Clinical Outcomes and Prognostic Determinants of Surgically Treated Depressed Skull Fracture in Addis Ababa University Neurosurgical Teaching Hospitals: A Prospective Multicenter Observational Study

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List of Abbreviations

AAU	Addis Ababa University
AEDs	Anti-Epileptic Drugs
AOR	Adjusted Odd Ratio
ALERT	All Africa Leprosy TB Rehabilitation and Training Center (ALERT Center).Trauma center
ATLS	Advanced Trauma Life Support
CT	Computed Tomography
COR	Crude Odds Ratio
DSF	Depressed Skull Fracture
EDH	Epidural Hematoma
EMA	Ethiopian Medical Association
EPTS	Early Post Traumatic Seizure
LPTS	Late Post Traumatic Seizure
ESA	Ethiopian Surgical Society
GCS	Glasgow coma scale
GOS-E	Extended Glasgow outcome scale
ICH	Intracerebral Hematoma
IRB	Institutional Review Board
IVH	Intraventricular Hematoma
SAH	Subarachnoid Hemorrhage
SCF	Cerebrospinal Fluid
SDH	Subdural Hematoma
SENSP	Society of Ethiopian Neurological Surgery Professionals
SPSS	Statistical Package for the Social Sciences
TASH	Tikur Anbessa Specialized Hospital
ZMH	Zewditu Memorial Hospital

Abstract

Background: Depressed skull fracture (DSF) is one of the commonest neurosurgical emergencies in Ethiopia. The clinical outcome after surgical management and what factors predict the outcome is not well-studied, especially in low-income countries like Ethiopia. Our study aimed to assess the clinical outcomes of DSF and identify predictors of the outcome in surgically treated adult patients.

Methodology: A prospective, multicenter, observational study was undertaken on 197 surgically treated patients with DSF from June 1, 2018, to June 30, 2020, at four selected neurosurgical teaching hospitals in Ethiopia. Adult patients with clinically palpable or CT evidence of DSF who underwent surgery for the primary indication of the DSF were included in this study. Data on patients' socio-demographics, mechanisms of injury, clinical findings at presentation, imaging, and intraoperative findings, and postoperative course was collected and analyzed. The outcome was assessed by the extended Glasgow outcome scale (GOS-E): as favorable or unfavorable. Bivariate analysis was done to identify factors that correlate with the clinical outcome and multivariate logistic regression analysis was done to identify independent predictors of the outcome.

Results: The overall clinical outcome was favorable in 81.2% of 197 patients. The mean age of participants was 27.77 +/- 10.21 years with a male to female ratio of 23.6:1. The most common mode of injury was violence-related 157 (79.7%). The DSF was compound in 186 (94.4%). Post-traumatic motor deficit and early posttraumatic seizures were witnessed in 24.4% and 8.1% respectively. Based on post-resuscitation GCS 182(92.2%) patients had mild TBI, 12(6.1%) moderate TBI, and only 3(1.5%) were in severe TBI. The most common site of fracture was frontal bone involved in 103 (52.3%) of cases, followed by parietal bone in 48 (24.4%). Associated intracranial lesion was identified in 172 (87.3%) of cases. The median days of hospital stay were 4.7 days. Totally 8(4.1%) patients underwent reoperation and the overall mortality was 0.5%. In bivariate and multivariate analysis, posttraumatic motor deficit (adjusted OR 13.8, 95% CI: 4.13-46.17, P=0.000), post-resuscitation GCS ≤13 (adjusted OR 10.36, 95% CI: 1.93-55.56, P=0.006), pneumocephalus on brain CT scan (adjusted OR 12.93, 95% CI: 3.12-53.52, P=0.000), hospital stay for ≥ 3 days (adjusted OR 4.39, 95% CI: 1.18-16.3, P=0.027) and reoperation (adjusted OR 6.92, 95% CI: 1.091- 43.97, P=0.04) were statistically significant independent predictors of unfavorable outcome.

Conclusion: The overall outcome of surgical treatment for DSF in this study was favorable. The presence of *motor deficit, post-resuscitation GCS ≤ 13, pneumocephalus, reoperation, and hospital stays for ≥ 3 days* were independent predictors of an unfavorable outcome.

1. Introduction

1.1. Background

Head injury is one of the most important public health problems worldwide. Especially with rapid urbanization and a tremendous increase in high-speed traffic flow, the incidence of trauma is increased both in developing and in developed countries(1,2). One of the serious head injuries is a skull fracture. Skull fractures are classified in three ways: by pattern (linear, comminuted, and depressed), by anatomic location (vault convexity, base), and by skin integrity (open, closed).

Depressed skull fractures are one of the common emergency neurosurgical conditions. A skull fracture is considered depressed when any portion of the outer table of the fracture line lies below the normal anatomical position of the inner table. Complex depressed fractures are those in which the dura is torn. Skull fracture results from large energy forces applied to the head. The extent and type of skull fracture are determined by the kinetic energy of the striking object, the geometry of the striking object, the direction of the impact force, and the anatomic site of the impact. DSFs typically occur when objects with a large amount of kinetic energy make contact with the skull over a fairly small area(3,4). The underlying brain can be affected either directly by damage to the neurological tissue and its vasculature, or it can be affected indirectly by subdural and/or extradural hematoma which forms under the skull and compresses the underlying brain tissue. X-ray of the skull will delineate the type, severity, and place of depression. Computed Tomography (CT) scan of the head without contrast is the gold standard as it not only demonstrates the depressed fracture but also show associated intracranial lesion(5).

DSF can be managed either surgically or conservatively. Surgical treatment may vary in complexity from simple skin debridement and wound closure to fracture elevation, evacuation of hematoma, debridement of the contused brain, repair of a dural defect, and dural venous sinuses(6). The indications for surgery are neurological deficit related to the underlying brain, cerebrospinal fluid leakage (dural tear), depression greater than the inner table of the bone of the skull (>10 mm depression), cosmetic purpose, and associated intracranial hematoma(6,7). More conservative treatment is recommended for simple fracture or fracture overlying major dural venous sinuses(8). Furthermore, the management of head injury in trauma patients has undergone drastic changes after the introduction of Advanced Trauma Life Support (ATLS). However, there have been only a few recent studies analyzing the overall outcomes of patients with surgically treated DSF and what determines the outcomes and also most of these studies were retrospective or with a limited number of cases. Hence, the purpose of this prospective multicenter study is to assess the overall outcome of surgically treated DSF and analysis of the outcome determinants. The result of this research will be the major input for the development of a national guideline for the management of DSF and it may also be used for other developing countries or the globe at large.

1.2. Statement of the problem

Depressed skull fracture (DSF) is a serious injury to the head that occurs in up to 6% of all head injuries(9). A skull fracture is considered depressed when any portion of the outer table of the fracture line lies below the normal anatomical position of the inner table. The etiology is usually posttraumatic either following a traffic accident, assault, or fall down accident. With rapid urbanization and a tremendous increase in high-speed traffic flow, the incidence of trauma is increasing both in developing and in developed countries.

This makes it universal health and social problem. DSF may be closed or open (compound) type. Compound fracture account for up to 90% and the associated infection rate of DFS is 1.9 to 10.6% and with an 11% neurological deficit. 5% to 12% of patients also develop early or late post-traumatic or post-surgical epilepsy. The mortality rate of DSF might be as high as 13% (3%-13%)(10–12). Treatment depends upon the degree of depression, communication with the exterior and neurological deficit. DFS should be treated properly and timely to prevent complications such as infection, seizures, the progression of neurological deficit, and post-traumatic hydrocephalus. Midline DSF deserves a special mention among skull fractures and should always be treated with caution.

1.3. Significance of the study

Although there are some studies conducted around the world to study the overall outcome of surgically treated DSF and what determines the outcome, most of these studies have limitations like being retrospective, or prospective with a limited number of cases, or done in all age groups which are difficult to generalize. There are also few published studies from some African countries with the same limitation and in Ethiopia despite the surgical treatment of DSF in many hospitals for many years; the outcome of the treatment is not studied. Hence this study being multicenter and prospective in tertiary hospitals in the capital of Ethiopia with a high flow of patients with DSF, the result will give us more accurate data on the overall outcome of surgically treated DSF and main determinants of the outcome to improve our approach and to fill any gap on the management of patients with DSF. The result of this study might also serve as an important input for the development of a national guideline for the management of patients with DSF and will also provide data for health care professionals in other developing countries as well as the in the globe at large.

2. Literature review

The first description of skull fracture is in Edwin Smith's papyrus, the oldest known surgical journal, where a conservative and expectant approach towards the management of skull fracture is described. Even after 100 decades later, Hippocrates (ca.460 BC –ca.370 BC) in "On Injuries to the Head" also advised against trepanation in cases of depressed fractures (Hippocrates, 1928). The explanation given was that these fractures were less dangerous because of the wide openings in the bone. Hippocrates advised against elevating fragments as well, preferring to let them elevate spontaneously. From this Hippocratic time until 1800, the evolution of depressed skull fracture management took several strange twists and turns. From 1800 onwards, there was gradual progress of knowledge and practice towards modern methods of treatment(1,13).

Head injury is the leading cause of morbidity and mortality not only in the developed countries but also in developing countries and accounts for almost 50% of all the deaths from trauma. DSF is one of the serious traumas which occurs in head injury patients dominantly affecting the productive age group. Most studies agreed that the younger age groups are the most commonly affected population group by depressed skull fractures since this age group is more involved in outdoor activities(14,15). Prakash et al. (2019), from a series of 453 patients a maximum incidence was found in the age groups of 16–30 years (30%) and followed by age group of 31–45 years (26%). Another study by Adrian Kelly et al. (2018) showed 68.2% of patients were between 20-40 years of age(3). This is also true in our country as shown by the result of Salia et al (2018) study, most patients (90.7%) were <45 years old (9). There is also agreement on the finding of literature that males are predominately affected. The male: female ratio in Glasgow (1968), Prakash, et al., (2019), and Salia, et al (2018) series was 4.99:1, 6.94:1, and 8.1:1 respectively(9,14). Yavuz MS et al (2003), by the study of the correlation between skull fractures and intracranial lesions, try to explain the higher ratio in males could be due to thicker and stronger skull which can absorb the impact force(16). Hence, males are more likely to get depressed fractures while females are more prone to linear fractures.

There is a wide divergence in the results of the causes of depressed skull fracture. The results from Al-Haddad SA et al. (2002) and Prakash, et al., (2019) showed alleged assault was the most common cause of depressed skull fractures followed by road traffic accidents(14,17). On the contrary, the results of the study by Ozer FD et al (2005) and Amir S, Qadir M (2017) showed road traffic accidents as the most common etiology followed by alleged assault(18,19). The other most commonly mentioned mode of injuries are railway accidents, heavy objects fall on the head in construction areas, fall from a height, and sport-related injuries. The predominance of a particular type of mode of injury can be due to selection bias in a hospital which caters to a particular subsection of society such as construction workers or trauma center on a highway or since the introduction of road safety measures in some areas have drastically reduced the number of RTAs.

The presenting features could be a headache, loss of consciousness, bleeding, vomiting, or abnormal body movement. Salia, et al (2018), the headache was the most common presenting symptom (84.4%) followed by loss of consciousness that occurred (76.6%). In other studies like Nikita G Rolekar (2014), Ali et al. (2003) and Hossain et al. (2008) loss of consciousness was the most common cause of presentation, 56%, 40%, and 25% respectively(7,11). Additionally, level of consciousness at presentation was one of the outcome predictors; Satardey RS et al (2018) found that patients with a GCS score of 13 or more (74%) fared well with the better long-term outcome as against those with a GCS score below it(20).

There is no much difference in the most common site of DSF. Satardey RS et al (2018) and Al-Derazi et al (2008) series showed the most common site for DSF was the parietal region (48% vs. 44%), followed by frontal (34% vs. 32%) temporal (10% vs. 18%) and occipital (6%). Salia, et al (2018), also showed a similar result. Less commonly there may be involvement of more than one area. Satardey RS et al (2018), identified 2% of study subjects were having more than one area involvement (frontoparietal and occipitotemporal). The patients with involvement of two or more areas had more morbidity and mortality compared with single bone involvement(9,20).

Compound fractures are the most common type in most studies. The results of the study series by Glasgow (1968), Satardey RS et al (2018) and Prakash, et al., (2019) showed 90%, 89%, and 75% incidence of compound fracture respectively. The higher incidence of compound fractures may be a consequence of a higher number of cases due to alleged assault and RTA, from which higher force is delivered over a concentrated area of the skull, thereby, is more likely to cause a depressed and compound fracture(14,20).

Venous sinuses were involved in 11.5% to 16.3% of cases in Satardey RS et al (2018) and Prakash, et al., (2019) studies. The study by Aziz MM. et al (2019) showed the superior sagittal sinus (SSS) was most commonly involved 70.59% followed by torcular herophili 23% and transverse sinus in 5%. The same study recommended conservative management unless the depressed segment causes venous obstruction or neurologic deficit(8).

Associated intracranial injuries such as EDH, SDH, SAH, contusions, dural tear are other important factors that may affect the management approach and outcome in patients with DSF. The result of a single study in our country by Salia et al (2018) revealed contusion/ ICH were the most common associated injuries occurring in 63.3% of patients with compound DSF followed by pneumocephalus in 57.8%, acute EDH in 26.6%, acute SDH in 3.9 % and intraventricular hemorrhage in 1.6%(9). The same study found a dural tear in 55.5% of the cases and have created a sensitive algorithm that predicts dural laceration using the presence (or absence) of pneumocephalus or cerebral contusion and the depth of the fracture. However, the outcome as well as the effect of these associated injuries on the outcome was not studied.

The management of depressed skull fractures is different from institution to institution and one hospital from the other, guided by the various factors and the protocol followed by different neurosurgeons. The options of management are either conservative or operative. Non-operative management is suggested for closed and simple DSF. The most commonly used indications for surgery in depressed skull fracture as per review by Sherman C. Stein et al 2019 are significant fractures with signs of dural breach or neurologic deficit from the fracture(8,13). These are also the surgical indication used for operating patents with DSF in our hospitals, even though based on the study results done on other populations. Hence the results of the current study will be the major input.

In a recent retrospective study by Prakash, et al., (2019) on 453 patients, 91% were managed surgically most of them were operated within 24 h with an overall mortality rate of 17% and 15% infection rate. This study also revealed the increased incidence of mortality in the age group of 16–45 years(14). Another study was prospectively done by Bidur KC et al (2018) on 50 patients from whom 68 % managed surgically. A dural tear was observed in 47% of cases that were operated on. Early epilepsy was seen in 4% and late epilepsy in 2% and an infection rate of 2%. The overall outcome was Favorable in 98% of patients(21).

Many factors may negatively affect the outcome of patients with DSF. A study by Satardey et al.2019 on 50 cases prospectively analyzed the factors affecting the outcome and found that the age group of 20–40 years had the most number of patients with good outcome (81.3%), nearly 97.3% of patients who presented with GCS between 13 and 15 had good outcome as against 16.7% patients who had GCS of 8 or below, patients with frontal bone fractures had the best outcome and worst in those involving >2 bones and patients with contusions showed poor outcome (47.1%) as against those without it (97%)(20). The same study also revealed 97.2% patients of those without dural tear had good outcome as against 35.7% of those having a dural tear and patients with wound infection had greater morbidity and mortality (71.4%) than those without it. These studies had limitations most being retrospective and those prospectively done were with a small number of patients, which is not adequate to make a generalized conclusion and to depend on it to develop guidelines. So our study may overcome some of the limitations of previous studies and assess the clinical outcome and determinants of the outcome in surgically treated DSF at Addis Ababa university neurosurgical teaching hospitals. The result of this study may provide the best tangible information for decision making in the management of patients with DSF.

3. Objectives

3.1. General objective

- To assess the clinical outcomes and identify predictors of the outcome in surgically treated adult DSF patients

3.2. Specific objectives

- To describe the outcome of surgically treated DSF patients in terms of Extended Glasgow outcome scale (GOSE)
- To identify factors predicting the clinical outcomes of DSF in patients treated with surgery

4. Methodology

4.1. Study setting and study design

A hospital-based multi-center prospective observational study was done to assess the clinical outcome and identify outcome predictors in surgically treated DSF patients.

This study was conducted in four hospitals in Addis Ababa, Ethiopia, that provides neurosurgical services: Addis Ababa University Tikur Anbessa Specialized Hospital, All Africa Leprosy TB Rehabilitation and Training Center (ALERT Center) trauma center, Zewditu Memorial Hospital, and Myungsung Christian General Hospital, with a surgical bed capacity of 300, 53, 45, and 40 beds respectively. Nine consultants and 43 resident neurosurgeons work in these hospitals on a rotational basis. These hospitals are among the few hospitals which provide neurosurgical services in the capital of Ethiopia and the surrounding with an estimated population of more than ten million .These hospitals also provide neurosurgical referral service from the whole nation of more than 100 million populations. The majority of the trauma either from the capital or referrals from the periphery is managed in these hospitals.

4.2. Study Period

The study period was from June 1, 2018, to June 30, 2020.

4.3. Source and Study populations

Source population: All adult neurosurgical patients, who underwent surgery for DSF in four selected hospitals in Ethiopia.

Study population: All adult neurosurgical patients who underwent surgery for DSF in four selected hospitals in Ethiopia within the study period and fulfilling the inclusion criteria.

4.4. Inclusion criteria

- ✓ Patients with DSF which is managed by surgery, DSF being the primary indication
- ✓ A patient who has given informed consent to be included in the study

4.5. Exclusion criteria

- ✓ Age < 14 years

- ✓ Patients with DSF which is managed conservatively
- ✓ All Patients having EDH with thickness ≥ 1.5cm/MLS ≥ 5mm or SDH with thickness ≥ 1cm/MLS ≥ 5mm or ICH with volume ≥ 30cc
- ✓ Patients with severe polytrauma
- ✓ Non-consenting patients

4.6. **Sampling method and sample size**

All patients fulfilling the inclusion criteria during the study period were enrolled in the study by using convenience sampling.

4.7. **Study variables**

4.7.1. **Independent variables:**

- ✓ Age
- ✓ Sex
- ✓ Residency
- ✓ Mechanism of injury
- ✓ Symptoms at presentation
- ✓ Post resuscitation GCS
- ✓ Neurologic deficit
- ✓ Non-severe concomitant injury
- ✓ Pre hospitalization delay
- ✓ Posttraumatic seizure
- ✓ CT scan findings
- ✓ Intraoperative findings
- ✓ GCS at discharge
- ✓ Total days of hospital stay

4.7.2. **Dependent variables:**

- ✓ Clinical outcomes using GOS - E classification at the end of the follow up as favorable (for 7 and 8) or unfavorable (for 6 and below):
    1. Dead
    2. Vegetative state
    3. Lower severe disability
    4. Upper severe disability
    5. Lower moderate disability
    6. Upper moderate disability
    7. Lower good recovery
    8. Upper good recovery

4.8. **Operational definitions**

- ➢ **DSF** is a fracture of the skull where any portion of the outer table of the fracture line lies below the normal anatomical position of the inner table.
- ➢ **Compound DSF** is when the fracture is associated with scalp laceration or directly communicates with paranasal air sinus or middle ear structures.
- ➢ **The Glasgow coma Scale (GCS)** is a clinical assessment tool to determine the level of consciousness by assessment of eye-opening, speech, and motor function.

- **The Glasgow Outcome Scale (GOS)** is a global scale for the functional outcome that rates patient status into one of five categories: Dead, Vegetative State, Severe Disability, Moderate Disability, or Good Recovery. The Extended GOS (GOSE) provides more detailed categorization into eight categories by subdividing the categories of severe disability, moderate disability, and good recovery into a lower and upper category. (See annex)
- **Early posttraumatic seizures** are those appearing within the first week after trauma, after that, it is a late posttraumatic seizure.
- **Total hospital stay** is the time-lapse in days from admission to discharge of the specified patient.
- **A postoperative complication** is any event in the postoperative period for which the patient required specific treatment.

4.9. Data collection and analysis

The data was collected using a predesigned questionnaire in the wards regarding age, sex, mode of injury, presenting symptoms, GCS, focal neurologic deficit, concomitant injuries, brain CT scan findings, operative producers, and findings, postoperative complications, and total days of hospital stay. For missed patients, basic data were collected from prospectively collected data in the neurotrauma registry. All patients were appointed at the outpatient clinic on the 3rd and 6th months postoperatively. At follow up patients were assessed for functional outcome based on GOS-E by neurosurgical residents and principal investigators using the predesigned questionnaire, and for patients not seen at follow-up, an evaluation was done via telephone. The collected data was then cleaned and coded. The statistical analyses were performed using SPSS for Windows software (version 25.0; IBM SPSS, Armonk, NY, USA).

All variables were analyzed using the relevant descriptive statistics. For the outcome analysis, GOS-E classification was dichotomized into favorable (upper and lower good recovery) and unfavorable (lower moderate disability and worse). To identify factors associated with the outcome variable, bivariate analyses were carried out using the Fisher exact test, Pearson chi-square test, as well as the exact chi-square test when appropriate for categorical variables, and the Mann–Whitney U-test for continuous nonparametric data. To pick out factors independently predict the outcome, multivariate analyses were performed by entering all variables with a p-value < 0.05 from previous univariate analyses into a forward stepwise binary logistic regression. The strength of association was evaluated using an adjusted odds ratio (AOR) and 95% confidence interval (95% CI). A p-value of less than 0.05 was considered statistically significant.

4.10. Ethical consideration

Ethical clearance was obtained from the department of the surgery research committee and Institutional Review Board (IRB) of the College of health sciences. The procedure of the study was explained to the study participants that harm would hardly happen to them regarding the study conducted. The patient’s data were kept anonymous and stored in a secure place to keep confidentiality.

5. Result

Out of all patients with depressed skull fractures admitted in four hospitals, a total of 197 patients underwent surgical intervention during the study period to meet the eligibility criteria to be included in the study. Out of 197 patients, the clinical outcome was favorable in 160 (81.2%) and unfavorable in the remaining 37 (18.8%) as shown in figure 2.

5.1. Socio demographics

The majority of the participants, 161(86.3%) were 15 to 35 years old. The mean ages of participants were 27.77 ± 10.21 years. The majority patients were males accounting for 95.9% (189) with a male to female ratio of 23.6:1. 127 (64.5%) were referred from outside the city and 70(35.5%) were from different parts of the city (Table 1).

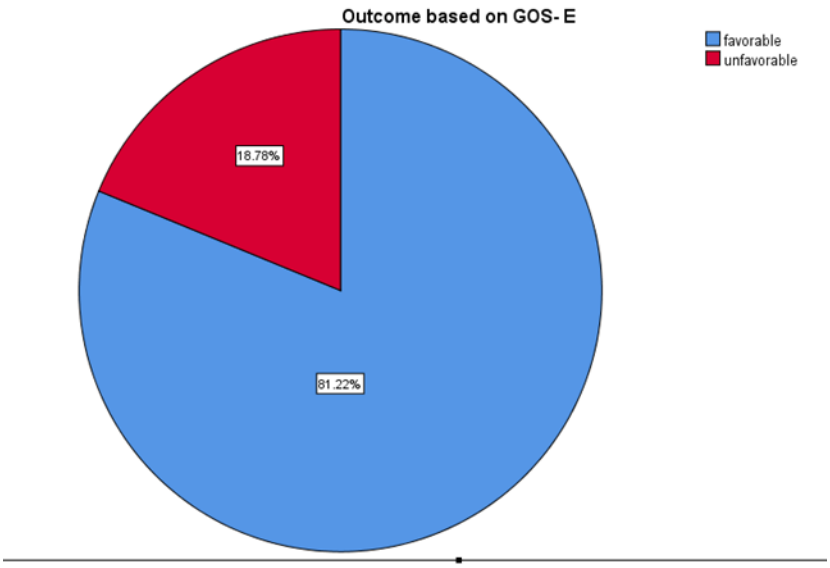

Figure 3 A pie chart showing the outcomes of the study population at the final follow up (N=197)

Table 7 Baseline characteristics and clinical outcome of study participants (N=197)

Baseline characteristics		Clinical outcome based on GOS - E		
		Favorable Count (%within group)	Unfavorable Count (%within group)	Total Count (%within group)
Age category in years	14 - 25	86 (53.8)	13 (35.1)	99 (50.3)
	25 – 35	55 (34.4)	16 (43.2)	71 (36.0)
	35 – 45	11 (6.9)	4 (10.8)	15 (7.6)
	> 45	8 (5.0)	4 (10.8)	12 (6.1)
Gender	Male	154 (96.3)	35 (94.6)	189 (95.9)
	Female	6 (3.8)	2 (5.4)	8 (4.1)
Marital status	Single	117 (73.1)	23 (62.2)	140 (71.1)
	Married	43 (26.9)	14 (37.8)	57 (28.9)
Mechanisms of Injury	Violence related	132 (82.5)	25 (67.6)	157 (79.7)
	RTA	13 (8.1)	5 (13.5)	18 (9.1)
	Constriction site related injury	2 (1.3)	4 (10.8)	6 (3.0)
	Fall down accident	2 (1.3)	1 (2.7)	3 (1.5)
	Tree fall on head	2 (1.3)	0 (.0)	2 (1.0)
	Stone fall on his head from height	1 (0.6)	1 (2.7)	2 (1.0)
	Hit by animal	5 (3.1)	0 (.0)	5 (2.5)
	Fall from tree	3 (1.9)	1 (2.7)	4 (2.0)
Residency	Addis Ababa	57 (35.6)	13 (35.1)	70 (35.5)
	Outside Addis Ababa	103 (64.4)	24 (64.9)	127 (64.5)
Origin of referral	Direct	12 (7.5)	1 (2.7)	13 (6.6)
	Health center	41 (25.6)	11 (29.7)	52 (26.4)
	Hospital	95 (59.4)	22 (59.5)	117 (59.4)
	Private centers	12 (7.5)	3 (8.1)	15 (7.6)

5.2. Mechanisms of injury and presenting symptoms

The most common mode of injury was violence-related 157 (79.7%), from which assault by stone and stick were reported in 87(52.2%) and 42(26.8%) respectively. RTA was the cause in only 18(9.1%) of cases (Table 1). The minimum time between the trauma and intervention was six hours and the maximum delay was 2160 hours (90 days). The median time for intervention was 72 hours and in 114 (57.9%) the intervention was in less than 24 hours. Bleeding from the wound, ear and nose was the presenting symptom in 186 (94.4%), headache in 170(86.3%), and loss of consciousness in 154 (78.2%). Compound DSF was diagnosed in 186 (94.4%). Focal neurologic deficit and early posttraumatic seizure were witnessed in 24.4% and 8.1%, respectively. Based on post-resuscitation GCS, 182(92.2%) patients had mild TBI, 12(6.1%) moderate TBI, and only 3(1.5%) were in severe TBI. The non-severe concomitant injury was identified in 18% of patients from which orbit and long bone were most involved (Table 2).

Table 8: Sign and symptoms at presentation and clinical outcome of study participants (N=197)

		Clinical outcome based on GOS – E		
		Favorable	Favorable	Total
Clinical variables		Count (%within group)	Count (%within group)	Count (%within group)
Headache	No	25 (15.6)	2 (5.4)	27 (13.7)
	Yes	135 (84.4)	35 (94.6)	170 (86.3)
Vomiting	No	87 (54.4)	9 (24.3)	96 (48.7)
	Yes	73 (45.6)	28 (75.7)	101 (51.3)
Loss of consciousness	No	40 (25.0)	3 (8.1)	43 (21.8)
	Yes	120 (75.0)	34 (91.9)	154 (78.2)
EPTS	No	146 (92)	33 (89.2)	181 (91.4)
	Yes	13 (8)	4 (10.8)	16 (8.6)
The severity of TBI at presentation	Mild	155 (96.9)	27 (73.0)	182 (92.4)
	Moderate	5 (3.1)	7 (18.9)	12 (6.1)
	Severe	0 (0.0)	3 (8.1)	3 (1.5)
Motor weakness	No	142(88.8)	21(56.8)	163(82.7)
	Yes	18 (11.3)	16 (43.2)	34 (17.3)
Concomitant injury	No	147 (91.9)	29 (78.4)	176 (89.3)
	Yes	13 (8.1)	7 (21.6)	21 (29.7)
Deep Scalp laceration	No	9 (5.6)	2 (5.4)	11 (5.6)
	Yes	151 (94.4)	35 (94.6)	186 (94.4)
Time delay in hours	< 24	92 (57.5)	22 (59.5)	114 (57.9)
	≥24	68 (42.5)	15 (40.5)	83 (42.1)

5.3. **Radiologic findings**

All participants were evaluated by a precontrast brain CT scan before surgical intervention. The most common site of fracture was frontal bone involved in 103 (52.3%) of cases, followed by parietal bone in 48 (24.4%). More than two bone fractures were found in 30(15.2%) patients and midline were crossed by a fracture in 33 (16.8%). Cranial air sinuses and dural venous sinuses were involved in 17.1% and 16.8% respectively (Table 3). Associated intracranial lesions were identified in 172 (87.3%) of cases from which underling contusion was the most common found in 161(81.7%), followed by pneumocephalus in 96(48.7%), non-significant EDH in 16%, and SDH in 5.1% of cases.

Table 9 Imaging characteristics and clinical outcome of study participants (N=197)

		Clinical outcome based on GOS – E		
		Favorable	Favorable	Total
Radiologic findings		Count (%within group)	Count (%within group)	Count (%within group)
Skull fracture site on CT	Frontal	93 (58.1)	10 (27.0)	103 (52.3)
	Parietal	39 (24.4)	9 (24.3)	48 (24.4)
	Occipital	3 (1.9)	4 (10.8)	7 (3.6)
	Temporal	7 (4.4)	2 (5.4)	9 (4.6)
	≥ 2 sites	18 (11.3)	12 (32.4)	30 (15.2)
Crossing air sinus	NO	123 (76.9)	33 (89.2)	156 (79.2)
	Frontal	30 (18.8)	2 (5.4)	32 (16.2)
	Mastoid	3 (1.9)	0 (0.0)	3 (1.5)
	Multiple	4 (2.5)	2 (5.4)	6 (3.0)
Crossing Dural sinus	No	149 (93.1)	34 (91.9)	183 (92.9)
	Crossing SSS	10 (6.3)	3 (8.1)	13 (6.6)
	Crossing TS	1 (0.6)	0 (0.0)	1 (0.5)
Underling contusion	No	35 (21.9)	1 (2.7)	36 (18.3)
	Yes	125 (78.1)	36 (97.3)	161 (81.7)
EDH	<1.5cm/ <30cc	28 (17.5)	4 (10.8)	32 (16.2)
SDH	<1cm /MLS< 5mm	7 (4.4)	3 (8.1)	10 (5.1)

5.4. **Surgical approach**

The main surgical procedure was debridement of the devitalized scalp, contused brain with dural repair if any. The bone was replaced primarily in 159 (80.7%) of the cases and was discarded in 5 (2.5%) of cases because of severe contamination. The intraoperative dural tear was found in 119(60.4%) of cases (Table 4), which was repaired with pericranial tissue graft in 87 (73%) and primarily in 32(27%) cases.

Perioperative antibiotics were given for all patients either as prophylaxis or therapeutically. The antiepileptic drug was used for 90% of patients, as prophylaxis for 86.4% and therapeutically for (3.6%).

Table 10 Post-operative characteristics and clinical outcome of study participants (N=197)

Post-operative characteristics		Clinical outcome based on GOS – E Favorable Count (%within group)	 Favorable Count (%within group)	 Total Count (%within group)
Dural tear	No	68 (42.5)	9 (24.3)	77 (39.1)
	Yes	92 (57.5)	28 (75.7)	120 (60.9)
Early infection	No	152 (95.0)	31 (83.8)	183 (92.9)
	Yes	8 (5.0)	6 (16.2)	14 (7.1)
Late infection	No	158 (98.8)	34 (91.9)	192 (97.5)
	Yes	2 (1.3)	3 (8.1)	5 (2.5)
AED used	Not used	20 (12.5)	0 (.0)	20 (10.2)
	Used as prophylaxis	136 (85.0)	34 (91.9)	170 (86.3)
	Used as treatment	4 (2.5)	3 (8.1)	7 (3.6)
LPTS	No	159 (99.4)	34 (92.2)	193 (98)
	Yes	1 (.6)	3 (7.8)	4 (2)
GCS at discharge	≤ 14	158 (98.8)	30 (81.1)	188 (95.4)
	≥ 13	2 (1.3)	7 (18.9)	9 (4.6)
Reoperation	No	157 (98.1)	32 (86.5)	189 (95.9)
	Yes	3 (1.9)	5 (13.5)	8 (4.1)

5.5. **Postoperative morbidity and mortality**

About 19(9.5%) patients developed an infection of which 7 cases were localized brain abscess, 6 cases were superficial wound infections and meningitis in 2 cases. The sepsis of chest focus was seen in 3 (1.5%) of cases. For all patients with infection, appropriate antibiotics were used. The mortality was 0.5%, this was one of the patients with sepsis of chest focus which was uncontrolled.

The shortest hospital stay was 2 days while the longest stay was 41 days. The median hospital stay was 4.7 days. Around 188(95.4%) patients were discharged with GCS of 13 to 15 and the remaining 8 (4.1%) with GCS between 9 and 13. Posttraumatic neurologic deficit showed improvement in 95.7% of patients on follow up. The late posttraumatic seizure has occurred in 5(2.5%) of patients, which was controlled by a single AED.

Totally 8(4.1%) patients underwent reoperation (Table 4). The main indication was localized brain abscess in 7(87.5%) and postoperative CSF leak in 1(12.5%).

5.6. **Overall functional outcome and Factors Influencing the outcome**

Overall at the mean final follow up of 12.95 ± 6.86 months, 161 patients (81.2%) were in good recovery (GOSE 7 and 8), while 35 patients (17.8%) were in moderate disability (GOSE 6 and 5) and no patient was in severe disability or vegetative state.

To determine which independent factors influenced the clinical outcome, outcomes were dichotomized as favorable (GOSE 7 and 8 with complete functional independence) versus unfavorable (GOSE 6 and below with physical dependency on others) at final follow up.

Potential prognosticators were evaluated using bivariate analysis and the p-value was set at < 0.05 to say the correlation is significant. Variables with significant correlation with unfavorable outcomes were identified as shown in table 5.

Table 11 Bivariate analysis for predictors of clinical outcome in surgically treated DSF (N= 197)

Variables	P-value	COR (95% CI)
Socio-demographic variables		
Age ≥ 35 years	0.079	3.308 (0.871 - 12.562)
Residency (other than AA)	0.995	1.022 (0.483 - 2.160)
Mechanism of injury	0.045	0.442 (0.199 - 0.984)
Time delay ≥24 hours	0.828	0.922 (0.446 - 1.909)
Clinical presentation		
H/A	0.103	3.241 (0.732 - 14.343)
Vomiting	0.001	3.708 (1.645 - 8.359)
Duration of LOC	0.001	0.257 (0.116 - 0.568)
EPTS	0.508	1.495 (0.454 - 4.928)
Deep scalp laceration	0.985	1.043 (0.216 - 5.042)
Post resuscitation GCS ≤13	0.001	11.48 (3.640 - 36.213)
Motor weakness	0.001	10.46 (4.689 - 23.339)
Concomitant injury	0.021	3.119 (1.187 - 8.201)
Radiographic findings		
≥ 2 site of DSF	0.001	3.787 (1.626 - 8.816)
Involvement air sinus	0.103	0.795 (0.421 - 1.502)
EDH	0.344	0.571 (0.187 - 1.742)
SDH	0.322	1.929 (0.474 - 7.841)

SAH	0.081	4.618	(0.893 - 23.869)
Pneumocephalus	0.001	3.561	(1.616 - 7.847)
Underling contusion/ICH	0.007	10.08	(1.334 - 76.142)
Surgical approach and post OP course			
Mode of surgery (primary bone replacement)	0.319	0.567	(0.186 - 1.733)
Dural tear	0.045	2.300	(1.019 - 5.189)
Post traumatic infection	0.024	3.677	(1.192 - 11.347)
Hospital stay ≥ 3 days	0.001	6.899	(2.558 - 18.607)
GCS at discharge ≤ 13	0.003	12.34	(2.293 - 66.448)
LPTS	0.075	9.086	(0.801 - 103.017)
Re-operation	0.007	8.177	(1.860 - 35.957)

5.7. Determinates of the clinical outcome

All factors with potential correlation with unfavorable outcomes were included in multivariate analysis using a forward stepwise binary logistic regression. Of several factors analyzed as shown in table 6: occurrence of posttraumatic motor deficit (adjusted OR 13.8, 95% CI: 4.13-46.17, P=0.000), post-resuscitation GCS ≤13 (adjusted OR 10.36, 95% CI: 1.93-55.56, P=0.006), having pneumocephalus on brain CT scan (adjusted OR 12.93, 95% CI: 3.12-53.52, P=0.000), prolonged hospital stay for > 3 days (adjusted OR 4.39, 95% CI: 1.18-16.3, P=0.027) and reoperation (adjusted OR 6.92, 95% CI: 1.091- 43.97, P=0.04) were found to be significant independent predictors of unfavorable outcome after surgery for DSF (Table 6).

Table 12 Multivariate analysis for predictors of clinical outcome in surgically treated DSF (N= 197)

						95% C. I for AOR	
Independent Predictors	B	S.E.	Wald	Sig.	AOR	Lower	Upper
Motor weakness	2.401	.665	13.030	.000	11.030	2.996	40.613
Pneumocephalus	2.560	.725	12.477	.000	12.933	3.125	53.521
GCS ≤ 13	2.338	.857	7.446	.006	10.361	1.932	55.560
Hospital stay ≥ 3 days	1.480	.669	4.888	.027	4.392	1.183	16.306
Re operation	1.936	.943	4.214	.040	6.928	1.091	43.978

6. Discussion

In this multicenter study involving 197 surgically treated DSF, the long term outcome of surgically treated DSF patients was favorable in 81.2% and unfavorable in 18.8% of patients. A comparable proportion of outcome was also reported in other studies(10,20,22): Venkati et al and Manne et al found similar findings (84.7% Vs 14.3%), Satardey et al (80% Vs 20%). Satadey et al also found neither severe disability nor a vegetative state in their series; the same was true in our study. What factors affect the outcome and which factors are independent predictors of the outcome are not known with certainty. In the current study, we identified more than ten factors that have a significant correlation with the outcome variables in univariate analysis using p-value < 0.05 for significance (Table 5). After multiple regressions, five of the factors were found to be independent predictors of unfavorable outcome in our study population (Table 6). To compare the findings of our study with available shreds of evidence:

6.1. Socio-demographic factors

In our study, more than 80% were in the age group between 15 to 35 years. The dominance of this group in DSF was also reported by Manne et al as 59% of patients were in the age group of 20 to 40 years and Salia et al report 90 % of patients were < 45 years(9,10). Similar to the finding from Manne et al, in the present study, there was no significant correlation between age and outcome. This is maybe due to the small number of older age groups in both studies. On the other hand, another study reported worse outcomes with increasing age(16).

Female patients were only 4.1% with male to female ratio of 23:1. The proportions of male patients were much higher in our study than Al-Hadad SA and Prakash et al which was 9:1 and 6.94:1 ratio respectively. The low proportions of female patients may be explained by the fact that females are less likely to engage in fights and brawls and are few in construction industries (14,17). There was no significant association between gender and outcome in Manne et al studies(10). Because of the small member of female participants, it is difficult to do an association based on gender in our study.

In the current study, the most common mechanism of injury was an alleged assault by stone or stick in 79.9% of cases. The second most common cause was RTA (9.1%), followed by construction site related injuries (3%). Assault and RTA were also the most common mode of injuries in Prakash et al, Houssain et al, and Salia et al studies(9,11,14). However other studies reported RTA as the most common mechanism of injury(7,22), while Satardey et al found a railway accident as the most common mode of injury(20). In our study, violence-related injuries were significantly associated with the unfavorable outcome when compared to non-violence related injures (p < 0.045, COR= 2.26, 95% CI: 1.017-5.036). Similar associations were also reported by Adrian Kelly et al and Manne et al(3,10). Despite the correlation, violence-related injuries were not independent predictors of an unfavorable outcome.

6.2. Clinical presentation

In our study, post-resuscitation GCS is found to be a significant predictor of the outcome. Patients presenting with GCS of >13 constitute 97% of patients in the favorable outcome group.

Post resuscitation GCS ≤ 13 at presentation were independent predictor of unfavorable outcome after multiple regressions ($p < 0.04$, AOR= 6.063, 95% CI: 1.062-34.615). In studies by Hossain et al and Venkati et al, low GCS scores both at admission and discharge were significantly correlated with unfavorable outcomes(11,22).

The median time between the trauma and intervention was 72 hours, with a minimum of 6 hours and a maximum of 90 days. This is higher compared to the meantime in the study by Irshad M et al and Satardey et al which was 6.7 hours and 5 hours respectively(12,20). Even though the median time to neurosurgical intervention is longer, we found no significant association between the time delay and the outcome.

Bleeding from the wound and ENT (94.4%), headache (86.3%), vomiting (51%), and loss of consciousness (LOC) (78.2%) were the most common presenting symptoms, which is per other studies. In univariate analysis, there was a significant correlation between the duration of LOC ≥ 30 minutes and vomiting with an unfavorable outcome. However, both factors were not significant predictors after multivariate analysis. Early post-traumatic seizure and CSF leak were noted in 8.1% and 6.6% of cases respectively, we found no significant association between these factors and the outcome.

In our study, motor disability was a strong independent predictor of an unfavorable outcome, which was identified in 17% of patients. Similar findings were also reported by Salia et al and Saiful et al, both studies found a motor weakness in 16.4% and 30% of patients in their series respectively(9,23). In our study, patients with motor disabilities were more likely to develop an unfavorable outcome when compared to those without motor weakness ($p < 0.001$, AOR= 11.03, 95% CI: 2.99-40.61). One of the concerning impact of motor weakness (inability to regain motor function) is ineffectiveness in labor-intensive works, which is the primary source of income in most of our patient population. As far as the author's knowledge, there is no data on the association between focal neurologic deficit and clinical outcome after surgical treatment for DSF. There is also a paucity of data on the impact of motor disability on the functional outcome of patients with traumatic brain injury(24). Based on our findings, posttraumatic motor weakness was found to be a major determinant of the functional outcome after surgical treatment of DSF. This also implies the necessity of intensive rehabilitation as part of the treatment to improve functional recovery.

6.3. Site of fracture and associated CT scan findings

In our study frontal bone was the most common site of fracture involved in 52.3%, followed by parietal bone fracture (24.4%). Frontal bone was also the most common site of fracture in the series of Yadav et al (59% frontal and 20.6% parietal) and Lee et al (55% frontal and 28% parietal)(10,22). On the other hand, Satardey et al, Salia et al, and others found the Parietal bone as the most common site of fracture. In our study frontal bone fracture was associated with a favorable outcome when compared to other sites. In his findings, Salia et al reported ≥ two site fractures in 39.4%, which is true in 30% of our cases. The involvement of two or more bone was significantly associated with unfavorable outcomes ($p < 0.02$) in our study, comparable to Satardey et al findings(9,20). However, there was no significant correlation between the fracture site and the involvement of multiple sites with the outcome in the Yadav et al report(22). The fracture was compound in the majority of our patients 92.4%, which is also true in other studies (Prakash et al (89%), Nikita G (68%), and Ali et al (78.5%))(7,10,14). There was no significant association between the type of fracture and the outcome.

In the current study, the most common associated CT scan findings at presentation were underlying brain contusion (81.7%), pneumocephalus (48.7%), EDH (16.2), and SDH (5.1%). In univariate analysis, we found significant correlations between the presence of both underlying contusions ($p< 0.007$) and pneumocephalus ($p< 0.005$) with unfavorable outcomes. The presence of underlying contusion and its correlation with unfavorable outcome was also reported by Adrian Kelly et al. and Satardey et al. On the other hand, Manne et al and Yadav et al found no significant association between the presence of pneumocephalus and outcome in DSF(3,10,20,22). On contrary, our analysis showed that pneumocephalus not only correlated with the outcome but also was found to be one of the statistically significant independent predictors of unfavorable outcomes in multivariate analysis ($p < 0.001$, AOR= 12.93, 95 % CI: 3.12-53.52). The presence of pneumocephalus may signify the severity of the injury in patients with DSF. We found no significant correlation between EDH and SDH with outcome variables.

Additionally, both walls of the frontal air sinus were fractured in 17.7% of cases, for which frontal sinus cranialization was done. There was no significant association between frontal sinus involvement and the functional outcome in our study.

6.4. Surgical approach

The main surgical approach in all study areas was debridement of devitalized tissues (contused brain or scalp), the elevation of depressed bone segments, and replacement of the bone primarily in not grossly contaminated. The primary replacement of the bone was done in 80.7% of cases. In 5 (2.5%) patients, the bone was discarded due to severe infection. Prakash et al also replaced the bone primarily in 88.8% of patients and discarded in 10.1% for the same reason as ours (severe infection). The same study also found no increase in the rate of infection or worse outcome with the primary replacement of the bone(14). In the present study also, no significant association was found between our surgical approach and outcome.

Intraoperative torn dura was found in 60.4% of our cases, it was also reported as torn in 49.3% and 55.5% in series of Al-Hadad et al and Salia et al respectively(9,17). A significant association with unfavorable outcomes was found by Satardey et al and in our study ($p < 0.05$). In the recent study by Venkati et al, no association was found between dural tear and functional outcome(22). In the multivariate analysis in our study, the association between dural tear and the outcome variable was not significant as an independent predictor.

6.5. Post-operative course

In our study, all patients were given perioperative intravenous antibiotics either as prophylaxis or therapeutically depending on the level of contamination. The overall infection rate was 9.2% in our patients which is comparable with the infection rate reported by Al- Hadad et al in 8.2%, but higher than the rate reported by Adrian Kelly et al in 2.4% of patients(3,17). For all patients who developed an infection appropriate duration of antibiotics was used. We also noted that the development of infection has a significant association with the unfavorable outcome with $p < 0.05$, but it was not a significant independent predictor of the outcome in multiple regressions.

For the majority (90.8%) of our patients' antiepileptic drugs were used either as prophylaxis (86.3%) or as treatment (3.6%). It was used as prophylaxis for patients with underlying contusion or for patients who have an early onset posttraumatic seizure and it was continued as a treatment for patients with late posttraumatic seizures after seven days. In our study population, the rate of early posttraumatic seizure was 8.1% and late posttraumatic seizure (LPTS) was found in only 2 % of cases. Similarly, Hossein et al used prophylactic AED for all their patients and they found no seizure at the 18th-month follow-up(11). On contrary, in the Al- Hadad series the rate of early post-traumatic seizure was 12.3%. In the same study, the rate of late post-traumatic seizures was 6.9% without prophylactic AED(17). In other studies that did not use prophylactic AED, the rate of LPTS was quoted from 7% to 15%. It is possible to put a conclusion based on the finding from our study and Hossain et al that the use of prophylactic AED can efficiently reduce the rate of LPTS.

The median length of hospital stay was 4.1 ± 3.8 days with the most common length of hospital stay was 3 days, which is lower than the report by Adrian Kelly et al(3). In our study length of hospital stay is an independent predictor of an unfavorable outcome, patients who stayed in the hospital for more than 3 days are more likely to develop unfavorable outcome when compared to who stayed for less than 3 days ($p< 0.006$, AOR = 10.36, 95% CI: 1.93-55.5).

In this study the rate of reoperation was 4.1%, however, we did not find another study regarding the rate of reoperation or its impact on the functional outcome of patients with DSF. The main indications for reoperation in our cases were a localized brain abscess and persistent postoperative CSF leak. Reoperation is also found to be an independent predictor of unfavorable outcome ($p<0.04$, AOR= 6.92 95% CI: 1.09-43.978).

7. Limitations and strengths

The major limitations of our study could be the retrieval of some of the data from the trauma registry which was collected prospectively and due to COVID -19 global pandemic, the follow-up of some patients was by phone call. Apart from these, our study was done prospectively with a relatively large number of sample size (n=197) from which the result can be generalizable.

To the best of our knowledge, the current study is the first to identify the independent predictors of the clinical outcome in surgically treated patients with DSF. Moreover, the present study is the first to analyze the outcome of surgical treatment for DSF in Ethiopia; hence the result of our study could be the major input for the development of management guidelines.

8. Conclusions

Our study comprised of 197 cases of DSF treated with surgery. The majority of patients showed good functional recovery. The use of prophylactic AED significantly reduced early post-traumatic seizures. Even though the mortality is very low in our study, patients with moderate disabilities are high compared to studies from other countries.

Motor weakness was the major determinant of functionality in our study. Patients presented with low GCS and having pneumocephalus on imaging were more likely to have an unfavorable outcome. Additionally, staying in the hospital for ≥ 3 days and undergoing reoperation were also reduces the likelihood of good functional recovery.

Since our study is the first to analyze the outcome of surgery for DSF in Ethiopia, the findings may help for prognostication as well as for the development of management guidelines.

9. Recommendations

Appropriate use of preoperative antibiotics and prophylactic AED should be continued. Attention should be given to meticulous surgery to reduce post-operative CSF leak, deep brain infections and the subsequent reoperations.

Hospitals, the ministry of health, and other stalk holders should work to improve pre-hospital care and rehabilitation centers in order to improve the functional recovery of the patients with disabilities.

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NB: Zotero was used for referencing by Vancouver style

Annex I: Questionnaire

Questionnaire

This is multicenter, prospective observational study on the analysis **Surgical Outcome in Depressed Skull Fracture and its Determinants**. Knowing this basic information is helpful to develop protocols for the management of patients with DSF and improve care of patients with head injury in general. Your participation is very helpful to this study. Thank you for participating!

1. Socio demographics

Name______________________ Card no. __________ Phone No.______________/__________

1.1 Age_____ 1.2 Sex 1. Male __ 2. Female

1.3 Marital Status: 0. single 1. Married 2. Divorced 3. Widowed

1.4 Occupation: 1. Farmer 2. Daily laborer 3. Student 4. Gov't Employee 5. Unemployed If other, please specify_____________

1.5 Location in kms 1.Addis Abeba 2. Outside, Adis Abeba ____________

1.6 Educational status 1. Illiterate 2. Primary 3. Secondary 4. Tertiary 5. Other,specify

2. Mechanism of injury

1. Violence related:-1.1. Stick injury 1.2. Stone injury 1.3 Metallic injury 1.4 If others, please specify______________

2. Road traffic accident: 1.1. Pedestrian 1.2. Passenger in a car 1.3. Passenger in a Bajaj 1.4. If others, please specify:_____________

3. Work site related injury: 3.1. Fall from a construction site 3.2. Hit by a construction equipment 3.3 if other, please specify: ________

4. Falling down accident: 1. Fall from a height 2. Fall from a standing height 3.fall from tree 4. Animal related injuries goring pushed fall

5. Sports injury

6. Other mechanism: Specify, ______________________

3. Time from trauma to surgical intervention in hours _______________________

4. Clinical findings at presentation

A. Chief complaint

1. Headache 2.vomiting 3.Loss of consciousness 4.Siezure 5.Scalp Laceration
6. Focal neurologic deficit 7.Others, _____________

B. CSF leak: 1. No 2. Yes if yes,,,,, 2.1.From wound site 2.2. from ENT
C. Bleeding: 1. No 2. Yes if yes,,,,, 2.1.From wound site 2.2.From ENT
D. Loss of consciousness: 1.NO 2. Yes if yes 2.1 for < 5 min 2.2 for 5-30 min 2.3 for > 30 min
E. Posttraumatic seizure 1. No 2. Focal 3. Generalized 4. Status epilepticus
F. Scalp laceration 1.No 2. Clean 3. Contaminated
G. GCS = (---/15) M=____ V=____E=____
H. Pupil anisocoria 1. Yes 2. No
I. Motor deficit 1. Yes 2. No

5. Concomitant injury: 1.No 2. Chest injury 3. abdominopelvic injury 4.Long bone fracture 5. other ______

6. What was the initial image 1. Skull X ray 2. Head CT 3. Brain MRI

7. Site of Skull fractures 1.Frontal 2.Parietal 3.Occipital 4.Temporal 5.Multiple specify…….

8. Side of fracture: - 1.Right 2.Left 3.Both

9. Depth of depression: 1. < 5 mm 2. 5mm-10 mm 3. > 10mm / Outer table below the inner table

10. Extend to Base of skull: 0. No 1. Yes

11. Crossing dural sinus: 0. No 1. Cross Sagittal 2. Cross Transverse 3. Cross Sigmoid

12. EDH 0. No 1. Thickness < 1.5cm / volume < 30cc 2. Thickness >/= 1.5cm / volume >/=30cc

13. SDH 0. No 1. Thickness < 1cm / MLS < 5mm 2. Thickness >/= 1cm/ MLS >/=5mm

14. Subarachnoid hemorrhage 0. No 1. Yes

15. Intraventricular hemorrhage 0. No 1. Yes

16. Pneumocephalus 0. No 1. Yes

17. Underlying Brain contusion/ICH 0. No 1. Yes

18 .Place of admission- 1. Ward 2. ICU

19. Treatment modality- 1. Conservative 2. Surgery

<u>If Surgical treatment</u>

20. What surgical treatments used:

1. Debridement of devitalized tissues and elevation of the bone with primary replacement of the bone

2. Debridement of devitalized tissues and elevation of the bone with discarding the bone for future cranioplasty

3. Debridement of devitalized tissues and elevation of the bone with cranalization of the paranasal sinus

21. Intraoperative findings

A. Dural tear 0. No 1. Yes , If yes How it was repaired 1. Done primarily 2. Done with duraplasty 3.Not possible just carpeted

B. sign of infection 0.No 1.Yes

C. Foreign body 0.No 1.Yes

22. Pre- operative antibiotics used 0.No 1.yes prophylactic 2. Yes therapeutic , if yes what antibiotics used 1. Ceftriaxone 2. Cefazolin 3. Combined 4 other, specify ……….

23. Anti-epileptics used 0.No 1.yes prophylactic 2. Yes therapeutic , if yes what AED used 1. Phenytoin 2. Valporate 3. Carbamazepine 4. Combined 5. Other specify…..

24. Early post-operative complications

A. SSI 0. No 1. Yes

B. Meningitis 0. No 1. Yes

C. Brain Abscess 0. No 1. Yes

D. Seizures 0. No 1. Yes

25. Total days of hospital stay………..

26. Early complications

A. Late post traumatic seizure 0. No 1. Yes If yes 1. Controlled 2. Uncontrolled

B. Late infection 0. No 1. Yes

C. Re operation 0. No 1. Yes

27. EGOS at 3rd months

1. Death
2. Vegetative state
3. Lower severe disability
4. Upper severe disability

5. Lower moderate disability

6. Upper moderate disability

7. Lower good recovery

8. Upper good recovery

Annex II: Extended GOS

Glasgow Outcome Scale - Extended

Patient's name: ___________________________________ Date of interview: ___________

Respondent: Patient alone ___ Relative/ friend/ carer alone __ Patient + relative/ friend/ carer___

Interviewer: ______________________________

CONSCIOUSNESS

1. Is the head injured person able to obey simple commands, or say any words? 1 = No (VS) 2 = Yes

Anyone who shows ability to obey even simple commands, or utter any word or communicate specifically in any other way is no longer considered to be in the vegetative state. Eye movements are not reliable evidence of meaningful responsiveness. Corroborate with nursing staff. Confirmation of VS requires full assessment as in the Royal College of Physician Guidelines.

INDEPENDENCE IN THE HOME

2a.Is the assistance of another person at home essential every day for some activities of daily living? 1 = No 2 = Yes

If "No" go to question 3a.

For a 'No' answer they should be able to look after themselves at home for 24 hours if necessary, though they need not actually look after themselves. Independence includes the ability to plan for and carry out the following activities: getting washed, putting on clean clothes without prompting, preparing food for themselves, dealing with callers, and handling minor domestic crises. The person should be able to carry out activities without needing prompting or reminding, and should be capable of being left alone overnight.

2b.Do they need frequent help or someone to be around at home most of the time?

1 = No (Upper SD) 2 = Yes (Lower SD)

For a 'No' answer they should be able to look after themselves at home for up to 8 hours during the day if necessary, though they need not actually look after themselves.

2c.Was assistance at home essential before the injury? 1 = No 2 = Yes

INDEPENDENCE OUTSIDE THE HOME

3a.Are they able to shop without assistance? 1 = No (Upper SD) 2 = Yes

This includes being able to plan what to buy, take care of money themselves, and behave appropriately in public. They need not normally shop, but must be able to do so.

3b.Were they able to shop without assistance before the injury? 1 = No 2 = Yes

4a.Are they able to travel locally without assistance? 1 = No (Upper SD) 2 = Yes

They may drive or use public transport to get around. Ability to use a taxi is sufficient, provided the person can phone for it themselves and instruct the driver.

4b.Were they able to travel without assistance before the injury? 1 = No 2 = Yes

WORK

5a.Are they currently able to work to their previous capacity? 1 = No 2 = Yes

If they were working before, then their current capacity for work should be at the same level. If they were seeking work before, then the injury should not have adversely affected their chances of obtaining work or the level of work for which they are eligible. If the patient was a student before injury then their capacity for study should not have been adversely affected.

5b.How restricted are they?

a) Reduced work capacity. 1 = a (Upper MD) b) Able to work only in a sheltered workshop or non-competitive job, or currently unable to work. 2 = b (Lower MD)

5c.Were they either working or seeking employment before the injury (answer 'yes') or were they doing neither (answer 'no')? 1 = No 2 = Yes

SOCIAL & LEISURE ACTIVITIES

6a. Are they able to resume regular social and leisure activities outside home? 1 = No

2 = Yes

They need not have resumed all their previous leisure activities, but should not be prevented by physical or mental impairment. If they have stopped the majority of activities because of loss of interest or motivation then this is also considered a disability.

6b.What is the extent of restriction on their social and leisure activities?

a) Participate a bit less: at least half as often as before injury. 1 = a (Lower GR)

b) Participate much less: less than half as often.

c) Unable to participate: rarely, if ever, take part.

2 = b (Upper MD)

3 = c (Lower MD)

6c.Did they engage in regular social and leisure activities outside home before the injury?

1 = No 2 = Yes

FAMILY & FRIENDSHIPS

7a.Have there been psychological problems which have resulted in ongoing family disruption or disruption to friendships?   1 = No   2 = Yes

Typical post-traumatic personality changes: quick temper, irritability, anxiety, insensitivity to others, mood swings, depression, and unreasonable or childish behavior.

7b.What has been the extent of disruption or strain?

a) Occasional - less than weekly 1 = a (Lower GR)

b) Frequent - once a week or more, but tolerable.

c) Constant - daily and intolerable.

2 = b (Upper MD)   3 = c (Lower MD)

7c.Were there problems with family or friends before the injury?   1 = No   2 = Yes

If there were some problems before injury, but these have become markedly worse since injury then answer ‘No’ to Q7c.

RETURN TO NORMAL LIFE

8a Are there any other current problems relating to the injury which affect daily life?

1 = No (Upper GR)   2 = Yes (Lower GR)

Other typical problems reported after head injury: headaches, dizziness, tiredness, and sensitivity to noise or light, slowness, memory failures, and concentration problems.

8b.Were similar problems present before the injury?   1 = No   2 = Yes

If there were some problems before injury, but these have become markedly worse since in jury then answer ‘No’ to Q8b.

Scoring: The patient’s overall rating is based on the lowest outcome category indicated on the scale.

1. Dead

2. Vegetative State (VS)

3. Lower Severe Disability (Lower SD)

4. Upper Severe Disability (Upper SD)

5. Lower Moderate Disability (Lower MD)

6. Upper Moderate Disability (Upper MD)

7. Lower Good Recovery (Lower GR)

8. Upper Good Recovery (Upper GR)