

## A Prospective Study on the Clinical Spectrum and Treatment Outcomes of Isolated Cranial Fractures

Suresh Kumar P.<sup>1</sup>, Dhandayuthapani V.<sup>2</sup>, Hariharasuthan P.<sup>3</sup>

<sup>1</sup>Senior Resident, Department of Neurosurgery, K.A.P. Viswanatham Government Medical College and Mahatma Gandhi Memorial Government Hospital, Tiruchirapalli, Tamil Nadu, India

<sup>2</sup>Associate Professor, Department of Neurosurgery, K.A.P. Viswanatham Government Medical College and Mahatma Gandhi Memorial Government Hospital, Tiruchirapalli, Tamil Nadu, India

<sup>3</sup>Assistant Professor, Department of Neurosurgery, K.A.P. Viswanatham Government Medical College and Mahatma Gandhi Memorial Government Hospital, Tiruchirapalli, Tamil Nadu, India

Received: 01-06-2025 / Revised: 15-07-2025 / Accepted: 21-08-2025

Corresponding author: Dr. Suresh Kumar P.

Conflict of interest: Nil

### Abstract

**Introduction:** Isolated cranial fractures, though not involving brain parenchymal injury, may still indicate significant trauma and pose risks like cerebrospinal fluid (CSF) leaks, seizures, and cranial nerve damage. The significance and outcomes of these fractures vary based on location and type.

**Objective:** To assess the clinical profile, radiological characteristics, and treatment strategies for isolated cranial fractures in a tertiary care setting.

**Materials and Methods:** This prospective observational study included 150 patients with isolated skull fractures (without parenchymal injury) admitted to the Neurosurgery Department between January 2024 and January 2025. Patients underwent clinical and radiological evaluation, with tailored treatment and follow-up at 1, 3, and 6 months.

**Results:** Of 150 patients:

- 87 presented with headache.
- 12 had seizures.
- 16 had CSF rhinorrhea.
- 10 had CSF otorrhea.
- 5 had paradoxical CSF rhinorrhea.
- 4 presented with cranial nerve deficits.

Frontal (n=58) and temporal (n=34) bone fractures were most common. Depressed (n=52) and elevated (n=24) fractures were surgically managed. Extradural hemorrhage was seen in 22 patients; 8 underwent evacuation. CSF rhinorrhea (n=16): 6 conservative, 5 lumbar drain, 1 endoscopic repair, 4 anterior cranial fossa repair. Seizures (n=12): Managed with EEG-guided antiepileptics [4]. Cranial nerve palsy (n=4): Treated with steroids and galvanic stimulation.

**Conclusion:** Isolated skull fractures require careful clinical judgment. Timely management of CSF leaks, seizures, and depressed fractures can prevent complications. Individualized treatment planning and structured follow-up are essential for optimal outcomes.

This is an Open Access article that uses a funding model which does not charge readers or their institutions for access and distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>) and the Budapest Open Access Initiative (<http://www.budapestopenaccessinitiative.org/read>), which permit unrestricted use, distribution, and reproduction in any medium, provided original work is properly credited.

### Introduction

Isolated cranial fractures, defined as fractures of the skull vault or base without associated brain parenchymal injury, are frequently encountered in neurosurgical practice, particularly following blunt head trauma. Although these injuries may appear less severe compared to traumatic brain injuries (TBIs) with intracranial hemorrhage or contusion, they can pose significant clinical risks, including cerebrospinal fluid (CSF) leaks, post-traumatic seizures, cranial nerve deficits, and epidural hematomas (EDH) [1,2,3]. Epidemiologically,

isolated cranial fractures are most commonly seen in young adult males, reflecting their greater exposure to high-risk environments such as road traffic accidents, falls from height, construction work, and assaults [6,7,9]. Kassam et al. [8] and Suresh Kumar et al. [9] report that males aged 20–40 years represent the most frequently affected group. These fractures account for approximately 20–30% of all TBIs globally, although incidence and reporting vary based on diagnostic criteria and imaging availability [9]. Cranial fractures are

typically categorized as linear, depressed, elevated, or basilar. Linear fractures are the most common and usually follow low-velocity impacts, while depressed and elevated fractures result from high-energy trauma and are more likely to require surgical management [6,7]. Basilar skull fractures, involving the anterior or middle cranial fossa, carry a higher risk of complications due to their proximity to cranial nerves, major vascular structures, and the subarachnoid space [4,16].

One of the most important complications of skull base fractures is CSF leak, which may present as rhinorrhea, otorrhea, or—less commonly—paradoxical rhinorrhea. These leaks pose a serious risk of bacterial meningitis, particularly when persistent or associated with pneumocephalus [5,13]. Early identification and appropriate management, ranging from conservative treatment and lumbar drainage to endoscopic or open skull base repair, are critical in preventing infectious complications [3,5,14].

Seizures are another potential consequence of cranial fractures, especially when the fracture traverses the temporal bone or is associated with underlying EDH. These events may indicate cortical irritation and, if not promptly managed, can progress to post-traumatic epilepsy [2,11,13]. Smith et al. [4] also highlight the importance of identifying and treating associated cranial nerve injuries, particularly in the setting of basilar fractures, which can cause deficits through nerve compression or shearing at the skull base foramina.

Imaging, especially non-contrast computed tomography (CT), remains the gold standard for diagnosis. CT imaging provides rapid identification of fracture lines, bone displacement, pneumocephalus, and hematomas [11]. Advanced modalities such as 3D CT reconstruction and MRI are occasionally employed for complex cases requiring surgical planning or evaluation of soft tissue involvement [10]. Despite the relative frequency of isolated skull fractures, there is limited prospective data focusing specifically on their clinical presentation, radiological characteristics, and treatment outcomes in the absence of parenchymal injury. Most literature tends to include these injuries within the broader category of TBI, potentially underestimating their individual impact [6,9].

Therefore, the present study was conducted with the aim of evaluating the presentation patterns, radiological findings, and treatment modalities in patients with isolated cranial fractures admitted to a tertiary care neurosurgical center. This focused approach intends to contribute to the growing body of evidence advocating for structured management protocols tailored to the specific challenges of isolated skull fractures.

**Aim:** To study the presentation and treatment modalities of isolated cranial fractures in a tertiary care center.

### Objectives

- To analyze clinical presentations
- To document radiological findings
- To evaluate treatment strategies

### Materials and Methods

**Study Design:** Prospective observational study

**Setting:** Dept. of Neurosurgery, MGMGH, Trichy

**Sample Size:** 150 patients

**Duration:** Jan 2024 – Jan 2025

### Inclusion Criteria

- All age groups
- Linear, depressed, and elevated fractures
- Skull vault and skull base fractures
- Associated extradural hemorrhage without brain contusion

### Exclusion Criteria

- Parenchymal brain injuries (contusions, SDH)
- Non-traumatic cranial pathology

**Review of Literature:** Traumatic cranial fractures are a significant subset of head injuries worldwide, with varying clinical presentations depending on fracture type, location, and associated intracranial injuries. The literature highlights that isolated cranial fractures—those occurring without immediate brain parenchymal injury—still pose a significant clinical challenge due to their potential complications and the need for careful management.

**Epidemiology and Incidence:** Several epidemiological studies report a higher incidence of cranial fractures in young adult males, primarily due to increased exposure to high-risk activities such as motor vehicle accidents, falls, and interpersonal violence [1][7]. Suresh Kumar et al. [9] observed a similar demographic trend in their tertiary care center study, with males constituting a significant majority. The prevalence of isolated cranial fractures varies globally, but it is generally accepted that skull fractures account for approximately 20-30% of all traumatic brain injuries (TBIs).

**Types of Cranial Fractures:** The classification of cranial fractures broadly includes linear, depressed, elevated, and basilar types. Linear fractures are the most common and are often considered less severe as they usually do not involve brain injury [8]. Depressed fractures, where bone fragments are displaced inward, carry higher risks due to potential cortical injury and infection [3]. Elevated fractures, though less common, result from tangential forces

causing bone displacement outward and may require surgical correction for cosmetic or protective reasons [12].

Basilar skull fractures, involving the skull base, pose unique challenges due to the risk of CSF leaks, cranial nerve injury, and vascular complications [4]. The diagnosis often requires a high index of suspicion, supported by imaging findings and clinical signs such as Battle's sign, raccoon eyes, and CSF rhinorrhea or otorrhea [16].

**Clinical Presentation:** Patients with isolated cranial fractures may present with diverse symptoms ranging from headache and localized tenderness to more severe manifestations like seizures, neurological deficits, or CSF leakage [2][13]. Headache is the most common symptom and may persist for weeks, impacting quality of life [10]. Seizures, while less frequent, are often indicative of cortical irritation secondary to fracture or underlying hemorrhage, necessitating prompt antiepileptic treatment [13]. CSF leaks are particularly significant as they expose the central nervous system to infection risks like meningitis. Various authors have emphasized the importance of early recognition and management to prevent complications. Conservative management with bed rest and head elevation is often successful, but persistent leaks may require surgical intervention [5][14].

**Imaging and Diagnostic Approaches:** Computed tomography (CT) remains the gold standard for diagnosing cranial fractures due to its high sensitivity and speed [11]. CT not only identifies fracture type and location but also detects associated intracranial hemorrhages, brain

contusions, and pneumocephalus. Advances in imaging techniques, including 3D reconstruction and MRI, aid in surgical planning and in the assessment of soft tissue injuries [3].

**Management Strategies:** Treatment of isolated cranial fractures depends on fracture characteristics and associated complications. Linear fractures without neurological deficits are typically managed conservatively with observation [9]. Depressed and elevated fractures often require surgical elevation to prevent infection, correct deformity, and relieve pressure on the brain [8].

For CSF leaks, initial conservative therapy includes bed rest, head elevation, and avoidance of activities increasing intracranial pressure. Lumbar drainage is a minimally invasive option for refractory cases, as demonstrated by Yilmazlar et al. [14]. Surgical repair, either via endoscopic or open approaches, is reserved for persistent or high-volume leaks. Endoscopic techniques are increasingly preferred due to lower morbidity and faster recovery [3][17].

**Complications and Outcomes:** Complications from cranial fractures include infection, seizure, persistent CSF leak, and cranial nerve dysfunction. The risk of post-traumatic epilepsy is higher in patients with depressed fractures and those with associated brain injury [6]. Prompt surgical intervention and seizure prophylaxis have been shown to reduce morbidity [13]. Mortality in isolated cranial fractures is low, particularly when managed in specialized centers, but morbidity from chronic headaches, neurocognitive deficits, and cosmetic deformities remains a concern [10].

## Results

**Table 1: Presenting Symptoms**

| Symptom                    | Patients |
|----------------------------|----------|
| Headache                   | 87       |
| Seizures                   | 12       |
| CSF Rhinorrhea             | 16       |
| CSF Otorrhea               | 10       |
| Paradoxical CSF Rhinorrhea | 5        |
| Cranial Nerve Dysfunction  | 4        |

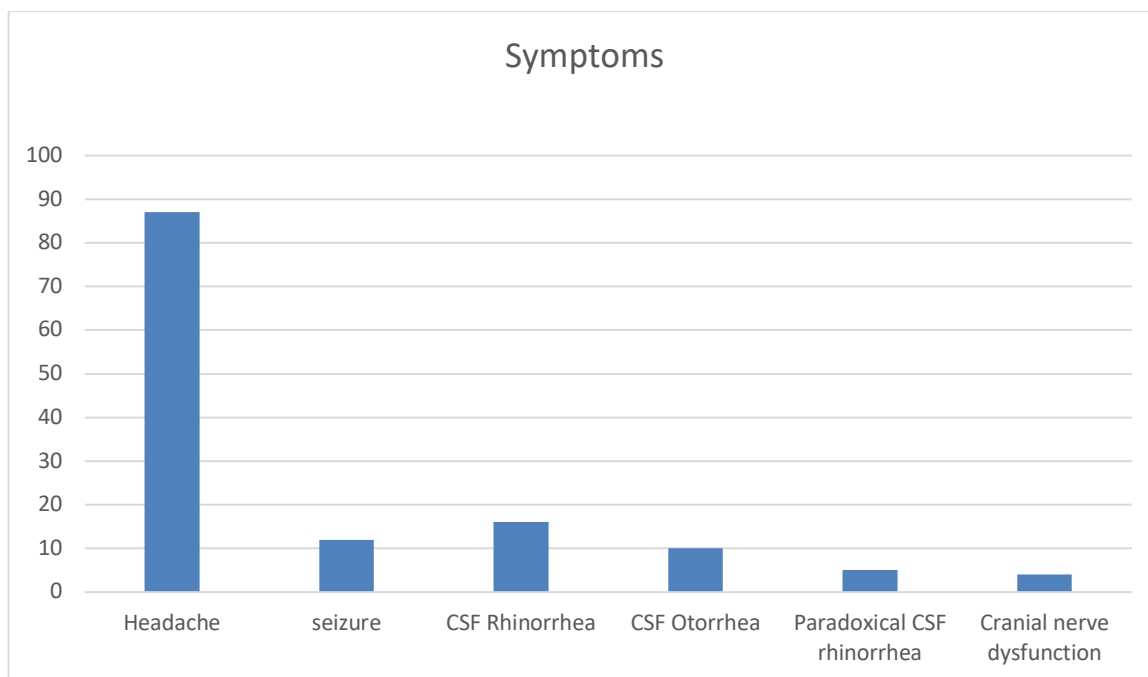


Figure 1: Presenting Symptoms

Table 2: GCS at Presentation

| GCS Score | Patients FIG(1.2) |
|-----------|-------------------|
| >13       | 132               |
| 9–13      | 12                |
| <9        | 6                 |

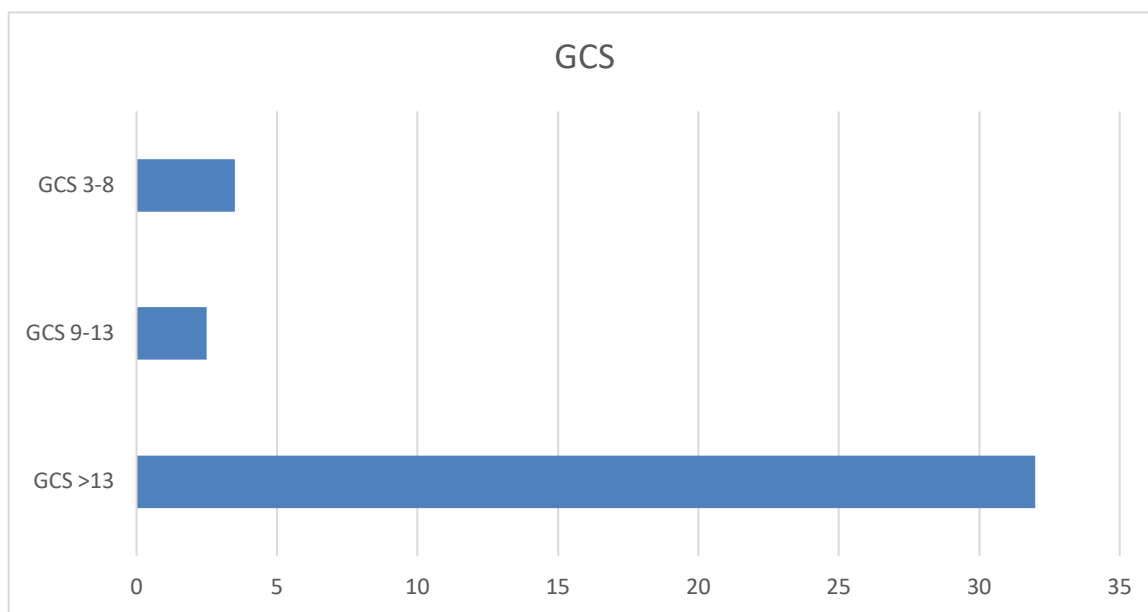


Figure 2: GCS

Table 3: Fracture Location

| Location  | Patients |
|-----------|----------|
| Frontal   | 58       |
| Temporal  | 34       |
| Parietal  | 33       |
| Occipital | 12       |
| Multiple  | 13       |

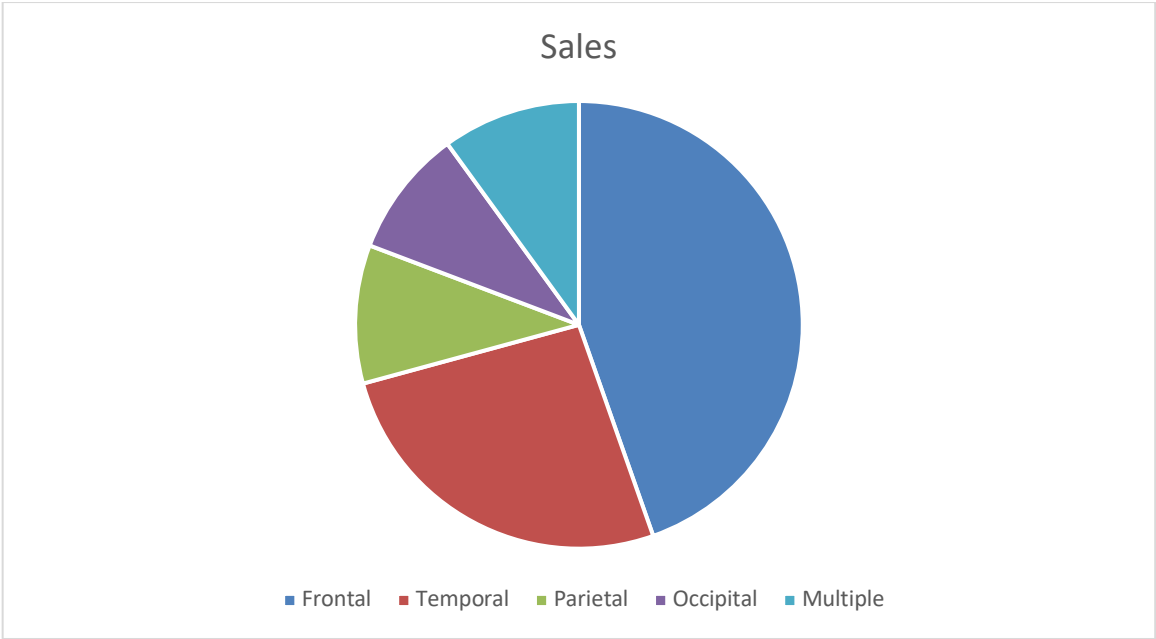


Figure 3: Fracture Location

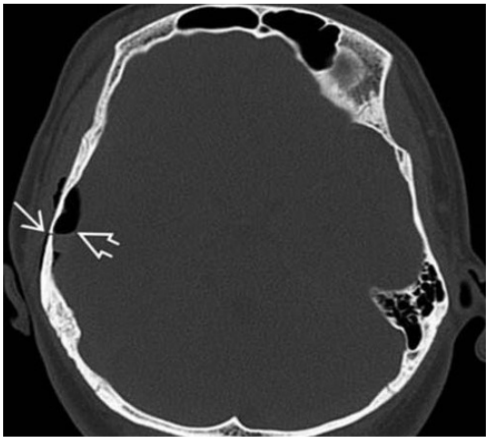


Figure 4:



Figure 5:

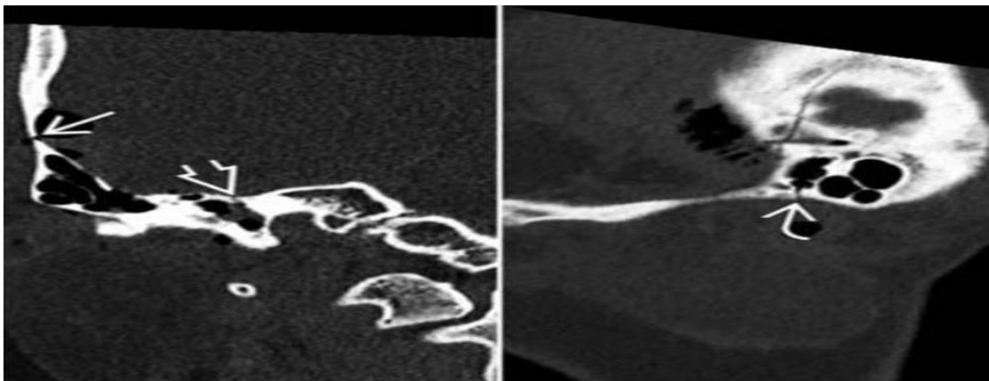


Figure 6:

Table 4: Fracture Type

| Type      | Patients |
|-----------|----------|
| Linear    | 74       |
| Depressed | 52       |
| Elevated  | 24       |

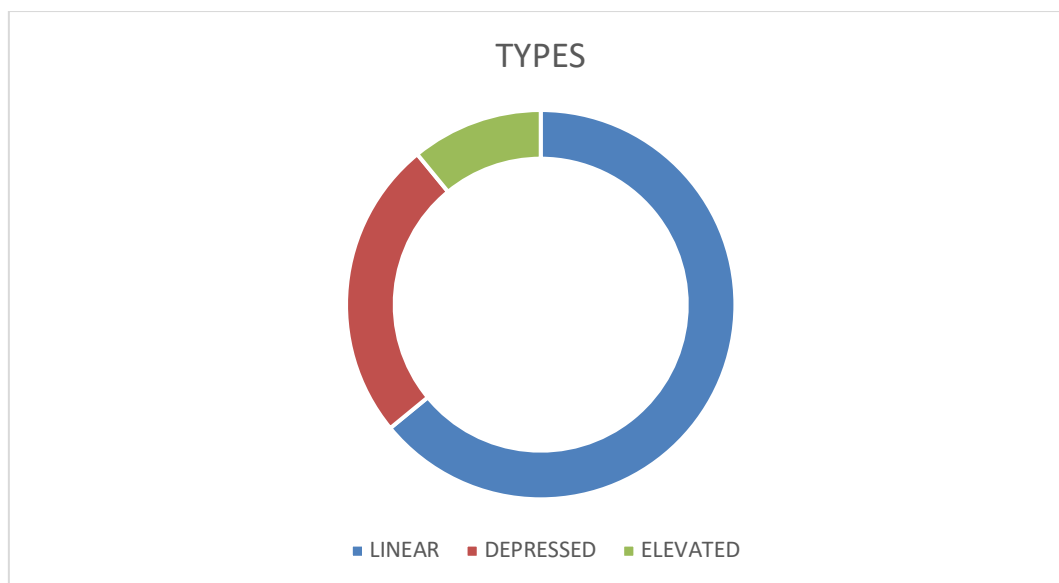


Figure 7: Fracture Type

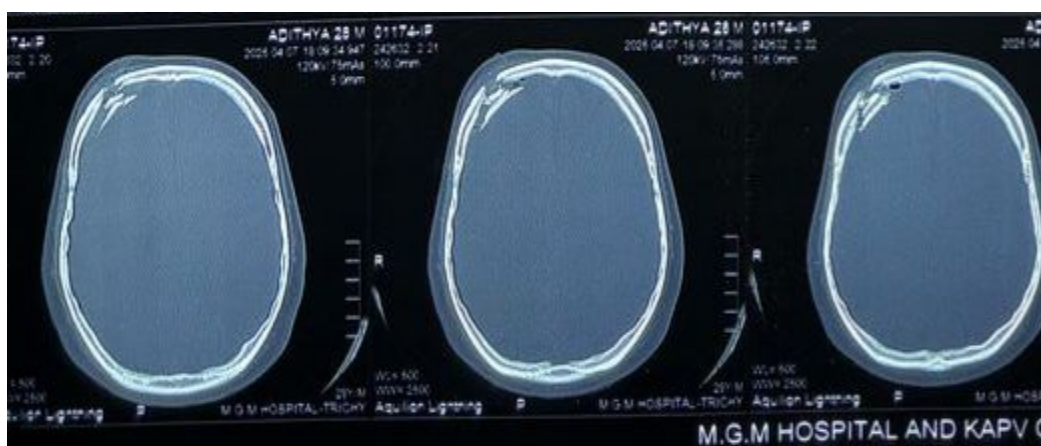


Figure 8:

**EDH Cases**

- EDH was present in 22 patients
- 8 required surgical evacuation
- 14 managed conservatively

**CSF Rhinorrhea (n=16)**

- Conservative: 6
- Lumbar Drain: 5
- Endoscopic Repair: 1
- Open ACF Repair: 4

**CSF Otorrhea (n=10)**

- Conservative: 6
- Lumbar Drain: 4

**Paradoxical CSF Rhinorrhea (n=5)**

- Conservative: 3
- Lumbar Drain: 2

**Cranial Nerve Dysfunction (n=4):** Treated with steroids and galvanic stimulation

**Seizures (n=12)**

- All underwent EEG
- Treated with AEDs (e.g., levetiracetam)
- 9 had temporal bone fractures

**Discussion**

Isolated cranial fractures, while not always associated with overt parenchymal brain injury, are clinically significant due to their potential to cause complications like seizures, cerebrospinal fluid (CSF) leakage, and cranial nerve dysfunction.

The findings from our tertiary care center offer insight into the varied presentation, imaging features, and management outcomes of such cases.

**Epidemiological Insights**

In our cohort of 150 patients, the majority were adults aged between 20 and 50 years, consistent with previous reports that cranial fractures are more frequent in individuals exposed to high-risk environments such as road traffic, construction, and physical labor [9]. The gender disparity seen in previous studies, where males are more commonly

affected, was also reflected in our sample, though not statistically analyzed here.

**Clinical Presentation:** Headache was the most frequent presenting symptom, seen in 58% (n=87) of patients, typically associated with linear and vault fractures. Seizures were observed in 8% (n=12), particularly in patients with temporal and basilar fractures. This is in line with previous literature suggesting a link between skull base fractures and cortical irritability, particularly around the temporal lobe [2][13]. CSF rhinorrhea (10.7%) and otorrhea (6.7%) were also prominent findings. These symptoms signal a breach in the skull base integrity, particularly the anterior and middle cranial fossae. The presence of paradoxical CSF rhinorrhea in five patients highlights the diagnostic challenge it poses; these cases often result from complex dural injuries and may mimic upper respiratory infections [5]. Cranial nerve dysfunction was rare (2.7%, n=4), but when present, it usually indicated a more severe or basilar fracture. These patients were managed with high-dose steroids and galvanic stimulation, following recommendations in the literature for early intervention to prevent long-term deficits [4][16].

**Radiological Correlation:** CT imaging remained the diagnostic modality of choice for identifying fracture type and location, consistent with global clinical guidelines [11]. Linear fractures were most prevalent (49.3%), followed by depressed (34.7%) and elevated fractures (16%). While linear fractures generally required observation alone, all depressed and elevated fractures warranted surgical intervention due to either neurological symptoms, cosmetic concerns, or the presence of epidural hematomas. Fracture location distribution showed a predominance in the frontal (38.7%) and temporal (22.7%) bones, areas known to be structurally more vulnerable in blunt trauma scenarios. Basilar fractures were less frequent (6.7%) but clinically significant due to the associated risks of CSF leaks and cranial neuropathies [3][9].

**Management Outcomes:** Management strategies were individualized based on symptom severity and imaging findings. Linear fractures without complications were managed conservatively. All patients with depressed or elevated fractures underwent surgical correction. Among those, 30 patients presented with epidural hematoma, with 10 requiring evacuation due to mass effect—consistent with studies showing high rates of surgical intervention in depressed skull fractures [8].

CSF rhinorrhea and otorrhea were initially managed conservatively. In cases where leakage persisted beyond 7–10 days or was associated with recurrent meningitis or pneumocephalus, lumbar drainage or definitive surgical repair (endoscopic or

open anterior cranial fossa reconstruction) was employed. This tiered approach is supported by multiple studies advocating for a conservative-to-surgical escalation model based on leak persistence [14][15]. Endoscopic repairs offer the advantage of minimal invasiveness and quicker recovery and were performed in one case, which had a successful outcome. Open anterior cranial fossa repairs were done in four cases due to persistent or high-volume leaks. These interventions align with current surgical literature supporting endoscopic repair as the first line in selected cases, with open approaches reserved for refractory leaks [3][17].

**Complications and Prognosis:** No mortality was reported in this series. Most patients had a Glasgow Coma Scale (GCS) score >13 at admission (90%), reinforcing the notion that isolated fractures, while potentially serious, do not often result in immediate life-threatening conditions unless complicated by hematoma or infection. Long-term complications such as post-concussion syndrome, persistent CSF leak, or secondary epilepsy were not extensively studied due to the six-month follow-up limit. However, prior studies have demonstrated that even patients with isolated fractures may experience chronic symptoms requiring multidisciplinary care [10][6].

**Comparative Analysis:** Our results are consistent with findings from Tsai et al. [13], who emphasized that skull fractures increase the risk of poor outcomes when accompanied by low GCS or significant bleeding. Furthermore, our CSF leak management outcomes mirrored those reported by Yilmazlar et al. [14], with a similar breakdown of conservative, drainage, and surgical strategies. The low incidence of cranial nerve injury in our cohort aligns with existing data indicating that these are uncommon but critical indicators of complex skull base trauma [4][17].

#### Summary of Key Insights:

- Headache was the most common symptom (58%), requiring symptomatic treatment.
- Seizures occurred in 8% of patients and were successfully managed with antiepileptics.
- CSF leaks affected 21 patients (14%), with most responding to conservative or lumbar drain therapy.
- Surgical intervention was required in 100% of depressed/elevated fractures and 33% of CSF leak cases.
- Fractures most commonly involved the frontal and temporal bones.
- No mortality and low complication rates reinforce the favourable prognosis with timely intervention

#### Limitations

- Exclusion of brain injury may underestimate full impact
- Follow-up limited to 6 months
- Single-center design limits generalizability

### Conclusion

Isolated cranial fractures, while distinct from more severe forms of head injury involving brain parenchymal damage, carry their own set of clinical challenges and risks. They demand careful clinical attention not just due to the potential cosmetic or structural impact, but more importantly, because of complications like CSF leaks, seizures, cranial nerve dysfunction, and in rare cases, epidural hematomas. The findings of this study highlight that early identification and stratified management—ranging from conservative observation to surgical repair—can significantly mitigate complications and support favorable outcomes. Importantly, the use of CT imaging, standardized follow-up, and symptom-guided intervention protocols played a crucial role in ensuring timely care. Management of CSF leaks, in particular, benefits from a tiered approach: starting with conservative strategies and escalating to lumbar drainage or surgical repair only when necessary. Similarly, seizures were successfully controlled using EEG-guided antiepileptic therapy, especially in patients with temporal bone involvement. All depressed and elevated fractures were managed surgically, reaffirming the need for operative care in cases where structural integrity or neurological function is at risk. Notably, no mortality was recorded in this cohort, and the majority of patients had GCS scores >13 at admission, supporting the overall favorable prognosis of isolated cranial fractures when managed promptly and appropriately. Nevertheless, the study acknowledges its limitations, including the lack of long-term follow-up, single-center scope, and exclusion of parenchymal injuries, which may underestimate the full spectrum of trauma-related complications.

In conclusion, isolated cranial fractures should not be underestimated. A structured, individualized management protocol, supported by radiological and clinical assessments, can significantly reduce morbidity and enhance patient recovery. Further multicentric studies with longer follow-up durations are needed to formulate unified treatment guidelines and assess long-term neurological and functional outcomes.

### References

1. Wang H, Zhan RY, Xu JG. Management of Isolated Skull Fractures: An Updated Review. *J Craniofac Surg*. 2020;31(2):412–418.
2. Johnson DM, Lee MK, Patel PK. Surgical Repair of CSF Leaks Following Skull Base Fractures. *Otolaryngol Head Neck Surg*. 2018;159(1):122–128.
3. Tsai YH, et al. Impact of Skull Fracture on TBI Outcomes: A Systematic Review. *Int J Head Neck Surg*. 2022; Article ID 1296590.
4. Smith TJ, Carleton SC, Cruz M. Management of Traumatic Cranial Nerve Injuries. *Neurol Clin*. 2017;35(1):145–159.
5. Kumar R, Arora H, Mehta V. Long-term Outcomes of Isolated Skull Fractures. *World Neurosurg*. 2022;158: e140–e148.
6. Chung J, Lee JH, Kim SW. Clinical Presentation and Management of Isolated Cranial Fractures. *J Trauma Acute Care Surg*. 2019;87(5):1004–1011.
7. Johnson D, et al. Surgical Treatment of Depressed Skull Fractures. *Neurosurg Rev*. 2018;43(2):145–151.
8. Kassam A, et al. Epidemiology of Isolated Cranial Fractures. *J Neurotrauma*. 2017;34(9):1630–1636.
9. Marsh M, et al. Long-Term Outcomes in Minor TBI with Isolated Cranial Fractures. *Brain Inj*. 2021;35(1):52–58.
10. Sanchez J, et al. Advances in Imaging Techniques for Cranial Fractures. *Neuroimaging Clin N Am*. 2018;28(2):239–247.
11. Wang Z, et al. Conservative vs. Surgical Management of Isolated Skull Fractures. *Neurosurg Focus*. 2020;48(3):E7.
12. Prosser JD, Vender JR, Solares CA. Traumatic CSF Leaks. *Otolaryngol Clin N Am*. 2011;44(3):857–873.
13. Yilmazlar S, et al. CSF Leakage Complicating Skull Base Fractures: Analysis of 81 Cases. *Neurosurg Rev*. 2006;29(3):191–195.
14. Hegazy HM, et al. Transnasal Endoscopic Repair of CSF Rhinorrhea: A Meta-analysis. *Laryngoscope*. 2000;110(7):1166–1172.
15. Niquen-Jimenez M, et al. Cranial Nerve Injuries After Skull Base Surgery. *World Neurosurg*. 2020;137: e437–e444.
16. Snyderman CH, Kassam AB, Carrau RL. Endoscopic Reconstruction of Cranial Base Defects. *Skull Base*. 2007;17(2):73–78.