



Outcome of primary bone replacement in depressed skull fractures: a prospective study

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Abstract

Depressed skull fracture is a cosmetic problem when forehead is involved. In open type it is a neurosurgical emergency. When brain evisceration is seen it creates panic. Neurosurgeons have not reached consensus on the best method of care for the patients. The objectives were to replace bone fragments in all comminuted depressed skull fractures, and then determine the infection rate, rate of fracture union and the functional outcome of the patients. It was a prospective descriptive study on thirty one patients with depressed skull fractures operated in our center from August 2010 to July 2014. Patients were resuscitated, operated on and the bone fragments removed during the surgery were replaced with adequate antibiotic cover. Adequate nutritional support was given to them. Patients were followed-up in out-patient clinic on discharge. Data were collected using structured proforma which was component of our prospective data bank that was approved by our research and ethics committee. Data were collected in accident and emergency, theater, wards and out-patient clinic. The data were analyzed using Environmental Performance Index (EPI) info 7 software. There were thirty one patients in the study. Males were twenty four. The mean age was 28.16 years. Commonest etiology was assault. The commonest intracranial lesion was cerebral contusion. Twenty two patients had open depressed skull fractures. All replaced fragments got united with rest of crania. Favorable outcome was 100%. Our study showed that all replaced bones took. Infection rate was low. All patients had favorable functional outcome.

Keywords: depressed skull fracture, outcome, primary bone replacement

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Received: June 10, 2015 Accepted: July 27, 2015. Published: September 20, 2015. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

Introduction

Depressed skull fracture is a fracture in which the depressed segment's outer table lies below inner table of surrounding intact skull [1, 2]. It could be closed or open depressed skull fracture based on communication with exterior. Hippocrates [3]

advocated trephination of all skull fractures except depressed skull fracture. MacEwen [4] advocated soaking the fragments in Bichloride of Mercury before replacing them. Coleman advocated replacement of fragments within 12 hours of injury [5]. Nadell et al. [6] noted that infection correlated better with the condition of the scalp than it did with operative delay. We prospectively studied 31 patients who had primary bone fragments replaced.

Methods

It was a prospective, cross-sectional study of patients with depressed skull fractures operated in our center from 1st August 2010 to 31stJuly 2014. The patients were resuscitated in accident and emergency using Advanced Trauma Life Support protocols. We used intravenous Normal Saline for adults and 4.3% Dextrose in 1/5 Saline for children, aiming at

euvolemia and normotension. Intravenous or intramuscular Paracetamol 15mg/kg every 8hours for children, and 1gm every 8hours for adult was given for pain control. Intravenous Ceftriaxone 1gm for adult and 100mg/kg for children was given once daily for those with open wounds. Intramuscular Tetanus toxoid 0.5ml was given for Tetanus prophylaxis. Their oxygen saturation was maintained at 95% in room air or by augmentation with Oxygen. History and physical examinations were obtained. Full blood count, serum electrolyte/urea/creatinine, urinalysis and Computed Tomography (CT) scan of brain were done. X-ray of the skull were done for those who could not afford CT scan. Those who could not afford either of them but clinically diagnosed were operated without them. Severe head injured ones were admitted in intensive care unit. Informed consents were obtained from the patients or their legal representatives after explaining the extent of the lesions, the surgeries to be done and the complications of the lesions, surgeries and anesthesia.

In theater, we used general anesthesia with muscle relaxant. Prep was done using 7.5% Povidone Iodine for cleaning and 10% Povidone Iodine for painting. We used bicoronal scalp flap for lesions on the forehead, trauma flap for temporal or fronto-temporal lesions, and horse-shoe flap for parietal lesions. Sometimes only extension of the wounds was done. The scalp flaps were raised between the galea and pericraium. Pericranial flaps were raised separately. Irrigation of wounds was done using 80mg Genticin/500ml Normal Saline solution. The depressed fragments were worked loose and removed. In tight cases, rongeur were used to nibble out bones or burr hole placed on normal cranium at the edge of the fracture to help work loose the fragments. The fragments were washed in Saline/Genticin solution and immersed in 10% Povidone Iodine gel till ready for replacement. In those with contusions, the contused brains were resected. In those who could not afford CT scan but had intact dura, we opened the dura and inspected the brain. Findings were treated accordingly. In sinus involvement, the mucosa of the sinus was exenterated by curetting and coagulation. The fronto-nasal ducts were plugged with muscles. Dura was closed, occasionally augmented with galea. Duro-pericranial stitches were applied. The bone fragments were replaced in mosaic fashion (fig 1). Occasionally, Nylon suture scaffolds were done and the fragments placed on them for better cosmesis. Povidone Iodine gel (10%) was generously applied over the dura and

fragments. The pericranial flap was used to cover the fragments and sutured to place (fig 2). Generous 10% Povidone Iodine gel applied all over the wound. Freshening of laceration edges was done before closure. In gunshot wound (fig 3), the edges were trimmed till visible bleeding occurred. Scalp mobilization was done in first and second surgeries for the patient with the gunshot wound above (fig 3) to remove dead scalp/scars and achieve primary closure and better cosmesis. We sutured scalp flap over active drain fashioned out from size eight or ten feeding tube and empty 500ml Normal Saline plastic bottle. The wound was then cleaned with 7.5% Povidone Iodine. The apposed edges of the wound were covered with 10% Povidone Iodine gel. Wad of gauze was applied, then crape bandage applied. Intravenous Ceftriaxone 1gm was routinely given at induction. Intravenous fluid was continued for twelve to 72hours. Drains were removed two to three days post-op. Oral or nasogastric feeding and drugs were commenced on discontinuation of infusions. For those with sinus involvement, intravenous Ceftriaxone and Metronidazole were continued for two weeks, then oral Cefuroxime 500mg twice daily and oral Metronidazole 400mg thrice daily for four weeks. For others oral Cefuroxime and Metronidazole were given for two weeks. All patients were given Vitamin C and Multivitamin tablets, one tablet three times daily each with duration same with antibiotics. Analgesics were stopped on the third day post-op. For the unconscious patients, high energy and high protein diet was commenced on the third day. The diet was constituted with 500ml pap, powdered milk two tablespoonful, soya bean powder two tablespoonful, cray fish powder one tablespoonful, and red oil one tablespoonful. Their daily fluid requirement was factored into the mixture. They were given five to six times daily.



Figure 1: Typical mosaic replacement of fracture segments.

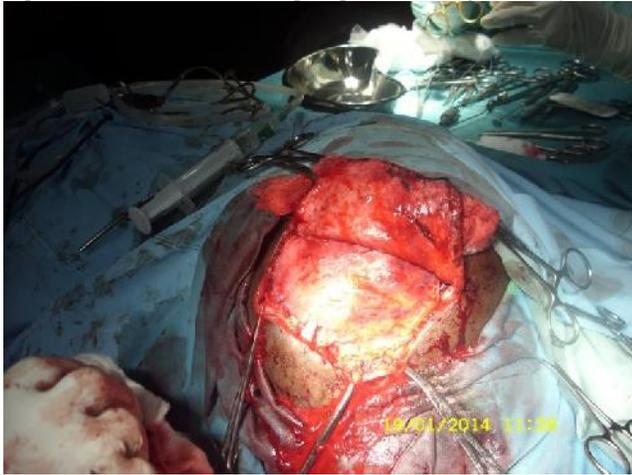


Figure 2: Fracture fragments covered with pericranial flap.



Figure 3: Depressed skull fracture from gunshot.



Figure 5: Extradural hematoma from a patient hit with motorcycle exhaust pipe.

On discharge, they were followed up in surgical out-patient clinic and by phone. The functional outcome was assessed with Glasgow

Outcome Score [7] three months post-injury. It classifies outcome into five categories: 1 death, 2 vegetative state, 3 severe disability, 4 moderate disability, 5 good recovery. The bone union was assessed three months post-surgery. Data were collected using structured proforma which was component of our prospective data bank that was approved by our hospital ethics and research committee. Their biodata, time of injury, etiology, prior intervention, physical findings, CT and X-ray findings were documented in accident and emergency. Surgical findings were documented in theater. The progress of the patients were documented in intensive care unit(ICU), wards and out-patient clinic. The data were analyzed with Environmental Performance Index (EPI) info 7 software. (Center for Disease Control and Prevention, Atlanta, Georgia, USA). We used the Visual Dashboard package; frequency and mean component of the analytical gadget for univariate variable, and MXN/2X2 and its advanced components for multivariate variables. Patients who had elevation of depressed skull fractures only were excluded from the study.

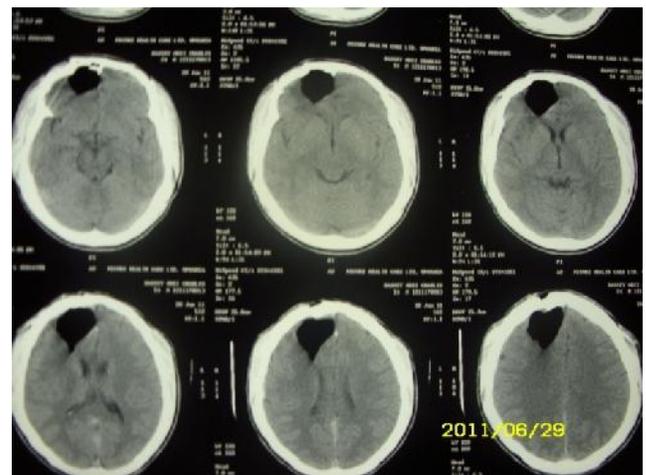


Figure 4: Tension pneumocephalus in fracture involving frontal sinus

Results

There were thirty one patients in the study. Males were twenty four, females seven. Their ages ranged from three years to sixty three years with mean of 28.16 years. The commonest etiology was assault, table 1. Closed depressed skull fractures were nine, open but healed depressed skull fractures were four, and open but fresh depressed skull fractures were eighteen. Three of the open but healed were for cosmesis, while the fourth had tension

pneumocephalus (fig 4). Nineteen patients did CT scan, six patients did skull x-ray, while six patients could not afford any of the two. There were three extradural hematoma (EDH), two diffuse axonal injuries (DAI), twenty contusions/intracerebral hematoma (contusion/ICH), one pneumocephalus and one subdural hematoma. Four patients did not have any lesion seen on CT scan or during inspection through incised dura. There was significant relationship between the type of depressed skull fracture and the intracranial lesions, $P=0.0089$, table 2. Over fifty percent of the lesions were in frontal region, table 3. In six patients, frontal sinus was involved. Six patients were operated within 24 hours, eleven patients between 24hours and 48hours, four patients between 48hours and 72hours, and ten patients after 72hours. There was significant relationship between the type of depressed skull fracture and the time to surgery, $P=0.0177$, table 4. There was no significant relationship between the time to surgery and complications, $P = 0.4891$. Twenty two patients had mild head injury, five had moderate head injury, while four had severe head injury. The favorable functional outcome was 100%. The outcome was significantly related to severity of injury, $P = 0.0306$, table 5. Five patients had post-traumatic seizures, two early, three late. Two patients

had cerebrospinal fluid rhinorrhea from frontal sinus involvement. One healed within ten days. The second failed to heal within two weeks but patient refused lumbar drainage. The rhinorrhea stopped after a bout of meningitis that occurred one month after surgery. One of the gunshot patients (high velocity) developed wound infection with osteomyelitis involving about 20% of the replaced bone fragment but the viable part had united with adjacent cranium. The patient had second surgery in which the fragment was re-fractured. We found that the united part was compact bone while the side with osteomyelitis was cancellous and they had clear demarcating line. The infected part was nibbled away with rongeur and the viable part was washed in Saline/Gentamicin solution and soaked in 10% Povidone Iodine gel. It was replaced and it got united with the cranium. The rest of the patients had the bone fragments united with the rest of their crania.

Etiology	Number	Percent (%)
Assault	14	45.16
Gun shot	2	6.45
Others	3	9.68
RTA	12	38.71
Total	31	100

Table 1: Etiology frequency

Type of fracture	Intracranial lesions					
	DAI (%)	EDH (%)	Contusion/ICH (%)	None (%)	Others (%)	Total (%)
Closed	0 (0)	2 (22.22)	7 (77.78)	0 (0)	0 (0)	9 (100)
Open	2(11.11)	1 (5.56)	11 (61.11)	4 (22.22)	0 (0)	18 (100)
Open but healed	0 (0)	0 (0)	2 (50)	0 (0)	2 (50)	4 (100)
Total	2 (6.45)	3 (9.68)	20 (64.52)	4 (12.90)	2 (6.45)	31 (100)

$P = 0.0089$

Table 2: Types of fracture vs intracranial lesions

Table 3: Site frequency

Site	Number	Percent (%)
Frontal	16	51.61
Parietal	9	29.03
Temporal	2	6.45
Two or more regions	4	12.90
Total	31	100

Type of fracture	Time to Surgery (hours)				
	24 (%)	24 – 48 (%)	48 – 72 (%)	72 (%)	Total (%)
Closed	0 (0)	4 (44.44)	1 (11.11)	4 (44.44)	9 (100)
Open	6 (33.33)	7 (38.89)	3 (16.67)	2 (11.11)	18 (100)
Open but healed	0 (0)	0 (0)	0 (0)	4 (100)	4 (100)
Total	6 (19.35)	11 (35.48)	4 (12.90)	10 (32.26)	31 (100)

$P = 0.0177$

Table 4: Type vs Time to surgery

Injury severity	GOS		
	4 (%)	5 (%)	Total (%)
Mild	0 (0)	22 (100)	22 (100)
Moderate	0 (0)	5 (100)	5 (100)
Severe	1 (25)	3 (75)	4 (100)
Total	1 (3.23)	30 (96.77)	31 (100)
P = 0.0306			

Table 5: Injury severity vs Glasgow Outcome Score [GOS]

Discussion

Of the thirty one patients in our study, males were majority, 24 (77.42%). High percentage of males in depressed skull fractures had been documented by other authors. Jamieson et al.[8] in their study of depressed skull in Australia found that males formed 80.1% of their patients. Emejulu et al.[9] in their study on delay in definitive treatment of open skull fractures found that males constituted 92% of their patients. High percentage of males in depressed skull fractures like other traumatic brain injuries had been attributed to males being more active than females in the quest to provide for the families.

In our study, the most common etiology was assault, followed by road traffic accident (RTA). In their study on depressed skull fracture, Hossain et al.[10] found assault as the most common etiology. Al-Haddad et al.[11] in Liverpool, found assault as the most common etiology. While these were in keeping with our finding, many authors' findings were different from ours. Emejulu et al.[9] found that RTA was most common, 50%. Rolekar[12] in 50 patients with depressed skull fractures he studied, found that RTA constituted 60%. Ali et al.[13] found fall as the most common etiology, 51.94%. Assault being the most common etiology in our study might be due to the location of our center in the most restive region of our country. The deprivation and neglect of the region by our government led to the restiveness. In their study of head injury from assaults among indigenous and non-indigenous Australians, Jamieson et al.[14] found very high traumatic brain injury from assault among the indigenous population. There was high level of alcohol consumption among them also. They recommended that tackling the alienation and disadvantage position of the indigenes should be addressed to reduce the rate of assault-related head injuries. There is high level of alcohol consumption in our city. Many clubbing centers in our city stay on till wee hours of the following morning. It had been noted that aggression was greater in communities where alcohol was easily obtained.[15] Badanich et

al.[16] found that ethanol reduces lateral orbitofrontal cortex function via glycine receptor dependent process which leads to aggression and impaired judgment. That might explain the high level of assault in our study.

Open skull fractures were twenty two, while closed fractures were nine. High percentage of open fractures was in keeping with findings in many series. Nadell et al.[6] found 77% open fractures in 110 cases they studied. Rolekar [12] found open fractures in 68% of the fifty patients he studied. Hossain et al.[10] found open fractures in 64% of the sixty seven patients they studied. Open fracture portrayed the high energy impact that was able not only to deform and fracture the skull, but also lacerated the soft tissues over the fracture. In their study, Yavuz et al.[17] found that the degree of skull deformation and the type of fracture produced depended on the striking force. Only nineteen patients could afford CT scan among our patients. Many findings were clinical and during the surgeries for those who could not afford CT scan. Many of those that did CT scan were assisted by relatives or friends, in most cases due to panic caused by brain evisceration. Many of them were from low income area of the city. The most common findings were contusion/ICH (20) and EDH (3). In their study of 67 patients, Hossain et al.[10] found contusion (21) as the most common intracranial finding, followed by EDH (15). Ali et al.[13] found brain evisceration most common(nine), followed by EDH (seven). The high number of contusions and EDH was likely due to high energy impact in localized area which was not only able to fracture the skull and injured the brain, but also caused stripping the dura off the inner table of the skull with resultant extradural hematoma formation. Ford et al.[18] found that localized impact strips off the dura from the inner table of the skull with resultant extradural hematoma formation, and the higher the force of the impact, the higher the stripping off, and the larger the volume of the hematoma formed. One of our patients with EDH who was hit with motorcycle exhaust pipe had depressed skull fracture with associated huge extradural hematoma (fig 4). All the patients with EDH had GOS of five. Nelson et al.[19] in their

Nnadi MON, Bankole OB, Olatosi JO, Edentekhe TA, Fente BG. (September 2015). Outcome of primary bone replacement in depressed skull fractures: a prospective study. *Jour of Med Sc & Tech*; 4(3); Page No: 216 – 222.

study of 890 CT scans of traumatic brain injury patients found that extradural hematoma positively predicted outcome.

The most common region involved was frontal, followed by parietal. Nadell et al.[6] in their 110 cases, found that frontal lesions were 65, followed by parietal with 32 cases. Nayak et al.[20] in 32 patients they studied found fronto-parietal 17 and basifrontal 11. The frontal region is the commonest area that is injured in deceleration/acceleration injury in head-on collisions in RTA. It is also injured in straight trauma in conflicts. In our study, six of the eighteen patients with fresh open depressed skull fracture had surgery within 24hours. Seven had surgery between 24hours and 48hours. Three had surgery between 48hours and 72hours, and two had surgery after 72hours. The only patient with wound infection/osteomyelitis was an open depressed skull fracture from gunshot wound. She had surgery within 24 hours of injury. That showed wound infection rate of 3.23%. If we include the patient with meningitis one month after surgery, the rate increased to 6.45%. In spite of the infection and time lag, all the patients' bone fragments got united with the rest of their crania. Kriss et al.[21] in 79 patients they had their primary bone fragments replaced, their surgeries were done within 24hours of injury. Two patients (2.53%) had wound infection but no osteomyelitis. They noted that gross contamination, even in presence of dural tear or brain laceration, does not contradict bone replacement provided the dura can be sutured and surgery done within 24hours. All the patients we replaced their bone fragments after 24hours did not have wound infection. Nadell et al.[6] did primary replacement in 110 patients with non-missile depressed skull fractures in which 75 were open fractures. Six of their patients (5.46%) had scalp wound infection. One had osteomyelitis. They noted that the incidence of infection correlated better with condition of the scalp than it did with operative delay. Al-Haddad et al.[11] operated on 73 cases of depressed skull fractures in which 84% were operated within 24hours and two after 48hours. Ninety percent had bone fragments replaced. The infection rate was 8.2%. Many other authors had reported good outcome in primary bone replacement.[4,22-25] One striking thing in the gunshot re-operation was the change from cancellous bone to compact bone by the fragment. Shehadi[26] showed that in trephined dogs bone dust spread on the dural surface would form a sheet of bone; histology examination showed proliferating osteoblast, bone trabecula, and compact

bone formation. The conversion of the fragment to compact bone must have limited the spread of the osteomyelitis as the Haversian canals were much reduced in number in compact bone. This might be the reason infection was less in replaced fragments. There might be antibiotic chemicals secreted by the proliferating bone cells.

The favorable functional outcome was 100% in our study. Al-Haddad et al.[11] found 78.1% favorable functional outcome and mortality of 1.4%. Emejulu et al.[9] found favorable outcome in 94.4% of their patients and mortality of 5.6%. The superior favorable functional outcome in our study might be due to the high energy mixture we used. Härtl et al.[27] in their meta-analysis of 1261 patients on the effects of nutrition on deaths due to severe traumatic brain injury found that nutritional support initiated within five days of trauma was associated with a significant reduction in 2-week mortality; the result stood after consideration for other parameters that affect mortality such as age, GCS, pupillary status, and others. Wang et al.[28] in their meta-analysis of 16 studies also found that early nutrition decreased mortality, reduced complications and facilitated recovery. The seizure rate in our study was 9.68. Kriss et al.[21] in their study found seizure in 11% of their patients. Brakmaan [22] found seizure in 7.5% in his series. Miller et al.[25] in their study found seizure in 9.5% of their patients. The seizure rate in our study was within the rates of above studies.

Conclusion

Our study showed that primary bone fragments replaced united with the crania, including those with missile injuries. Surgeries done after 48hours with adequate antibiotic cover were not infected. We found that cancellous skull bone transformed to compact bone during the fusion with the rest of the cranium. All our patients had favorable functional outcome. The infection rate was low and seizure was seen in 9.68%.

Recommendations: Primary bone fragment should be replaced in depressed skull fractures even in missile wounds. Replacement could be done after 72hours provided adequate antibiotic was given. Adequate nutrition started third day of injury should be aimed at. Future research should be done to check antibiotic chemicals produced in the wound by proliferating bone cells. More studies are needed in primary bone replacement in firearm injuries.

Conflict of interest: None
Financial Support: None

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