

# COMPOUND DEPRESSED SKULL FRACTURE, ITS ASSOCIATION WITH INFECTION AND IMPORTANCE OF THE TIME FROM THE ACCIDENT



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## ABSTRACT

### *Background*

Infection can occur after compound depressed skull fracture (DSF) if not timely treated.

### *Objectives*

To assess the time effect from accident to surgical intervention on surgical site infection (SSI).

### *Patients and Methods*

A retrospective cohort study was performed on 63 patients admitted to Shar Hospital from September 1, 2020, to May 13, 2021. Demographic features, type of trauma, time from accident to intervention, Glasgow Coma Scale (GCS), DSF location, associated brain injuries, dural tear, and admission to intensive trauma care unit (ITCU) were recorded. Patients followed up for 30 days.

### *Results*

Mean±SD (standard deviation) of ages was 23.8±18.1 years, ranging from 1-70. The male-to-female ratio was (4.25:1), and patient majorities (46% and 87.3%) were workers outside the city, respectively. Patients' ages, occupations, and residencies were significantly associated with SSI; p-values of <0.001, <0.001, and 0.004, respectively. 4.8% of patients were afflicted with SSI. Associations of admission GCS and DSF location with SSI were significant. Surgery was done for most patients (52.4%) within six hours, but the association of time from accident to surgery was non-significant. Mean±SD duration from accident to surgery was 8.1±5.1 hours, ranging from 1.5-29. All afflicted patients with SSI had basal skull fracture (BSF) and aerocele. The dural tear did not associate with SSI. All afflicted patients who underwent frontal sinus cranialization were admitted to the ITCU and significantly associated with SSI.

### *Conclusion*

There was no significant association between SSI occurrence and the time from the accident until surgical intervention.

**Keywords:** *Depressed skull fracture (DSF); Head injury; Head trauma; Infection; Surgical site infection (SSI).*

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## INTRODUCTION

In developing and developed countries, head trauma incidence is raised due to crowded traffic flow, making it a serious social and health issue globally (1–3). As a result, depressed skull fracture (DSF) is rising among head injuries. The patients are usually victims of falls, traffic accidents, assaults, or other high-energy forces applied to the skull (4). Further, DSF is a common traumatic disorder of the nervous system, and it needs special care and sophisticated types of equipment by trained personnel to save the life of the patients (5).

Usually, the DSF occurs due to a high-speed impact to the head with a small object, and both the inner and outer tables of the skull break simultaneously (5). As a result, the fragment of bone is displaced inward to a distance of the width or more of the calvarium (5). The type and extent of skull fracture are delineated by the kinetic energy and geometry of the striking object, the impacted force direction, and the anatomical site of the impact (1).

When scalp laceration is present with the DSF, it is known as open or compound DSF; otherwise, it is a simple or closed DSF (1,3,5). Compound DSF is a surgical emergency because, if not appropriately managed, complications like meningitis, Cerebritis, cerebral abscess, and osteomyelitis of the skull can occur (5). Therefore, treating the compound DSF as early as possible is suggested to decrease the frequency of associated infections (5,6).

Surgical site infection (SSI) is a common infection acquired during hospitalization, and it is classified into (7): Superficial incisional SSI: infection that involves only skin and subcutaneous tissue of the incision within 30 days of surgery. Deep incisional SSI: includes infection that involves deep tissues such as fascia and muscle layers within 30 days of surgery.

Organ/space SSI: infection that involves any organs and spaces other than the incision, opened or manipulated during the surgery within 30 days of surgery.

The current study aimed to evaluate the effect of time duration from the accident until the surgical intervention on developing SSI in our population.

## PATIENTS AND METHODS

A retrospective cohort study was performed on 63 patients admitted to the Emergency Department of Shar Hospital from September 1, 2020, to May 13,

2021. The patients were selected by using a simple random sampling method.

A formal acceptance letter was obtained from Shar Hospital before starting the study. Also, informed consent was taken from the patients for their inclusion in the study.

The inclusion criteria included patients with DSF after trauma to the head. However, the exclusion criteria included diabetes mellitus (DM), immunosuppression, injuries other than a head injury, and patients who already had an infection at the incision site.

The demographic features were recorded, including ages, gender, occupation, and residencies. In addition, types of trauma, time from the accident till admission to hospital and surgical intervention, Glasgow Coma Scale (GCS) at admission, location of DSF, associated dural tear and brain injuries, surgical intervention, and admission to intensive trauma care unit (ITCU), were recorded. The patients were followed up for 30 days to evaluate the SSI and its risk factors.

The “IBM SPSS Statistics version 25” software was used to analyze the data, and descriptive and inferential statistics were used. Further, a P-value of  $\leq 0.05$  was considered a statistically significant association. Also, Pearson Chi-Square was used to determine the significance of the association between categorical independent and dependent variable pairs.

## RESULTS

The mean $\pm$ SD (standard deviation) of the patients' ages was 23.8 $\pm$ 18.1 years, ranging from 1 to 70. The male-to-female ratio was (4.25:1), and the majorities of the patients (46% and 87.3%) were workers from outside Sulaimani city, respectively. Besides, patients' ages, occupations, and residencies were statistically significantly associated with SSI occurrence; however, the association of gender with the SSI was non-significant, (Table 1). As shown in (Figure 1), only 4.8% of the patients were afflicted with SSI, which was only superficial incisional SSI.

Although most of the patients (50.8%) developed DSF after RTA, the type of the trauma did not significantly associate with SSI. However, the associations of GCS on admission and the location of DSF were statistically significant with the occurrence of SSI, Table 2.

DSF = depressed skull fracture; FFH = fall from height; FOG = fall on ground; GCS = Glasgow coma scale; MVA

= motor vehicle accident; RTA = road traffic accident; SD = standard deviation; SSI = Surgical site infection. Although most of the patients (52.4%) had their surgical intervention within the first six hours from the accident, the association of the time duration from the accident to surgical intervention was statistically non-significant, (Table 3).

All the afflicted patients with superficial incisional SSI (4.8%) had basal skull fracture (BSF) and aerocele, which were statistically significantly associated with SSI occurrence. However, although all the patients

afflicted with SSI had dural tears, their association was statistically non-significant, (Table 4).

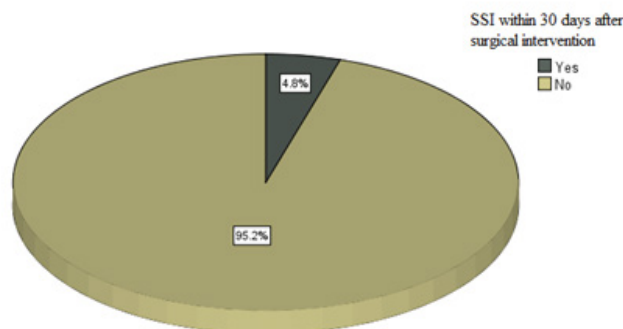
The association of the surgical interventions with SSI occurrence was statistically significant, and all the patients afflicted with SSI (4.8%) underwent dural repair for dural tears plus frontal sinus cranialization, (Table 5).

Further, all patients who developed superficial incisional SSI (4.8%) were admitted to ITCU, and their association was statistically significant, (Table 6).

**Table 1. Association of demographic features with the occurrence of SSI.**

Demographic features	SSI within 30 days after surgical intervention (%)		Total (%)	p-values
	Superficial incisional	No		
<b>Age groups (year)</b>	1 - 10	0 (0)	19 (30.2)	<0.001
	11 - 20	0 (0)	14 (22.2)	
	21 - 30	0 (0)	15 (23.8)	
	31 - 40	1 (1.6)	2 (3.2)	
	41 - 50	0 (0)	7 (11.1)	
	51 - 60	2 (3.2)	0 (0)	
	61 - 70	0 (0)	3 (4.8)	
<b>Gender</b>	Female	0 (0)	12 (19)	0.389
	Male	3 (4.8)	48 (76.2)	
<b>Occupation</b>	Child	0 (0)	18 (28.6)	<0.001
	Driver	0 (0)	3 (4.8)	
	Engineer	2 (3.2)	0 (0)	
	Housewife	0 (0)	3 (4.8)	
	Student	0 (0)	8 (12.7)	
	Worker	1 (1.6)	28 (44.4)	
<b>Residency</b>	Inside city	2 (3.2)	6 (9.5)	0.004
	Outside city	1 (1.6)	54 (85.7)	
<b>Total</b>	<b>3 (4.8)</b>	<b>60 (95.2)</b>	<b>63 (100)</b>	<b>—</b>

\*SD = standard deviation; SSI = Surgical site infection.



**Figure 1. Frequency of surgical site infection (SSI) after surgical intervention for depressed skull fracture (DSF)**

**Table 2. Association of the clinical findings with the occurrence of SSI.**

Clinical findings	SSI within 30 days after surgical intervention (%)		Total (%)	P-values
	Superficial incisional	No		
<b>Type of trauma</b>				
Bullet (suicidal attempt)	0 (0)	2 (3.2)	2 (3.2)	
FFH	1 (1.6)	12 (19)	13 (20.6)	
Fall from bicycle	0 (0)	2 (3.2)	2 (3.2)	
FOG	0 (0)	2 (3.2)	2 (3.2)	
Heavy objects	0 (0)	4 (6.3)	4 (6.3)	0.996
RTA	2 (3.2)	30 (47.6)	32 (50.8)	
MVA	0 (0)	4 (6.3)	4 (6.3)	
Stab wound	0 (0)	2 (3.2)	2 (3.2)	
Tire explosion	0 (0)	2 (3.2)	2 (3.2)	
<b>GCS on admission</b>				
<b>Mean±SD (range) = 13.4±2.2 (7 to 15)</b>				
Severe head injury (3-8)	0 (0)	5 (7.9)	5 (7.9)	
Moderate head injury (9-12)	2 (3.2)	5 (7.9)	7 (11.1)	0.007
Mild head injury (13-15)	1 (1.6)	50 (79.4)	51 (81)	
<b>Location of DSF</b>				
Frontal	0 (0)	17 (27)	17 (27)	
Fronto-parietal	2 (3.2)	5 (7.9)	7 (11.1)	
Occipital	0 (0)	4 (6.3)	4 (6.3)	
Parietal	0 (0)	27 (42.9)	27 (42.9)	<0.001
Parieto-occipital	0 (0)	4 (6.3)	4 (6.3)	
Temporal	0 (0)	3 (4.8)	3 (4.8)	
Temporo-parieto-occipital	1 (1.6)	0 (0)	1 (1.6)	
<b>Total</b>	<b>3 (4.8)</b>	<b>60 (95.2)</b>	<b>63 (100)</b>	<b>—</b>

DSF = depressed skull fracture; FFH = fall from height; FOG = fall on ground; GCS = Glasgow coma scale; MVA = motor vehicle accident; RTA = road traffic accident; SD = standard deviation; SSI = Surgical site infection.

**Table 3. Association of time from the accident with the occurrence of SSI.**

Time from the accident	SSI within 30 days after surgical intervention (%)		Total (%)	p-value
	Superficial incisional	No		
<b>Duration from the accident till surgical intervention (hour)</b>				
≤6	2 (3.2)	31 (49.2)	33 (52.4)	
>6	1 (1.6)	29 (46)	30 (47.6)	0.612
<b>Total</b>	<b>3 (4.8)</b>	<b>60 (95.2)</b>	<b>63 (100)</b>	
<b>Duration from the accident till admission (hour)</b>	Mean±SD = 3.5±3.3 (range: 0.5 to 24)			
<b>Duration from admission till surgical intervention (hour)</b>	Mean±SD = 4±1.6 (range: 1 to 9.5)			
<b>Duration from the accident till surgical intervention (hour)</b>	Mean±SD = 8.1±5.1 (range: 1.5 to 29)			

SD = standard deviation; SSI = Surgical site infection

Table 4. Association of dural tear and brain injuries with the occurrence of SSI.

Associated injuries	SSI within 30 days after surgical intervention (%)		Total (%)	p-values
	Superficial incisional	No		
<b>Associated brain injuries</b>				
None	0 (0)	27 (42.9)	27 (42.9)	
Aerocele, BSF and CSF leak	0 (0)	2 (3.2)	2 (3.2)	
EDH, contusions and aerocele	2 (3.2)	0 (0)	2 (3.2)	
ICH and SAH	0 (0)	4 (6.3)	4 (6.3)	
EDH and contusion	0 (0)	10 (15.9)	10 (15.9)	
EDH	0 (0)	8 (12.7)	8 (12.7)	<0.001
Frontal sinus fracture, contusions, brain coming out from the wound	0 (0)	2 (3.2)	2 (3.2)	
Contusion	0 (0)	4 (6.3)	4 (6.3)	
SSS injury	0 (0)	3 (4.8)	3 (4.8)	
Contusions, aerocele and BSF	1 (1.6)	0 (0)	1 (1.6)	
<b>Associated dural tear</b>				
No	0 (0)	23 (36.5)	23 (36.5)	0.178
Yes	3 (4.8)	37 (58.7)	40 (63.5)	
<b>Total</b>	<b>3 (4.8)</b>	<b>60 (95.2)</b>	<b>63 (100)</b>	—

BSF = basal skull fracture; CSF = cerebrospinal fluid; EDH = extradural or epidural hematoma; ICH = intracerebral hemorrhage; SAH = subarachnoid hemorrhage; SSI = Surgical site infection; SSS = superior sagittal sinus.

Table 5. Association of surgical intervention with the occurrence of SSI.

Surgical interventions	SSI within 30 days after surgical intervention (%)		Total (%)	p-value
	Superficial incisional	No		
<b>Simple suturing without operation</b>	0 (0)	7 (11.1)	7 (11.1)	
<b>Craniectomy</b>	0 (0)	10 (15.9)	10 (15.9)	
<b>Craniectomy and dural repair</b>	0 (0)	36 (57.1)	36 (57.1)	
<b>Craniectomy, dural repairs, and cranialization of frontal sinus</b>	3 (4.8)	2 (3.2)	5 (7.9)	<0.001
<b>Craniectomy, dural repairs, and evacuation of EDH</b>	0 (0)	3 (4.8)	3 (4.8)	
<b>Craniectomy and SSS injury repair</b>	0 (0)	2 (3.2)	2 (3.2)	
<b>Total</b>	<b>3 (4.8)</b>	<b>60 (95.2)</b>	<b>63 (100)</b>	

EDH = extradural or epidural hematoma; SSI = Surgical site infection; SSS = superior sagittal sinus.

Table 6. Association of intensive trauma care unit admission with the occurrence of SSI.

Intensive trauma care Unit admission	SSI within 30 days after surgical intervention (%)		Total (%)	p-value
	Superficial incisional	No		
<b>No</b>	0 (0)	51 (81)	51 (81)	
<b>Yes</b>	3 (4.8)	9 (14.3)	12 (19)	<0.001
<b>Total</b>	<b>3 (4.8)</b>	<b>60 (95.2)</b>	<b>63 (100)</b>	

SSI = Surgical site infection.

## DISCUSSION

There is a significant frequency of SSI following various surgical procedures, and infection constitutes persistent surgical procedure complications<sup>(8)</sup>. Further, the cost burden of surgeries is much higher in patients afflicted with SSI than in patients who did not get complicated with SSI<sup>(9-12)</sup>. Besides, the occurrence of SSI after surgical procedures leads to prolonged hospitalization and even prolonged admission to the intensive care unit (ICU)<sup>(13,14)</sup>. Therefore, the current study evaluated the risk factors for SSI after surgical interventions in the patients who sustained DSF and assessed the effect of time duration from the accident on its occurrence.

The current study showed that only superficial incisional SSI affected 4.8% of the patients afflicted with SSI. However, none of the patients was afflicted with other types of SSI. As the study performed by Oktay et al.<sup>(15)</sup> mentioned, surgical intervention should be performed as soon as possible to prevent infection after trauma, and the rate of infection is low if surgical intervention is performed within 72 hours after the trauma. Thus, the low frequency of SSI in the current study may be because all the surgical interventions were performed within 29 hours of the trauma. The current study finding is also in line with the study of KC et al.<sup>(16)</sup>. They showed no significant association of time from accident to presentation with SSI occurrence (p-value = 0.09).

The favourable outcome can only be achieved in patients presenting with head injury by preventing secondary brain injuries, such as infection<sup>(16)</sup>. Therefore, compound DSF is usually managed surgically to prevent infections with a high likelihood of dural tears and contact with the exterior<sup>(17)</sup>. However, the current study did not show a significant association between dural tears with SSI occurrence (p-value = 0.178).

Like the study performed by KC et al.<sup>(16)</sup> in Nepal, the mean age of the patients in the current study was 21.02±18.78 and 23.8±18.1 years, respectively. In addition, there was a male predominance in the current study; the male to female ratio was (4.25:1); however it was slightly less (2.13:1) in the study done by KC et al.<sup>(16)</sup>.

Various studies have mentioned the young and male predominance as risk factors<sup>(18,19)</sup>. It may be due to young males doing more risky work and adventures; 46% and 3.2% of the patients in the current study were

workers and engineers, respectively, and the infection was significantly associated with the occupation of the patients (p-value = <0.001).

However, although all the afflicted patients (4.8%) were males, the association of gender with SSI occurrence in the current study was non-significant (p-value = 0.389). Further, it may be due to the smaller numbers of females in the current study than males. Moreover, the majorities of the patients (87.3%) in the current study were from outside the city of Sulaimani, i.e., suburban and rural areas, and their association with SSI occurrence was statistically significant (p-value = 0.004). Although most patients (87.3%) were outside the city, 3.2% of afflicted patients with SSI resided inside the city. The 3.2% of afflicted patients were engineers from inside the city, although their accidents occurred outside the city, explaining why the frequency of afflicted patients was more inside the city. However, the real issue was outside the city and delayed time of arrival for getting medical assistance. The medical databases, especially PubMed, were searched; however, no study was found on the association between patients' residencies and SSI occurrence.

The common trauma mechanism in the current study was RTA, followed by falls; 50.8% and 27%, respectively. Besides, the mechanism of injury in the current study did not associate with SSI occurrence significantly. However, this finding was contrary to the findings found by KC et al.<sup>(16)</sup> in Nepal, who found falls (60%) as the primary mechanism of injury. Further, the mean±SD GCS at admission in the current study was 13.4±2.2 ranging from 7 to 15, and the majority (81%) of the patients had GCS of 13-15, followed by 11.1% who had GCS of 9-12.

However, none of the patients with a severe head injury was afflicted with SSI, but 3.2% and 1.6% of the moderate and mild head-injured patients sustained SSI, respectively. The association of GCS with SSI occurrence was statistically significant (p-value = 0.007). The current study finding was near to the study done by KC et al.<sup>(16)</sup> in Nepal, who found 86% of their patients had a GCS of 13-15 at admission. Usually, patients with DSF have no significant clinical features apart from the overt wound and fractures. Therefore, GCS at admission is usually not much decreased unless there are associated other brain injuries. Most DSF (61.9%) were in parietal bones alone or with other cranial bones. The findings were based on KC et al.<sup>(16)</sup>, who showed parietal bone as the commonest

fracture site, followed by the frontal bone. During trauma, the most overt area is likely to get the insult. Thus, the parietal bones are much more prone to be fractured.

About 57% of the patients in the current study sustained associated brain injuries. However, none of these patients was afflicted with the SSI except those afflicted with BSF, especially anterior cranial fossa BSF and aerocele. The current study finding may be because aerocele enters brain parenchyma through dirty sources from the sinuses; however, direct contact with the fresh atmospheric air may be purer.

Further, only 11.1% of the patients were managed by simple suturing. However, the rest of the patients (88.9%) were treated with either one of the following: craniectomy, dural repair, evacuation of EDH, superior sagittal sinus repair, and cranialization of the bony sinuses, accordingly. Surgical interventions in the current study were more than those performed by Hossain et al. <sup>(20)</sup>, who performed surgical interventions for 73% of their patients.

As the studies performed by Jenks et al. <sup>(13)</sup> and Nobile et al. <sup>(14)</sup> indicated, SSI occurrence leads to prolonged hospitalization and ICU admission. Therefore, in the current study, all afflicted patients with SSI were admitted to ITCU with a significant association (p-value = <0.001).

In conclusion, the risk factors of SSI after surgery for DSF were younger ages, occupation of worker, outside city residency, mild to moderate head injuries, fractured bone near to or through skull base, associated BSF and aerocele, fractures through bony sinuses, and admission to ITCU. However, there was no significant association between SSI occurrence and the time from the accident until the surgical intervention.

The current study's limitations may be its small sample size because of its short study duration. Therefore, performing further studies on larger samples is recommended.

#### **Conflict of interest**

The authors declare no conflict of interest.

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