in complication or reoperation rate.

Contrary to traditional neurosurgical dictum that shorter time from craniectomy to cranioplasty is associated with poor outcome, we found patients who had cranioplasty before 24 weeks had lesser complication rate compared to those who had surgery after 24 weeks. This finding is opposite to the finding of Rish and colleagues [17] published in 1979,in which they found that cranioplasties taking place 1–6 months after craniectomy had the highest complication rate (7.9%) and those performed 12–18 months after craniectomy had the lowest complication rate (4.5%). The purported advantage of this waiting period includes avoidance of operating on a potentially contaminated wound. However, because this study included only patients with penetrating head injuries, the results may not apply to patients who have undergone decompressive craniectomy in the setting of nonpenetrating injury.

## CONCLUSIONS

Cranioplasty is one of the common surgery performed in trauma settings. Even though considered simple surgery, cranioplasty is associated with very high complication rates. There was no significant difference in complications, reoperation or fusion between patients who had their bone flaps kept in tissue bank or subcutaneous pocket. Those who had bone kept in abdominal wall had significantly more blood loss, operation time, morbidity related to abdominal incision and patient discomfort. There was no correlation of complications or need for re operations with type of materials (synthetic/autologous), timing of surgery even though there was a trend towards more complications with longer interval between decompressive craniectomy and cranioplasty. A seemingly smaller neurosurgical operation requires good surgical approach to minimize morbidity associated with cranioplasty.

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