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Research Article



# Surgical Management of Complicated Depressed Skull Fractures at Bacha Khan Medical Complex (MTI) Swabi

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## Abstract

**Background:** Depressed Skull Fractures (DSFs) are a severe form of head injury resulting from high-energy blunt trauma and are associated with significant morbidity if not managed promptly. Despite advances in diagnostic imaging and surgical techniques, management remains challenging in resource-limited settings. This study aimed to evaluate the clinical presentation, surgical management, and outcomes of complicated DSFs at Bacha Khan Medical Complex (MTI), Swabi.

**Methods:** This prospective observational study was conducted in the Department of Neurosurgery, Bacha Khan Medical Complex, from January 2023 to January 2024. A total of 80 patients (60 males and 20 females) aged 10–70 years with complicated DSFs were included. All patients underwent Computed Tomography (CT) for diagnosis and surgical planning. Surgical elevation and dural repair were performed when indicated, and outcomes were assessed using the Glasgow Coma Scale (GCS) over a 15-week follow-up period.

**Results:** Road traffic accidents were the leading cause of injury, followed by falls and physical assaults. The frontal bone was the most frequently involved site, and open (compound) fractures were most common. Surgical management was performed in 78.75% of patients. Favorable neurological recovery occurred in 75% of cases, while 15% had partial deficits, 6.25% had severe impairment, and 3.75% succumbed to their injuries.

**Conclusion:** Complicated DSFs predominantly affect young adult males, most often due to vehicular trauma. Early surgical intervention, particularly for open or comminuted fractures, improves neurological recovery and reduces complications. Strengthening road safety measures, occupational hazard prevention, and timely neurosurgical care are essential to lowering morbidity and mortality.

**Keywords:** Depressed skull fracture, Traumatic brain injury, Neurosurgical management, Surgical outcomes, Road traffic accidents, Craniocerebral trauma

**Abbreviations:** CSF: Cerebrospinal Fluid; CT: Computed Tomography; DSF: Depressed Skull Fracture, GCS: Glasgow Coma Scale; GKMC: Gajju Khan Medical College; MTI: Medical Teaching Institution; TBI: Traumatic Brain Injury.

## Introduction

A Depressed Skull Fracture (DSF) is characterized by inward displacement of a segment of the cranial vault beyond the normal thickness of the calvarium, most commonly resulting from high-energy blunt head trauma [1]. Depending on the severity, direction, and location of the impact, these fractures may occur with or without associated intracranial injury [2]. Depressed skull fractures are broadly classified as open (compound) when accompanied by a scalp laceration and as closed (simple) when the overlying scalp remains intact [2]. Complicated depressed skull fractures are associated with a substantial risk of morbidity, including intracranial infection, cerebral abscess formation, post-traumatic epilepsy, Cerebrospinal Fluid (CSF) leakage, and osteomyelitis, particularly when diagnosis and treatment are delayed [3]. Computed Tomography (CT) remains the imaging modality of choice for the evaluation of depressed skull fractures, as it allows accurate assessment of fracture depth, dural involvement, pneumocephalus, and associated intracranial lesions such as contusions or hematomas [4].

Current management strategies emphasize early surgical intervention in selected cases. According to contemporary guidelines, including those issued by the French Society of Neurosurgery

(2025), operative management is recommended for open or contaminated fractures, suspected dural tears, pneumocephalus, CSF leakage, significant mass effect, associated intracranial injuries, neurological deterioration, or marked cosmetic deformity [5-7]. In contrast, conservative treatment may be considered in patients with closed fractures who have no neurological deficit and no evidence of dural breach. Despite advances in diagnostic imaging, surgical techniques, and perioperative care, the management of complicated depressed skull fractures remains challenging, particularly in resource-limited settings. Delayed presentation, limited access to specialized neurosurgical services, and a higher risk of wound contamination and infection may adversely affect outcomes in such environments.

In this context, the present study was conducted to evaluate the clinical presentation, surgical management, and outcomes of patients with complicated depressed skull fractures treated at Bacha Khan Medical Complex (Medical Teaching Institution), Swabi. The findings aim to contribute local data to the existing literature and to highlight the importance of timely surgical intervention in improving neurological outcomes and reducing complications.

## Materials and Methods

This prospective observational study was conducted in the Department of Neurosurgery at Bacha Khan Medical Complex (Medical Teaching Institution), Swabi, over a one-year period from January 2023 to January 2024. The study included a total of 80 patients diagnosed with complicated depressed skull fractures, comprising 60 males and 20 females, with ages ranging from 10 to 70 years. Patients presenting with radiologically confirmed depressed skull fractures associated with complications such as dural tear, neurological deficit, Cerebrospinal Fluid (CSF) leakage, pneumocephalus, intracranial hematoma, or wound contamination were included in the study. Patients with non-depressed skull fractures, those who expired before complete clinical evaluation, and individuals younger than 10 years of age were excluded.

After initial stabilization in the emergency department, informed written consent was obtained from all patients or their legal guardians prior to enrolment. Detailed demographic and clinical data were recorded using a structured proforma, including age, gender, mechanism of injury, time interval between trauma and hospital presentation, level of consciousness at admission, site and type of fracture, and associated injuries.

All patients underwent non-contrast Computed Tomography (CT) scanning of the brain for definitive diagnosis and assessment of fracture depth, dural involvement, brain contusion, intracranial hematoma, and other associated intracranial injuries. Skull radiographs were obtained only in cases where CT imaging was temporarily unavailable. Management decisions were made in accordance with the 2025 French Society of Neurosurgery guidelines. Surgical intervention was indicated in cases of open or contaminated fractures, suspected or confirmed dural tear, CSF leakage, pneumocephalus, significant mass effect, neurological deficit, associated intracranial lesions, or major cosmetic deformity. Conservative management was reserved for closed depressed skull fractures without neurological deficit, dural breach, or intracranial complications.

Surgical procedures were individualized based on fracture location and pattern. Scalp incisions (linear, S-shaped, or horseshoe) were used to adequately expose the fracture site. Operative steps included elevation and removal of depressed bone fragments, thorough wound debridement, hemostasis, evacuation of associated hematomas when present, and repair of dural tears using appropriate techniques. Primary wound closure was performed in all feasible cases. Postoperatively, all patients received broad-spectrum intravenous antibiotics and anticonvulsant therapy as per departmental protocol to prevent infection and post-traumatic seizures. Patients were monitored clinically, and neurological recovery was assessed using the Glasgow Coma Scale (GCS). Follow-up evaluations were conducted for a period of 15 weeks. Collected data were entered and analyzed using Statistical Package for the Social Sciences (SPSS) version 27.0. Categorical variables were expressed as frequencies and percentages, while continuous variables were presented as means with standard deviations.

## Results

A total of 80 patients diagnosed with complicated depressed skull fractures were included in the study, comprising 60 males (75%) and 20 females (25%), with a marked male predominance. The patients' ages ranged from 10 to 70 years, with a mean age of 42.6 ± 12.4 years. Most cases (50%) occurred in individuals under 40 years of age, indicating that younger adults were more vulnerable to such injuries. Patients aged 40–50 years constituted 31.25%, while those aged 50–70 years represented 18.75% (Table 1).

**Table 1:** Age distribution of patients with complicated depressed skull fractures. Mean age = 42.6 ± 12.4 years. Half of the patients were under 40 years of age, indicating a higher prevalence among younger adults.

| Age group (years) | Male (n) | Female (n) | Total (n) | Percentage (%) |
|---|---|---|---|---|
| < 40 | 30 | 10 | 40 | 50 |
| 40–50 | 20 | 5 | 25 | 31.25 |
| 50–70 | 10 | 5 | 15 | 18.75 |
| Total | 60 | 20 | 80 | 100 |

Regarding the etiology of injury, road traffic accidents were the leading cause, accounting for 43.75% (35 patients), followed by falls in 25% (20 patients) and physical assaults in 18.75% (15 patients). Industrial or workplace trauma contributed to 7.5% of cases, while sports-related injuries were the least common at 5%. The predominance of road traffic–related injuries highlight the role of vehicular trauma as the principal source of cranial injury in this population (Table 2).

**Table 2:** Causes of injury by gender in patients with complicated depressed skull fractures. Road traffic accidents were the most frequent cause of depressed skull fractures, followed by falls and physical assaults.

| Cause of Injury | Male (n) | Female (n) | Total (n) | Percentage (%) |
|---|---|---|---|---|
| Road traffic accidents | 28 | 7 | 35 | 43.75 |
| Falls | 14 | 6 | 20 | 25.00 |
| Physical assault | 13 | 2 | 15 | 18.75 |
| Industrial/workplace trauma | 6 | 0 | 6 | 7.5 |
| Sports injuries | 4 | 0 | 4 | 5.00 |
| Total | 65 | 15 | 80 | 100 |

Analysis of fracture location revealed that the frontal bone was the most frequently affected site (37.5%, 30 patients), followed by the parietal bone (28.75%, 23 patients) and temporal bone (20%, 16 patients). The occipital bone was involved in only 13.75% (11 patients). Males exhibited a higher incidence of fractures across all cranial sites compared with females (Table 3).

**Table 3:** Anatomical sites of depressed skull fractures.

The frontal bone was the most frequently affected site, followed by the parietal and temporal bones.

| Site of fracture | Male (n) | Female (n) | Total (n) | Percentage (%) |
|---|---|---|---|---|
| Frontal bone | 22 | 8 | 30 | 37.5 |
| Parietal bone | 18 | 5 | 23 | 28.75 |
| Temporal bone | 12 | 4 | 16 | 20 |
| Occipital bone | 8 | 3 | 11 | 13.75 |
| Total | 60 | 20 | 80 | 100 |

In terms of fracture type, open (compound) fractures were the most common, observed in 43.75% (35 patients), followed by closed fractures in 40% (32 patients) and comminuted fractures in 16.25% (13 patients). Open and closed fractures together represented the majority of cases, reflecting the predominance of high-impact trauma mechanisms such as road traffic collisions (Table 4).

**Table 4:** Distribution of fracture types among patients with complicated depressed skull fractures.

Open (compound) fractures were the most frequent type observed, followed by closed and comminuted fractures.

| Type of fracture | Male (n) | Female (n) | Total (n) | Percentage (%) |
|---|---|---|---|---|
| Open (compound) | 28 | 7 | 35 | 43.75 |
| Closed | 22 | 10 | 32 | 40 |
| Comminuted | 10 | 3 | 13 | 16.25 |
| Total | 60 | 20 | 80 | 100 |

Most patients underwent surgical management (78.75%, 63 patients), while 21.25% (17 patients) were managed conservatively. Surgical intervention was most frequently performed in open and comminuted fractures all comminuted fractures (12.5%) required operative elevation and repair whereas conservative treatment was more common in closed fractures without neurological deficit (Table 5).

**Table 5:** Treatment modality according to fracture type

The majority of patients underwent surgical intervention, particularly in cases of open and comminated fractures, whereas conservative management was more frequent among closed fractures.

| Fracture type | Surgical management (n) | Conservative management (n) | Total (n) | Percentage (%) |
|---|---|---|---|---|
| Open (compound) | 34 | 3 | 37 | 46.25 |
| Closed | 19 | 14 | 33 | 41.25 |
| Comminuted | 10 | 0 | 10 | 12.5 |
| Total | 63 | 17 | 80 | 100 |

The clinical outcomes were generally favorable. Full neurological recovery was achieved in 75% (60 patients), while 15% (12 patients) exhibited partial neurological deficits. Severe impairment occurred in 6.25% (5 patients), and 3.75% (3 patients) succumbed to their injuries. Early diagnosis and timely surgical intervention were associated with better outcomes, underscoring the importance of prompt management in complicated depressed skull fractures (Table 6).

**Table 6:** Clinical outcomes following management of complicated depressed skull fractures

The majority of patients (75%) achieved full recovery, while a small proportion experienced neurological deficits or mortality.

| Outcome | Frequency (n) | Percentage (%) |
|---|---|---|
| Fully recovered | 60 | 75 |
| Partial neurological deficit | 12 | 15 |
| Severe neurological impairment | 5 | 6.25 |
| Expired | 3 | 3.75 |
| Total | 80 | 100 |

## Discussion

This study evaluated 80 patients with complicated depressed skull fractures and demonstrated a clear male predominance (75%) with a mean age of 42.6 ± 12.4 years. Most cases occurred in individuals under 40 years of age, and road traffic accidents were the leading cause of injury, followed by falls and physical assaults. The frontal bone was the most frequently affected site, and open (compound) fractures predominated. Surgical management was required in nearly four-fifths of the cases, and favorable neurological recovery was achieved in 75% of patients. These findings highlight the importance of timely diagnosis and early surgical intervention in achieving good neurological outcomes.

The demographic and etiological patterns observed in this study are consistent with previously published reports. *Kalhoro et al.* [8] reported similar trends at Liaquat University of Medical and Health Sciences, with young males representing the majority of cases and road traffic accidents being the most common cause. Adeleye and Ogun [9] also described comparable findings, noting that motor-

vehicle trauma remains the predominant mechanism of injury in developing countries. Global data confirm that Traumatic Brain Injury (TBI) is a major public health concern, especially in low- and middle-income countries such as Pakistan, where poor road safety practices and limited access to specialized care contribute to higher incidence and worse outcomes [9]. Studies by *Nnadi et al.* [10] and *Khan et al.* [9] likewise reported male predominance, frequent open fractures, and generally favorable postoperative recovery, reinforcing the benefits of early surgical elevation and debridement.

Although the present study identified road traffic accidents as the major cause, *Khan et al.* [11] observed falls from height as the predominant etiology. Despite such regional variations, all studies emphasize that early operative management improves neurological outcomes and reduces secondary complications. The mortality rate of 3.75% in our study aligns with previously reported figures of 0–5% [12,13], suggesting that timely surgical intervention and appropriate postoperative care are essential in minimizing fatal outcomes. The predominance of young adult males can be explained by greater exposure to outdoor work, occupational hazards, and vehicular traffic, which increases susceptibility to high-impact injuries. The frequent involvement of the frontal bone is likely due to its anatomical position and direct exposure during frontal impact, particularly in vehicular and fall-related trauma. The higher rate of open fractures reflects the intensity of the traumatic force, while comminuted fractures, though less frequent, indicate more severe cranial injury requiring surgical stabilization and dural repair.

These findings underscore the importance of rapid assessment and surgical management of depressed skull fractures, particularly in resource-limited settings. Early surgery prevents complications such as meningitis, cerebral abscess, and post-traumatic epilepsy, thereby improving long-term neurological outcomes. Adherence to modern surgical guidelines such as those of the French Society of Neurosurgery (2025) which recommend surgery for open or contaminated wounds, dural tear, CSF leakage, mass effect, or significant deformity, can help standardize care and improve outcomes. The prospective design of this study, standardized follow-up, and detailed documentation of both clinical and surgical parameters are major strengths. However, limitations include its single-center nature, relatively small sample size, and short follow-up period of 15 weeks. Furthermore, advanced imaging such as MRI was not routinely available, which might have allowed for a more detailed assessment of parenchymal injury. Future multicenter studies with larger cohorts and extended follow-up are recommended to validate these findings and identify prognostic factors influencing neurological recovery. In summary, this study demonstrates that young adult males are at the highest risk of sustaining complicated depressed skull fractures, most commonly due to road traffic accidents. The frontal bone was the most frequently affected region, and open fractures were the most prevalent type encountered. Surgical management remains the cornerstone of treatment and is strongly associated with favorable neurological recovery. These findings reinforce the critical need for improved road safety, early neurosurgical intervention, and better trauma-care infrastructure to reduce the burden of head-injury–related morbidity and mortality in developing regions.

## Conclusion

Complicated depressed skull fractures constitute a significant neurosurgical challenge, predominantly affecting young adult males as a result of high-energy trauma, particularly road traffic accidents. The findings of this study support the underlying theoretical framework that early identification and prompt surgical intervention in complicated depressed skull fractures are critical determinants of neurological outcome. Our results demonstrate that timely surgical elevation, adequate debridement, and dural repair, when indicated, are associated with favorable neurological recovery and a reduced rate of complications, even in resource-limited settings. These outcomes reinforce existing neurosurgical principles that emphasize early operative management for open, comminated, or neurologically significant fractures. Strengthening road safety measures, improving occupational hazard prevention, and ensuring rapid access to specialized neurosurgical care are essential strategies for reducing morbidity and mortality associated with depressed skull fractures in developing regions.

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## Conflict of Interest

The authors declare that there are no financial or personal relationships that could inappropriately influence or bias the content of this study. No conflict of interest exists.

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