Cross-sectional Study

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Magnitude of dural tear and its associated factors among patients with depressed skull fracture

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Introduction: Trauma is a huge problem seen in developed countries as well as developing countries. Head injury is a major factor responsible for mortality in young populations. Up to 6% of all head injuries and 11% of severe head traumas might result in a depressed skull fracture (DSF), a catastrophic injury. The aim of this study was to determine the prevalence of dural tear and to identify its predictors.

Method: A retrospective review of medical records of all patients operated on for DSFs at the University Comprehensive Specialized Hospital from 1 January 2021 to 1 January 2023 G.C. (Gregorian calendar) was conducted. A total of 163 patients were included in the study.

Results: A total of 163 patients [136 men (83.4%) and 27 women (16.6%)] had a mean age of 23.9 with a standard deviation of 14.8 (range from 3 to 65). Patients with penetrating injuries (missiles, axes) were excluded. The majority, 153 (93.9%) of the patients, were younger than 50 years of age. Physical assault accounted for 102 (62.5%) of the cases. Of the assaulted cases, 62 (38%) were assaulted by stone, 32 (19.6%) by stick, and 8 (5%) by other objects (beer bottle and shovel). Bleeding from the trauma site in 124 (76.1%), headache in 76 (46.6%), loss of consciousness in 75 (46%), and vomiting in 72 (44.2%) were the most common presentations. Based on the Glasgow Coma Scale (GCS), 123 (75%) patients had mild head injuries. Based on the site of fracture, frontal depressions are the most common (61, 37.4%), followed by parietal depressions (53, 32.5%). With regard to the associated injuries, brain contusion was seen in 52 (32%), epidural hematoma (EDH) in 26 (16%), subdural hematoma in 3 (1.8%), and intraventricular hemorrhage/subarachnoid hemorrhage (IVH/SAH) in 3 (1.8%). The median duration of presentation was 15 h, with an interquartile range (IQR) of 8–24 (1–96 h). From the multivariable logistic regression, brain contusion and EDH were significantly associated with dural tear.

Conclusion: The rules of our culture are reflected in the higher incidence of accidents and fractures among men. Physical assault, particularly with stones, was the most common cause of DSFs. Frontal depressions were the most common site of fracture, followed by parietal fractures. Brain contusion and EDH were significantly associated with dural tears. School-aged children are more vulnerable to injuries from horse or donkey kicks and falls.

Keywords: depressed, dural tear, factors, fracture, skull

Introduction

Traumatic brain injury (TBI) is a brain injury that develops as a result of an external mechanical impact and may be accompanied by loss of consciousness or altered mentation. One of the main factors contributing to morbidity and mortality is TBI[1]. Global fatality rates following head injuries range from 91 to 546 per 100 000 people. One-quarter to one-third of all accidental deaths are caused by brain injuries, which are on the rise in emerging nations[2-4]. Depressed skull fractures (DSFs) are a common type of TBI, resulting from significant forces applied to the skull, causing displacement or indentation of the bone. These fractures can be associated with complications such as dural tears, which refer to a breach in the dura mater, the outermost membrane covering the brain[5,6].

HIGHLIGHTS

- Trauma is a huge problem seen in the developed countries as well as developing countries.
- Traumatic brain injury (TBI) is a brain injury that develops over time as a result of an external mechanical impact and may be accompanied by sensory loss or modification.
- Depressed skull fracture (DSF) develops when the amount of bone displacement exceeds the whole thickness of the neighboring calvarium.

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DSF, which typically results from forceful trauma, develops when the amount of bone displacement exceeds the whole thickness of the neighboring calvarium. Fractures that also have a scalp laceration and galea disruption are known as compound DSF[7]. Different studies have reported male gender predominance over the female gender in patients with compound depressed skull fracture[8]. Elevating the depressed fragment, removing the hematoma, cleaning the wound, and repairing the dura and dural venous sinuses are all surgical procedures. To avoid consequences including infection, seizures, the progression of neurological deficiency, and post-traumatic hydrocephalus, DSF should be appropriately and promptly treated[9]. Dural tears pose a risk of infection, cerebrospinal fluid (CSF) leak, and neurological complications. Recognizing predictors of dural tear in DSF patients is crucial for appropriate management and reducing potential complications[7,10].

The aim of our study was to identify the etiological factors of DSF, the prevalence of dural tear and its predictors, and surgical management and treatment outcomes in patients operated on for DSF due to blunt head trauma. Penetrating head injuries secondary to bullet and axe injuries were excluded.

Methods and materials

Study design, setting, and population

A retrospective review of medical records of all patients operated for DSF from 1 January 2021 to 1 January 2023 G.C. (Gregorian calendar) was conducted. According to the 2015 report of the central statistical agency of the country, the city has a population of 323 900[11]. The city has one public comprehensive specialized hospital, which is one of the oldest teaching hospitals in the country and provides health services for more than 7 million people in the city and surrounding catchment areas[12].

This work has been reported in line with the Strengthening The Reporting of Cohort, Cross-sectional and Case–control Studies in Surgery (STROCSS) criteria[13].

Data collection

The clinical data were collected using a data extraction sheet from the patient's medical charts. Data on sociodemographic characteristics, mechanism of injury, clinical conditions at presentation, intraoperative findings and complications, and patient outcome were gathered.

Ethical approval

An ethical clearance was obtained from the Ethics Review Committee of the School of Medicine, College of Medicine and Health Sciences, with reference number SBMLS/648/2023.

Data processing and analysis

The data were checked for inconsistencies, coding error, completeness, clarity, and missing values before they were entered. The data were entered using EPI DATA 3.1 version and exported to the IBM SPSS Statistics 25 statistical software for further data cleaning and statistical analysis. Descriptive statistical analyses such as frequency, percentage, cross-tabulation, mean, standard deviation, median, and interquartile range (IQR) were performed. The mean surface area of the depression was compared using independent *t*-test. Univariate and multivariate analyses were used to establish predictors of dural tear.

Results

A total of 163 patients [136 males (83.4%) and 27 females (16.6%)] with a mean age of 23.9 and a standard deviation of 14.8 (range from 3 to 65) were studied. Patients with penetrating injuries (missiles, axes) were excluded. The majority, 153 (93.9%) of the patients, were younger than 50 years of age. Physical assault accounted for 102 (62.5%) of the cases. Of the assaulted cases, 62 (38%) were assaulted by stones, 32 (19.6%) by sticks, and 8 (5%) by other objects (beer bottles and shovels) (Tables 1 and 2). Bleeding from the trauma site in 124 (76.1%), headache in 76 (46.6%), loss of consciousness in 75 (46%), and vomiting in 72 (44.2%) were the most common presentations (Table 3).

Based on the Glasgow Coma Scale (GCS), 123 (75%) patients had a mild head injury. Based on the site of the fracture, frontal depressions are the most common (61, 37.4%), followed by parietal 53 (32.5%). With regard to the associated injuries, brain contusion was seen in 52 (32%), epidural hematoma (EDH) in 26 (16%), subdural hematoma (SDH) in 3 (1.8%), and intraventricular hemorrhage/subarachnoid hemorrhage (IVH/SAH) in 3 (1.8%) (Table 4). The median duration of the presentation was 15 h, with an IQR of 8–24 (1–96 h). All patients were operated on (elevation of the depressed segment and repair of the dural tear, if any) by a neurosurgeon and senior general surgery residents. At surgery, a dural tear was found in 71 (55.5%) patients, whereas 57 (44.5%) had intact dura. The independent sample *t*-test showed a statistically significant difference ($t = 4.059$, df = 126, $N = 163$, $P < 0.001$) in the mean surface area of depression in the two groups. Subsequently, univariate and bivariate analyses were done, and variables with a *P*-value of less than 0.2 in the univariate analysis were selected for binary logistic regression. Those variables with a *P*-value greater than 0.2 were excluded from further analysis.

Table 1

Sociodemographic characteristics and mechanism of injury of patients operated for depressed skull fracture ($n = 163$).

Sociodemographic characteristics		Frequency ($n = 163$)	Percentage
Age	≤10	34	20.8
	11–20	41	25.1
	21–30	49	30.06
	31–40	16	9.8
	41–50	13	7.9
	≥51	10	6.13
Sex	Male	136	83.4
	Female	27	16.6
Residence	Urban	52	31.9
	Rural	111	68.1
Mechanism of injury	Assault by stone	62	38
	Assault by stick	32	19.6
	RTA	18	11
	Fall down	24	14.7
	Horse/donkey kick	19	11.7
	Assault by beer bottle	3	1.8
	Other	5	3.1
Type of fracture	Closed	44	27
	Compound	119	73

Table 2

Etiologic classification in pediatric and adult patients.

Mechanism of injury	Pediatric patients (below the age of 18)	Adults (>18)	Total
Assault by stone	12	50	62
Assault by stick	6	26	32
Road traffic accident	7	11	18
Fall-down accident	19	4	24
Horse/donkey kick	19	0	19
Beer bottle	1	2	3
Others (shovel, etc.)	1	4	5

RTA, road traffic accident.

From the multivariable logistic regression, brain contusion and EDH were significantly associated with dural tears. The odds of having a dural tear were 8.8 times higher in patients with brain contusion when compared to patients without contusion [adjusted odds ratio (AOR) = 8.8; 95% CI: 2.183–35.64]. Patients who had a DSF with EDH had a 13 times higher risk of having dural tears than those without EDH (AOR = 13.42; 95% CI: 1.26–142.8). However, patients with closed DSFs had a lower risk of having dural tears compared with compound fractures (AOR = 0.016; 95% CI: 0.001–0.222). In addition, parietal fractures had a lower risk of having dural tears compared with other sites of fractures (AOR: 0.113; 95% CI: 0.018–0.72) (Tables 5, 6, and 7).

Discussion

Trauma is a huge problem seen in developed countries as well as developing countries. Head injury is a major factor responsible for mortality in the young population[14]. Up to 6% of all head injuries and 11% of severe head traumas might result in a DSF, a catastrophic injury. Most DSFs (68–86%) are complex, and a large fraction of these (10–52%) have dural tears, which are strongly associated with cranial infections[6]. DSF, a type of cranial fracture that typically results from forceful trauma, develops when the amount of bone displacement exceeds the whole thickness of the neighboring calvarium. Fractures with an adjacent scalp laceration and galea disruption are known as compound DSF. Conventionally, unless paired with concurrent localized lesions, such as contusions and hematomas, closed (nonmissile) linear cranial fractures are regarded as nonoperative lesions[7]. One study proposed and implemented a strain-rate-dependent material model for cranial bone in subject-specific finite element (FE) head models to accurately predict skull fractures in real-world fall accidents, and the FE models successfully predicted the occurrence and extent of skull fractures in all cases,

Table 3

Clinical presentation of the patients operated for depressed skull fracture (*n* = 163).

Clinical presentation	Frequency (*n* = 163)	Percentage
Bleeding from the wound site	124	76.1
Headache	76	46.6
Loss of consciousness	75	46
Vomiting	72	44.2
Language deficit	20	12.3
Seizure	17	10.4
Focal neurologic deficit	16	9.8
Other signs or symptoms (ear/nose discharge, confusion, etc.)	5	3.1
ENT bleeding	5	3.1

ENT, ear nose throat.

Table 4

Site of depressed fractures and frequencies of associated injuries in patients operated for depressed skull fracture (*n* = 163).

Anatomic site	Frequency (*n* = 163)	Percentage
Frontal	61	37.4
Parietal	53	32.5
Temporal	11	6.7
Occipital	4	2.4
Two or more bones were involved	34	20.8
Associated injuries		
Brain contusion	52	31.9
Brain necrosis	22	13.5
EDH	26	16
SDH	3	1.8
SAH/IVH	3	1.8

EDH, epidural hematoma; IVH, intraventricular hemorrhage; SAH, subarachnoid hemorrhage; SDH, subdural hematoma.

Table 5

Univariate analysis with cross-tabulation for predictors of dural tear in patients operated for depressed skull fracture (*n* = 163).

Variables	Categories	DSF Yes	DSF No	Total	*P*
Sex	Male	78	58	136	
	Female	12	15	27	0.22
Residence	Urban	26	26	52	
	Rural	64	47	151	0.353
Mechanism of injury	Assault by stone	32	30	62	0.357
	Assault by stick	20	12	32	
	RTA	8	10	18	
	Fall down	9	15	24	
	Donkey/horse kick	17	2	19	
	Others	4	4	8	
Clinical presentations					
Headache		41	35	76	0.55
Seizure		12	5	17	0.18
Focal neurologic deficit		10	6	16	0.54
Loss of consciousness		46	29	75	0.416
Vomiting		44	28	72	0.18
ENT bleeding		4	1	5	0.26
Language deficit		12	8	20	0.648
Bleeding from the wound site		74	50	124	0.04
Anatomic location of the fracture					
Frontal		39	22	61	0.38
Parietal		18	35	53	
Temporal		8	3	11	
Two or more bones involved		25	13	38	
Associated intracranial pathologies					
Brain contusion		43	9	52	0.000
Epidural hematoma		21	1	22	0.00
Subdural hematoma		17	9	26	0.258
SAH/IVH		2	1	3	0.689

Table 6

Binary logistic regression for the predictors of dural tear in patients with depressed skull fracture (n = 163).

Binary logistic regression						
					95% CI for OR	
Predictors	*B*	Wald	P	OR	Upper	Lower
Closed fracture	– 4.14	9.498	0.002	0.016	0.001	0.222
Parietal fracture	– 2.182	5.326	0.021	0.113	0.018	0.720
Brain contusion	2.177	9.339	0.002	8.823	2.183	35.649
Epidural hematoma	2.596	4.63	0.031	13.416	1.26	142.800

CI, confidence interval; OR, odds ratio.

with comparable fracture patterns to those observed in computed tomography (CT) scans and autopsy reports. Subject-specific head models and personalized human body models derived from accident reconstructions can contribute to the understanding of head injury mechanics and aid in injury prevention strategies[15].

Intracranial injuries are frequently accompanied by DSFs. These can vary based on the type and extent of the damage. Extradural hematoma (33.3%), contusions (31.25%), dural rupture (47.92%), and indriven bone fragments (14.58%) were the related cerebral pathologies[16,17]. In our study, among the associated injuries, dural tears occur in 55%, contusions in 31.9%, EDH in 16%, and SDH in 1.8%. Head injury with DSF is common in the frontal region and often presents with EDH. This is because many adult men were injured in road accidents[16]. Our study also showed that frontal DSF occurred in 37.4% of the patients who were operated on. However, unlike the other studies, the mechanism of injury was assault by a stone, stick, or fall.

Majority of our patients were children and young adults as well. The possible reasons for this include: First, thin skull bones: in children and adolescents, the bones of the skull are thinner compared to adults. This makes their skulls more susceptible to fracturing when faced with trauma[18]. Second, higher activity levels: children and adolescents are generally more active and engage in various physical activities, including sports and play. These activities increase the risk of falls, collisions, and accidents, which can lead to skull fractures[19]. Third, higher risk-taking behavior: adolescents often engage in risky behavior and experiment with new activities or sports. This can increase the likelihood of accidents and traumatic injuries, including skull fractures. Lack of protective instinct: young children may not have a fully developed protective instinct, making them more prone to accidents. They may not be able to recognize potential dangers or adequately protect themselves from traumatic events[20,21].

Table 7

Complications associated with depressed skull fracture.

Complications	Frequency (n=163)	Percentage
Wound infection	10	6.1
Meningitis	4	2.5
Brain abscess	2	1.2
Osteomyelitis	2	1.2
PTSD	2	1.2
Electrolyte disturbance (hypocalcemia)	1	0.6

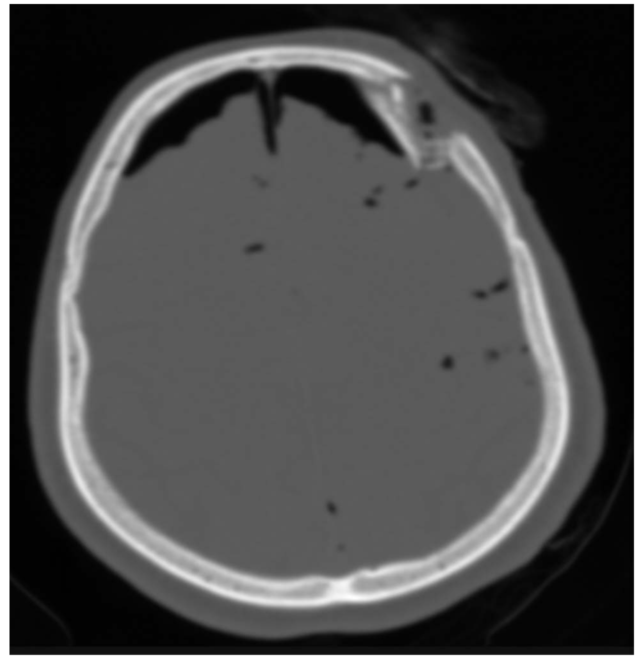

Figure 1. Axial head CT scan of the same patient showing depressed skull fracture. Intraoperatively, the patient had 2×3 cm dural tear. CT, computed tomography.

The type and extent of trauma, the GCS, and secondary brain lesions, such as a dural tear, are only a few of the elements that influence the overall outcome of TBI. If a dural tear is not appropriately treated, problems including CSF leakage and subsequent infection can be fatal. While primary TBI cannot be prevented, a secondary, deadly sequel can be when recognized and treated at the right time and with the right approach. Due to increased male involvement in driving and conflict (the main reason in our study), it is projected that male injuries will outnumber female injuries in all categories of head trauma[22].

According to one study, pneumocephalus, cerebral contusion, and depth of depression were the most predictive parameters for dural tears in patients with DSFs[22,23]. In our study, contusions and EDHs were predictive of dural tears. In addition, closed fractures were less likely to develop dural tears as compared with compound fractures. Moreover, parietal fractures were less likely to be associated with dural tears than other site fractures. The possible reasons include: (1) Structural characteristics: the parietal bone is relatively thicker and more robust compared to other cranial bones, such as the temporal or occipital bones. This thickness makes it less prone to fracture and less likely to cause damage to the underlying dura mater, which is the protective membrane covering the brain. (2) Location: parietal fractures often occur in the upper and middle parts of the skull, away from critical structures like the sinuses or base of the skull, which are more vulnerable to dural tears. As a result, the force needed to cause a parietal fracture is not typically strong enough to tear the dura mater[17,24]. (3) Surrounding anatomy: unlike some other cranial bones, the parietal bone does not have adjacent bony prominences or irregular shapes that can increase the risk of dural tears during a fracture. The absence of such anatomical features decreases the chance of the dura being directly traumatized[25].

Based on preoperative radiological parameters, dural tears can be radiologically expected in cases of TBI. The pathology with the highest risk is DSFs, particularly those associated with pneumocephalus (Fig. 1). These forecasts can help with safer handling and better preoperative preparation[26].

Surgery is recommended for DSFs, leaks of the CSF, compound depressed fractures, more so than the inner table of bone that is not depressed, focal neurological impairments brought on by fragment pressure during depression, various related lesions, such as an underlying hematoma, and for esthetic reasons, especially if the forehead has a depressed fracture[26–29]. Elevation of the depressed fracture fragment, primary reconstruction (whether by grafting or primary dura repair), and other surgical procedures make up surgical treatment, removing the underlying hematoma, gel foam hemostasis, or venous sinus repair as necessary[25,30,31]. In our study, complications were seen in 12.8% of the patients, of which 6.1% had wound infection, 2.5% had meningitis, and 4% had other complications [brain abscess, osteomyelitis, post-traumatic stress disorder (PTSD), and hypocalcemia].

Overall, our patients had good prognoses, except two patients (1.2%) who were presented with GCS of 3 and 4, who died after 2 and 3 days of hospital stay, possibly due to the critical head injury, respectively.

Strengths and limitations of the study

Strengths

- The identification of etiological factors and predictors of dural tear in DSF patients can help in early diagnosis and appropriate management of these cases, potentially reducing the risk of complications and improving treatment outcomes.
- The study highlights the importance of considering the mechanism of injury, such as assault or falls, in determining the site and severity of DSFs.
- The findings emphasize the need for preventive measures, particularly in school-aged children, to reduce the frequency of trauma from horse or donkey kicks and falls.
- The paper also highlights the socioeconomic burden of trauma and the importance of spreading education about preventive measures throughout society.

Limitations of the study

- The study was conducted retrospectively, which may introduce biases and limitations in data collection and analysis.
- The study was conducted at a single hospital, which may limit the generalizability of the findings to other settings or populations.
- The sample size of the study was relatively small, with 163 patients included, which may limit the statistical power and precision of the results.
- The study focused on patients who underwent surgery for DSF, which may exclude patients managed conservatively or those with less severe injuries, leading to potential selection bias.
- The study contains patients across different age groups (3–65), which may affect the outcome assessment of the results.

Key findings of the research

- Trauma, including head injury, is a significant problem in both developed and developing countries. DSFs are a catastrophic injury that can result from severe head trauma, with up to 11% of severe head traumas leading to DSFs.
- The majority of patients with DSFs are younger than 50 years old, and physical assault is a common cause of these injuries. Stone, stick, and other objects are frequently used in assaults.
- Common symptoms of DSFs include bleeding from the trauma site, headache, loss of consciousness, and vomiting.
- Frontal depressions are the most common type of DSFs, followed by parietal fractures. Brain contusion and EDH are significantly associated with dural tears.
- Preventive measures should be implemented, especially for school-aged children who are vulnerable to injuries from horse or donkey kicks and falls.

Conclusion

A neurosurgical emergency like a DSF requires prompt surgery to lower the risk of infection. Along with dural repair and/or evacuation of the underlying hematoma as/if necessary, the treatment of choice includes wound washing, debridement, and elevation of the affected fragment. Physical assault, particularly with stones, was the most common cause of DSFs. Frontal depressions were the most common site of fracture, followed by parietal fractures. Brain contusion and EDH were significantly associated with dural tears.

Ethical approval

An ethical clearance was obtained from the Ethics Review Committee of the School of Medicine, College of Medicine and Health Sciences, University of Gondar, with reference number SBMLS/648/2023.

Consent

Written informed consent was obtained from the patients and patients' parents/legal guardians for publication and any accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal on request.

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Author contribution

Y.D.M.: conceptualization, proposal writing, and result writing; H.T.A.: data collection and entry; S.A.K.: data collection and clearing; D.A.G. data entry; S.A.A.: data analysis and revision; H.E.T.: data collection and entry; A.G.D.: revision. All authors contributed to the conception, writing, and editing of this manuscript. All authors agreed to be accountable for all aspects of it.

Conflicts of interest disclosure

No potential conflicts of interest relevant to this article were reported.

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Data availability statement

The authors of this manuscript are willing to provide any additional information regarding the case report.

Provenance and peer review

Not applicable.

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