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Research Article

Clinical Characteristics and Fracture Patterns of Skull Base Injuries Following Motorcycle Accidents: A Retrospective Cohort Study

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Abstract

Background

Skull base fractures (SBFs) are among the most serious consequences of high-energy motorcycle accidents because of their close relationship with cerebrospinal fluid (CSF) leakage, cranial nerve injury, and intracranial infection. Understanding fracture distribution and associated clinical manifestations is important for improving diagnosis and management.

Objective

To describe the anatomical distribution, injury severity, and clinical presentation of skull base fractures in patients admitted after motorcycle-related trauma.

Methods

A retrospective review was performed of 886 patients admitted with skull base injuries between January 2018 and December 2023. Demographic characteristics, fracture location on computed tomography (CT), injury severity according to Glasgow coma scale, and clinical evidence of CSF leakage were extracted from hospital records. Fractures were classified as anterior, middle, or posterior skull base fractures and or depressed frontal bone fractures. Injury severity was categorized as mild GCS 13-14, moderate9-12, or severe below 9, according to institutional trauma assessment protocols. Descriptive statistics were used to summarize the findings.

Results

The study included 686 males (77.4%) and 200 females (22.6%). Most patients sustained moderate (40.6%) or severe (36.1%) injuries, while 20.3% had mild trauma. The anterior skull base was the most frequently involved region (44.0%), followed by depressed frontal bonefractures (36.1%), middle skull base fractures (20.3%), and posterior skull base fractures (9.0%). Rhinorrhea occurred in 480 patients (54.2%), whereas otorrhea was documented in 220 patients (24.8%). These findings indicate that anterior skull base injuries are common after motorcycle accidents and are frequently accompanied by CSF leakage.

Conclusion

Motorcycle-related skull base fractures are predominantly associated with anterior cranial fossa involvement and a high incidence of CSF rhinorrhea. Early recognition, accurate radiological assessment, and multidisciplinary management may help reduce complications and improve patient outcomes.

Keywords: Skull base fracture, motorcycle accident, cerebrospinal fluid leak, rhinorrhea, traumatic brain injury, neurosurgery

Introduction

Motorcycle accidents remain a leading cause of traumatic brain injury worldwide and are responsible for a substantial proportion of skull base fractures, particularly in low- and middle-income countries (1–3). Because the skull base contains numerous cranial nerves, major blood vessels, brainstem, and communicates directly with the paranasal sinuses and middle ear, fractures in this region are associated with significant neurological morbidity and potentially life-threatening complications (4,5).

Among the most important complications of skull base fractures are cerebrospinal fluid (CSF) leakage, meningitis, cranial nerve dysfunction, and vascular injury (4,6). CSF leakage, presenting as rhinorrhea or otorrhea, results from disruption of the dura and osseous skull base. Persistent leaks increase the risk of ascending intracranial infection and frequently require prolonged observation or surgical repair (6–7). Early diagnosis and timely management are therefore essential to minimize infectious complications and improve neurological outcomes (5,8).

The anatomical location of the fracture strongly influences clinical presentation and prognosis. Fractures involving the anterior skull base are commonly associated with CSF rhinorrhea,
whereas middle and posterior skull base fractures are more frequently associated with cranial nerve deficits, hearing impairment, and vascular complications (4,6,9). Although these associations are well recognized, the distribution of fracture patterns and their clinical manifestations vary considerably among trauma populations and mechanisms of injury (2,9).
Most published studies have evaluated skull base fractures resulting from mixed mechanisms of trauma, whereas comparatively fewer investigations have focused specifically on motorcycle-related injuries. Motorcycle crashes frequently involve high-energy impacts that produce complex craniofacial fracture patterns, posing significant diagnostic and therapeutic challenges (1–3). Characterizing the anatomical distribution of these injuries and their associated clinical manifestations may facilitate earlier diagnosis and more effective treatment strategies.

The present study retrospectively analyzed 886 patients with motorcycle-related skull base fractures to describe demographic characteristics, injury severity, anatomical fracture distribution, and the frequency of cerebrospinal fluid leakage. Improved understanding of this injury patterns may assist clinicians in identifying patients at increased risk of complications and support the development of standardized management protocols.

Materials and Methods

Study Design, setting and duration

This retrospective cohort study was conducted in the Department of Neurosurgery Peoples' university of medical and health sciences Nawabshah and included patients admitted between January 2018 and December 2023 with skull base fractures following motorcycle accidents.

Study Population

A total of 886 consecutive patients with radiologically confirmed skull base fractures were identified from the institutional trauma database. Patients with incomplete medical records, inadequate imaging studies, previous skull base pathology, or non-traumatic skull lesions were excluded.

Data Collection

Clinical and radiological data were obtained from medical records. Variables included: Age and sex
Injury severity

Anatomical location of skull base fracture Presence of cerebrospinal fluid leakage
Fracture location was determined using high-resolution computed tomography (CT) and categorized into:

Anterior skull base Middle skull base

Posterior skull base

Depressed frontal bone fractures

Clinical evidence of CSF leakage was recorded as rhinorrhea or otorrhea based on documented clinical examination.

Statistical Analysis

Descriptive statistics were used to summarize demographic and clinical variables. Categorical variables are presented as frequencies and percentages. Data was analyzed by SPSS version 21.

Results

A total of 886 patients were included in the analysis. Males represented the majority of the study population (686, 77.4%), while females accounted for 200 cases (22.6%).

Regarding injury severity, 180 patients (20.3%) sustained mild injuries, 360 (40.6%) had moderate injuries, and 320 (36.1%) experienced severe trauma, indicating that most patients presented with moderate-to-severe head injury.

Analysis of fracture morphology demonstrated that the anterior skull base was the most commonly affected anatomical region, involving 390 patients (44.0%). Depressed frontal bone fractures were identified in 320 patients (36.1%), followed by middle skull base fractures in 180 patients (20.3%) and posterior skull base fractures in 80 patients (9.0%). Figure 2.
Clinical manifestations showed that CSF leakage was common within the study population. Rhinorrhea was observed in 480 patients (54.2%), whereas otorrhea occurred in 220 patients (24.8%). These findings indicate that CSF leakage represents a frequent complication of motorcycle-related skull base trauma. Figure 1

Overall, anterior skull base fractures and depressed frontal bone injuries constituted the predominant fracture patterns observed in this cohort.

Table 1

Variable	Number (n)	Percentage (%)
Male	686	77.4
Female	200	22.6
Total	886	100

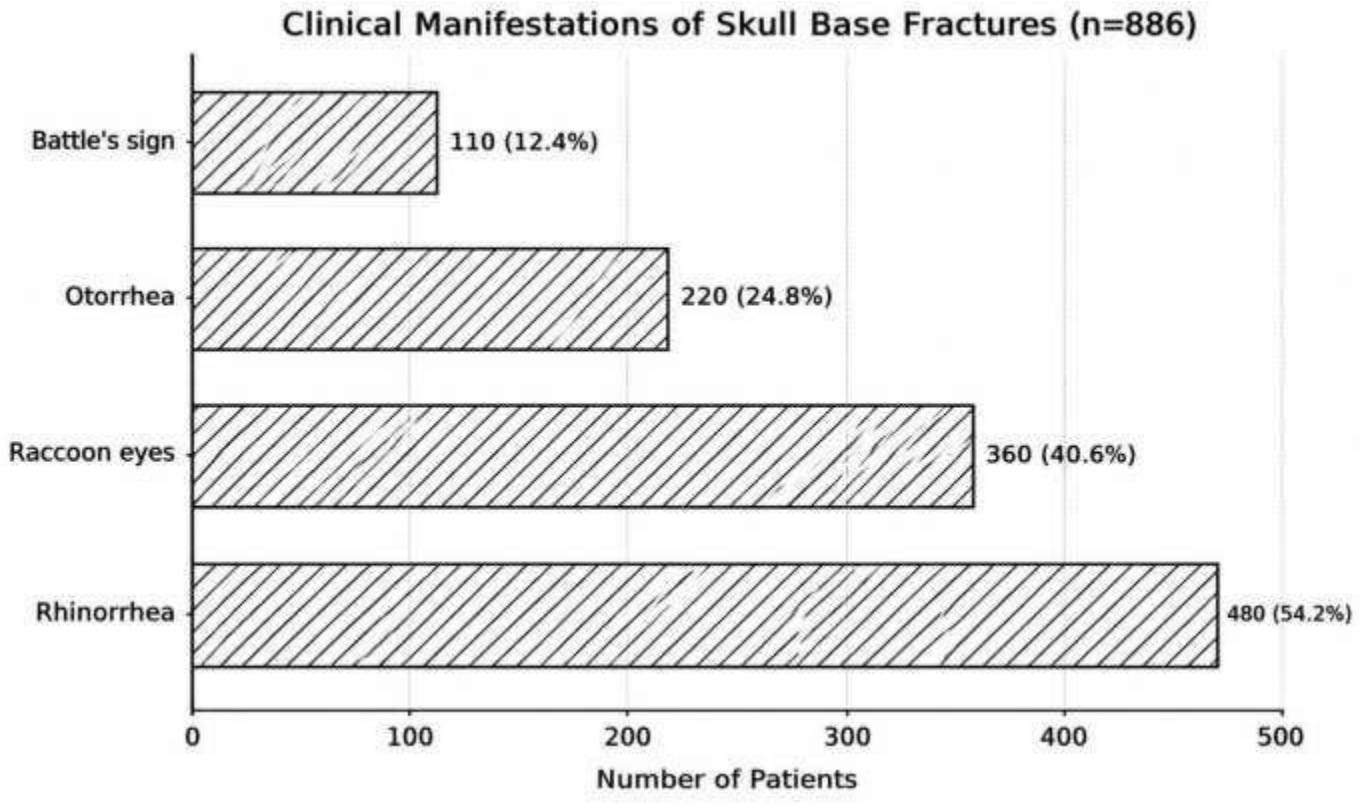

Figure 1

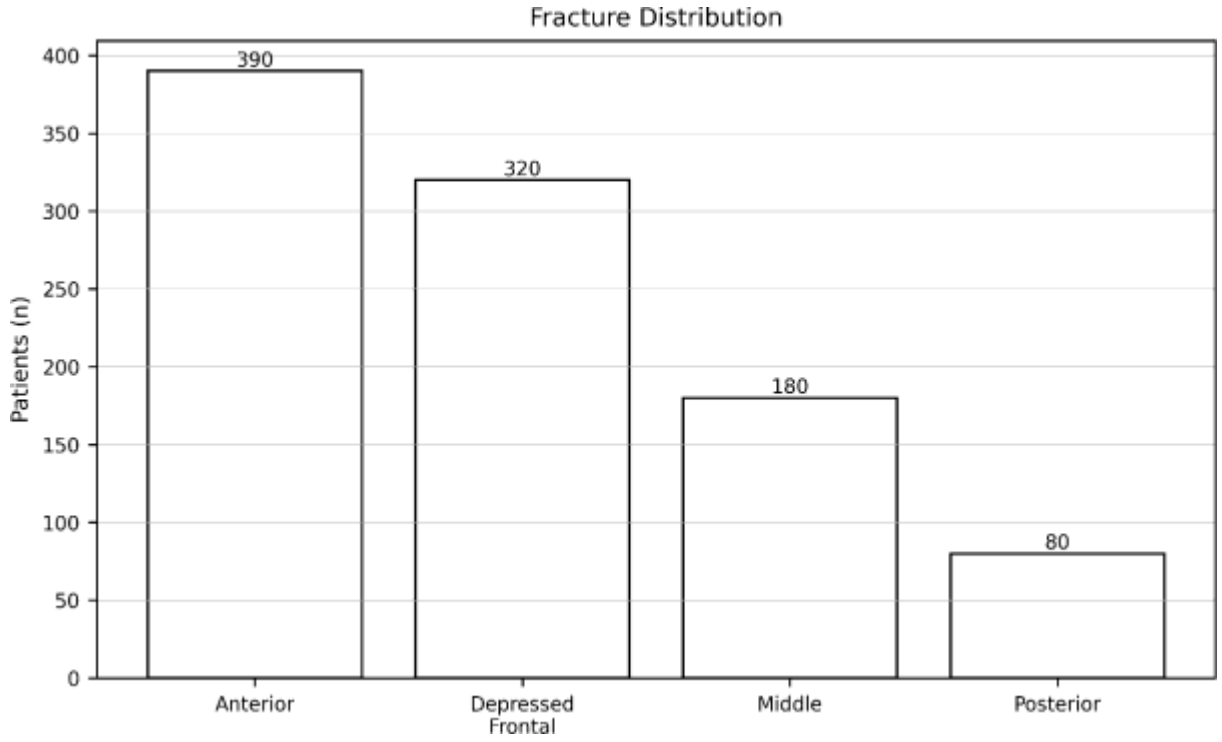

Figure.2

Discussion

This study provides a comprehensive overview of skull base fractures in a large cohort of patients injured in motorcycle accidents. The findings demonstrate a marked male predominance, with most patients sustaining moderate to severe head injuries. This
demographic pattern is consistent with previous studies reporting that young adult males are disproportionately affected by high-energy road traffic accidents because of greater exposure to motorcycle use and risk-taking behaviors (10-11).

Anterior skull base fractures were the most frequently observed injury pattern in the present cohort. This finding agrees with previous reports demonstrating that frontal impact mechanisms commonly involve the anterior cranial fossa because of its relatively thin osseous structure and close anatomical relationship with the frontal sinus and ethmoid complex (12-13). Disruption of the dura in this region predisposes patients to cerebrospinal fluid (CSF) leakage and increases the risk of intracranial infectious complications (14-15).

More than half of the patients presented with rhinorrhea, making it the most common clinical manifestation in this study. This observation is consistent with previous investigations identifying CSF rhinorrhea as the predominant presentation of anterior skull base fractures (6–8). Persistent CSF leakage is clinically significant because it provides a direct communication between the extracranial environment and the subarachnoid space, thereby increasing the risk of bacterial meningitis and frequently necessitating prolonged observation or surgical repair when

conservative management is unsuccessful (16-17)

Most patients sustained moderate or severe injuries, emphasizing the considerable clinical burden associated with motorcycle-related skull base trauma. These findings underscore the importance of prompt radiological evaluation, careful neurological monitoring, and multidisciplinary management involving neurosurgeons, trauma surgeons, otolaryngologists, neuroradiologists, and critical care specialists to optimize patient outcomes (10-17).

Although this study provides valuable epidemiological data regarding fracture morphology and clinical presentation, several limitations should be acknowledged. The retrospective design may have introduced selection and information bias, while detailed follow-up regarding neurological recovery, cranial nerve function, and long-term complications was not consistently available. In addition, the absence of multivariable statistical analysis precluded adjustment for potential confounding variables, limiting the ability to identify independent predictors of clinical outcomes (18).

Future prospective, multicenter studies incorporating standardized imaging protocols, long-term neurological follow-up, and multivariate risk analysis are warranted to identify predictors of persistent CSF leakage, post-traumatic meningitis, cranial nerve dysfunction, and functional recovery. Such studies would provide stronger evidence for developing standardized management algorithms for patients with skull base fractures (16-17-18).

Conclusion

Motorcycle-related skull base fractures are associated with considerable morbidity and predominantly involve the anterior cranial fossa. Most patients sustain moderate-to-severe injuries, and CSF rhinorrhea represents the most frequent clinical manifestation. Prompt recognition, high-quality CT imaging, and multidisciplinary management are essential for reducing complications and improving clinical outcomes. Prospective studies are needed to further clarify prognostic factors and optimize treatment strategies.

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