

Single Stage Debridement and Titanium Mesh Cranioplasty in Patients of Compound Depressed Skull Fracture, an Institutional Experience

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Abstract

Background and Aim: Compound skull fracture accounts for 6% of head injuries. It is usually managed through surgical debridement of devitalized, contaminated soft tissues, fractured segments and dealing the intracranial pathology at the same time. The calvarial defects following debridement are conventionally left behind and cranioplasty is done 2 to 3 month after, to avoid infection related complications. Our aim is to analyze the result of single stage titanium mesh reconstruction in the management of compound and comminuted skull fracture and review the previous studies.

Method: It is a retrospective study conducted at the VIMSAR, Burla, Sambalpur, odisha where case records of 43 patients of head injury associated with compound skull fracture admitted to neurosurgery department and had undergone debridement, followed by immediate titanium mesh cranioplasty procedure were analyzed between the year 2018 and 2020. The standard technique of debridement was followed in all cases. The presence of depression more than the thickness of surrounding bone, compound nature of the wound, associated dural injury with or without underlying brain injuries in CT was considered to be the most important criteria for the early debridement. All had undergone cranioplasty. Patients having very low GCS, extensive scalp laceration with skin loss and those having delayed presentation, post debridement brain swelling were excluded for cranioplasty. All Patients were followed until 3 month after their discharge from ward. The clinico-radiological follow up and outcome was evaluated.

Results: A total of 43 patients were included in the study. Road traffic accident (RTA) was the predominant mechanism of injury (60.5%). The frequency of skull fracture was significantly higher in men (93%) than that in women. The mean Glasgow coma scale was 13.357 at admission and 14.905 at discharge. Fracture was located most commonly in the frontal region (65.11%). 41.9 % of patients had paranasal sinus involvement and 69.8 had associated dural injury. A total of 40 patients achieved good surgical outcome. A very low incidence of complications was found amongst patients during their stay in the hospital and 3 month follow up. One patient developed surgical site infection, one patient had a sinus formation with intermittent discharge needed removal of mesh and two had transient post operative CSF leak. There was no immediate post operative seizure. Post operatively antibiotic was given for average 9 days and the mean hospital stay was 11 days.

Conclusion: Immediate cranioplasty does not pose increased risk of infection as thought earlier. Early and thorough debridement and copious saline irrigation are two most important surgical principles by which infectious complications can be reduced to minimum. So whenever feasible single stage cranioplasty should be preferred over staged procedure for early overall recovery and return to work.

Keywords: Skull fracture; Cranioplasty; Titanium mesh.

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Introduction

Skull fracture is a very common occurrence after trauma to the head accounting 6% of traumatic brain injuries.¹ Mostly blunt trauma is accountable in majority of cases. Although All fracture does not warrant attention of neurosurgeon, complicated

skull fracture needs particular attention. Among the complicated skull fracture, skull base fracture and depressed vault fracture are of particular importance. The skull base fracture carries risk of cranial nerve injury, vascular injury as well as risk of cerebrospinal fluid leak in form of CSF rhinorrhoea or otorrhoea. Vault fracture is associated with it the problem of cosmesis and in more complicated state it is associated with laceration of overlying scalp and galea in continuity with fracture site and underlying Dural and brain parenchyma injury contributing to associated neurological deficit. Sometimes leaking brain matter through the scalp wound, through the nose or ear itself forecasts the presence of fracture and is a tale tale sign of definitive brain injury. Such situations needs particular attention by neurosurgeons to avoid the fore coming complications associated with such type of injuries. The complications those are mostly encountered in compound injuries are wound infection, osteomyelitis, sinusitis, meningitis, brain abscess, increase seizure disorder (both immediate and late), and peculiar but rare brain fungus. In addition the overall well being of the patient depends upon the early and prompt management of the problem. In children the skull fracture is associated with a very recognized complication, which is growing fracture of the skull. So special attention and skill is necessary to avoid complication associated with skull fracture, particularly the compound ones.

Linear, undisplaced skull fracture does not warrant any treatment. Similarly all depressed fracture does not need surgical treatment. Debridement is required in compound depressed fracture of surgical importance. It is conventionally done if the degree of depression is equal to or exceeds the thickness of the adjacent intact bone or if there is associated underlying contusion or hematoma that needs to be evacuated.^{2,3} The process of debridement involves removal of comminuted fracture segments, identification of whole extent of Dural injury along with excision of devitalized Dural margin, removal of in driven bone fragments if any, contusectomy (if associated), Dural closure and finally closure of the calvarial defect along with tension free wound closure. The closure of the calvarial defect needs special consideration whether to be done or not in the same sitting of debridement as the risk of post operative infection is higher in these cases (2 to 10%).⁴ So usual protocol is to perform cranioplasty in a separate sitting (secondary cranioplasty). But our experience shows single stage cranioplasty is justified in

most of the cases after a thorough debridement and overzealous wound toileting with normal saline. Few recent studies have demonstrated no difference in infection rate between single stage cranioplasty and delayed cranioplasty. Titanium mesh cranioplasty is a suitable surgical option with potential benefits of being biologically inert and is cost effective.⁵ So considering cranioplasty in the same sitting seems to be justified in many cases than routinely deferring every case for future cranioplasty. It saves the patient from usual risks associated with repeat surgery and anesthesia and also from additional cost of treatment. Our objective of this study is to throw some light in the management of compound skull fracture and special emphasis on result of single stage cranioplasty.

Aim of Study

To analyze the benefits of primary reconstruction of the depressed fracture of skull with titanium mesh after thorough debridement and comparing it with the result of traditional secondary cranioplasty.

Materials and Methods

It is a retrospective study, conducted at department of Neurosurgery, Veer Surendra Sai Institute of medical Sciences and Research Burla, Sambalpur, and Odisha between the period 2018 and 2020. Case records of patients with compound skull fracture from September 2018, to July 2020, in whom surgical intervention was planned and carried out, were initially retrieved. These records were critically analyzed on the basis of various clinical, radiological and operative parameters. 43 patients were included in the study. The inclusion criteria was presence of significant depressed fracture with or without underlying parenchymal injury as confirmed by computed tomography (CT), fracture lying over motor area, migration of bony spicules into the brain parenchyma and associated CSF Leak or brain leak. Patients with very low GCS and, loss of scalp tissue, delayed presentation were excluded (Figure 1 and 2). All the selected patients had undergone debridement followed by titanium mesh cranioplasty in the same sitting (Figure 3). So far technical aspect is considered the standard technique with our own modification was followed and all surgeries had been performed by two neurosurgeons adopting the same surgical principles. The patient demographic

characteristics and the radiologic demographic characteristic were evaluated. The 3 month follow up data of patients were collected to analyze the follow up objective that is to find out the incidence of wound infection and CSF leak, implant rejection after cranioplasty and any other complication (Figure 4). The evidence of infection was assessed clinically by local examination of wound for any inflammation or discharge, association with fever, by measuring body temperature and biochemically through assessment of complete blood count and quantitative measurement of C- reactive protein.

Surgical Technique and Principle

All patients were given prophylactic antibiotic piperacillin and tazobactam along with metronidazole on T.I.D basis immediately after admission, which was continued throughout peri operative period up to one week post operatively.

Thorough scrubbing of the external wound and surrounding skin for at least 5 to 10 minutes with 7.5 % povidone iodine was routinely followed after anesthesia (Figure 2).

A skin flap* was preferred than extending the existing scalp wound for better exposure of the fracture segment and comfortable fixation of the titanium implant.

Removal of all foreign bodies, along with debridement of devitalized tissues and toileting of wound with hydrogen peroxide and copius saline was routinely carried out (Figure 3).

In case of opening of frontal sinus, scooping of mucosa and cauterization had been done followed by cleaning with dilute betadine solution. Obliteration of sinus was made with using peri cranial flap.

Standard burr hole technique was followed to identify adjacent normal Dura before elevation of the fractured segment and then circumferential craniectomy surrounding fractured segment was done for safe elevation of depressed fragments.

Delineation of whole extent of dural injury was carried out with separation of dural margin from adherent underlying brain parenchyma.

Decompression of contusion/hematoma was made in those cases only with underlying mass lesion causing mass effect.

Finally dural closures was made with or without patch graft followed by titanium mesh cranioplasty.

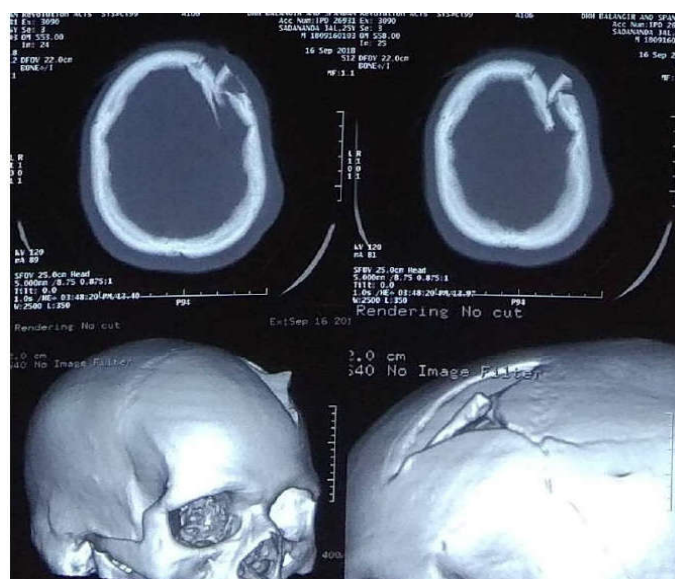
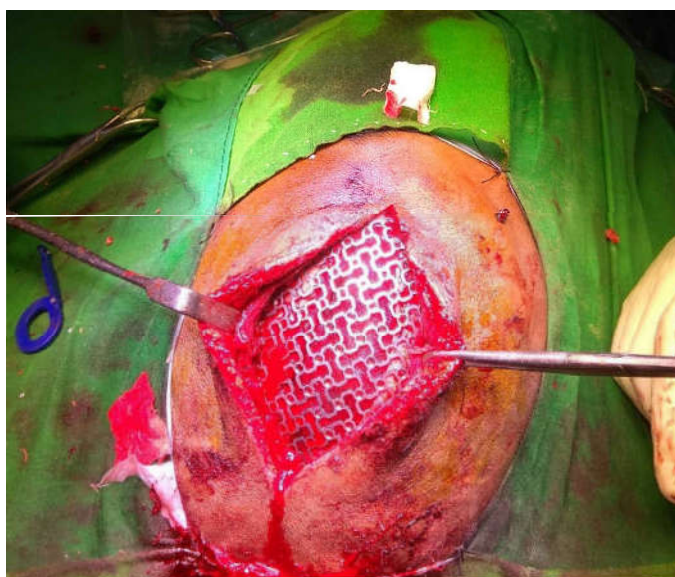
Lastly thorough toileting of the wound was done before closure, with copius normal saline to reduce the incidence of post operative infection. Primary scalp wound was dealt with trimming of margins and stitching in tension free two layers.

Results

A total of 43 consecutive patients who underwent immediate single stage reconstruction with titanium mesh for compound skull fracture were included in this study. (Table 1). The mean age of the patient was 28.477 years (Range, 3.5 to 65 year). 40 were male and 3 were female. The causes of fracture included direct impact in 10 patients (23.3%), fall in 7 patients (16.3%), traffic accidents in 26 patients (60.5%). The mean GCS score was 13.357 at admission and 14.905 at discharge. The location of fracture included frontal bone in 28 patients, parietal bone in 10 patients, and mixed fronto/temporal/parietal bone in 5 patients. Sinus involvement in case of frontal bone fracture was (41.9%). Dural injury was associated with 30 no of patients (69.8%) 9 No of patients were having leaking brain matter through the scalp wound (20.9%) Associated lesion in CT included contusion in 20 no of patients, ASDH in 5 patients, EDH in 3 patients and mixed pathology in rest of the patients. all patients underwent titanium mesh cranioplasty. mesh of size 6x6 was utilized in 34 no of patients and mesh of size 10x10 was utilized in 8 no of patients. Retrieved bone fragments were fixed with miniplate and replaced in a case of girl child. Post operative antibiotic was intravenously injected for an average 8.738 days following surgery. The incidence of post operative fever was 7%. The mean WBC count was 9342.857 preoperatively and 10509.286 after 7th post operative days. 3 patient developed wound infection with discharge of sero-sanguinous discharge from the wound but only one patient required removal of the implant after 3 month of surgery who had found to have a retained foreign body underneath scalp margin after re exploration (Figure 4 and 5). The incidence of post operative CSF leak was negligible. Few patients (2) who developed CSF leak were managed conservatively with acetazolamide and proper positioning, thereby it was controlled. None required secondary closure of the defect. All improved with conservative treatment. The mean duration of hospital was 10.721 days. The correction of deformity was acceptable. Mesh rejection was not observed in a single case.

Table 1: Descriptive Statistics.

	N	Minimum	Maximum	Mean	Std. Deviation
Age	43	3.5	65.0	28.477	13.7940
Gcsadmission	42	10.0	15.0	13.357	1.2845
Gcsdischarge	42	12.0	15.0	14.905	.4844
Hospitalstay	43	5.0	23.0	10.721	3.3899
Duration of Antibiotic	42	4.0	20.0	8.738	3.0847
TWC preop	42	4300.0	17300.0	9342.857	3215.2929
TWCpostop	42	5400.0	22300.0	10509.286	4204.5552
CRP	41	1.00	15.50	3.3154	3.29068
Valid N (listwise)	40				

**Fig. 1:** D CT Showing Coumpound Comminuted Fracured Segments Close to Midline.**Fig. 2:** Exploration of Whole Extent of Wound Showing the Fracured Segments.

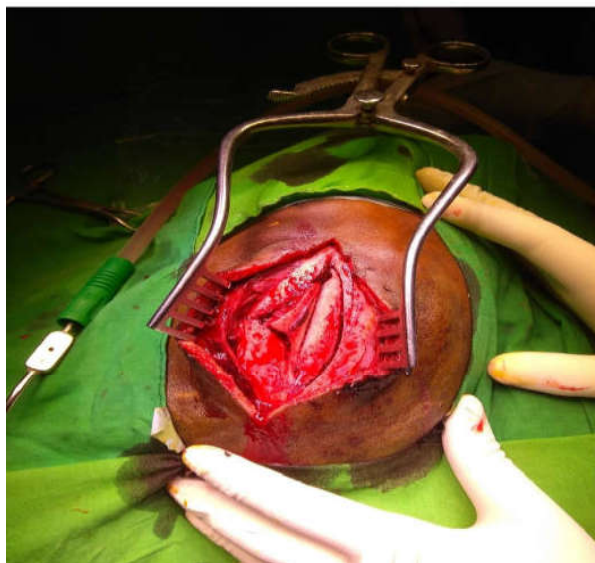


Fig. 3: Debridement Followed by Titanium Mesh Cranioplasty in the Same Sitting.



Fig. 4: Postoperative Picture after Recovery.

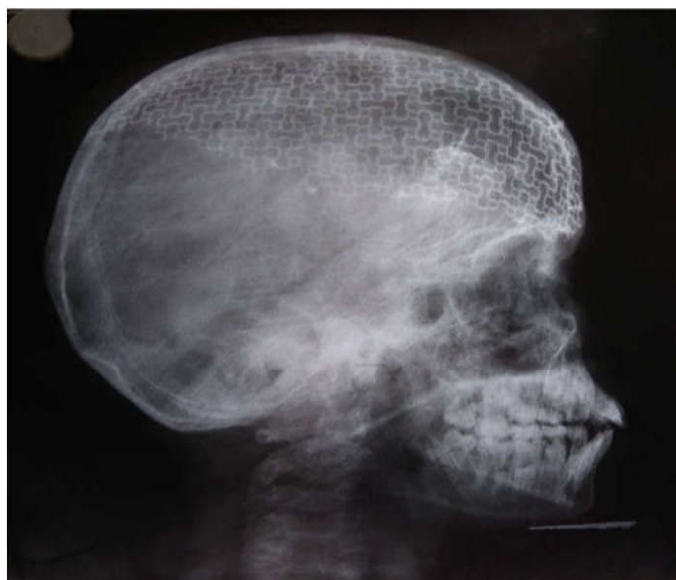


Fig. 5: Postoperative X-Ray Showing Titanium Mesh in Situ.

Discussion

In most of the depressed fracture the outer table of the fractured segment lies below the inner table.^{7,8} At the site of impact the inner table fractures first and is responsible for dural injury. The location of depressed fracture is fronto-parietal in 75% cases, temporal in 10 % cases, occipital 5% and others 10%. In 75 to 90% of cases the depressed fracture are compound in nature.⁹ Majority of the time the compound fracture is depressed and rarely is it elevated. Some studies don't advocate routine

debridement especially when the depression is not significant, or it is close to sinus. However patients having neurological deficit, having leaking brain matter, having persistent rhinorrhoea need debridement and closure of the Dural defect. Debridement of bone fragments hastens the recovery of focal neurological deficits and overall brain dysfunction takes several weeks to month to improve.⁹ Previously majority of studies were supporting cranioplasty as a staged procedure after initial debridement. Usually cranioplasty is advocated after few months of primary procedure. The major concern in the management of compound

depressed fracture is infection. So traditionally most neurosurgical centers perform initial early debridement and then closure of the calvarial defect as a secondary procedure. However few recent series have come up supporting the single stage cranioplasty in patients of compound depressed fracture with acceptable results so far risk of infection and other complications are concerned. The rationality of single stage cranioplasty is many folds. It not only avoids subjecting the patient into the usual risk of second surgery as well as anesthesia but also benefits the patient in terms of early return to work specially in people of urban areas. The poorly educated rural people from remote areas who are usually lost to follow-up once they are discharged, putting them shelves into the risk of accidental penetrating injury through the defect site could also be avoided by this single stage procedure. Another most important advantage of single stage cranioplasty is it is cost effectiveness as compared to two surgeries which is always a Borden for the people of poor economic group. The following series supports the single stage procedure. Jennet and miller reported 359 no of patients with compound depressed fracture with a infection rate of 10.6% which is linked to neurological deficit, post traumatic seizure and poor outcome.⁶ They have also reported that there is no difference in infection rate when the bone fragments are removed and replaced even in presence of Dural injuries with a conclusion that primary surgery is considered to be advantageous. Marbacher and Andres in their small series of 5 consecutive patients reported a zero infection rate with excellent cosmetic result. They conclude that primary reconstruction of open skull fracture with titanium mesh is feasible, safe and cosmetically acceptable than the conventional staged approach.¹⁰ Wylen et. al. Retrospectively reviewed 32 consecutive patients of compound skull fracture treated with debridement and elevation of compound depressed skull fracture with primary replacement of bone fragments within 72 hour and conclude that there is no increased infection rate after immediate replacement.¹¹ A Study of 19 consecutive patients by KiSeong Eom, korea concluded immediate bony replacement and reconstruction with titanium mesh for compound comminuted depressed.

fracture did not increase infectious sequelae, even though it involves sinus. He told single stage reconstruction with titanium mesh is a suitable surgical option with potential benefits in terms of cost effectiveness, safety and cosmetic and psychological outcome. pratap and Ramchandra

et. al. reported combined bone and titanium mesh cranioplasty is a suitable option for primary reconstruction of compound skull fracture which positively affects cerebral metabolism and facilitates patient rehabilitation.¹² Mohapatra and nayak et. al. in their series of 32 patient subjected to primary fracture reconstruction concluded with a message that it should be carried out whenever it is feasible and titanium implants are cost effective as well as better option to any other available measures.⁵ Iqbal ahmad in his paper primary titanium mesh cranioplasty in open depressed fracture conclude that primary reconstruction should be attempted because it is feasible, safe and cosmetically preferable than the conventional staged approach.¹³

In our series we have preferred this titanium material in all adult population sparing the children of growing age where the retrieved bone fragments were utilized for reconstruction using titanium plate and screw.

So far the cranioplasty material is concerned titanium mesh is a suitable alternative than other available material like PMMA, Carbon, PEEK, Hydroxyapatite, ceramics, osteoconductive bioresorbable material because of its easy handling, high tensile strength, biological inactivity, association with low infection rate, nil magnetic and paramagnetic properties and excellent biocompatibility. So now- a days it is widely preferred material for closure of the calvarial defect not only in skull fracture but also in many situations where removal of a portion of skull is part of the procedure.

In this study the mean duration from admission to surgery was over a wide range but all patients were started antibiotic immediately after admission. This suggests that immediate administration of antibiotics in the Emergency room and early surgery after TBI definitely reduced the likelihood of infectious complications. Post operatively the antibiotic was used for an average of 9 days. The mean WBC count remained within normal range with slight increase in post operative period and was not indicative of infection. The mean hospital stay was 11 days which is much less compared to other types of traumatic neurosurgical cases.

So far surgical technique is considered apart from standard technique we followed our own techniques for proper handling of the surgical site. Firstly we preferred to raise flap around the

fractured segment than extending the primary scalp wound. It helped in two ways. Better exposure, generous debridement to expose the whole extent of dual injury and finally comfortable mesh cranioplasty. So far Dural injury was considered, small injuries were closed primarily but bigger injury were closed by artificial Dural substitute. Dural injury extending to skull base was closed by on lay patch of Dural substitutes in two layers and better result was achieved. The most important aspect to prevent infection was through debridement and copious saline irrigation at the end of procedure.

Conclusion

Based on author's experience and review of literature it is clear that immediate calvarial reconstruction does not increase the infectious sequelae compared to two stage procedure with delayed cranioplasty. Primary reconstruction of open skull fracture should be attempted whenever feasible. Single stage procedure not only benefits the patient in terms of early recovery but also assures immediate protection to the brain. It takes care of the psychological aspects and allows the patient early return to work. In the present era of advanced technology and among wide range of available customized skull prosthesis the titanium implants is a suitable options because of its high biological acceptability, high tensile strength and its cost effectiveness. So far infectious complication is considered the Importance of thorough debridement and copius saline irrigation cannot be over emphasized. More over a holistic approach and better controlled studies are needed to justify this changing trend from conventional staged procedure to a single stage one.

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