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INCIDENCE OF CEREBROSPINAL FLUID RHINORRHEA IN PATIENTS WITH SKULL BASE FRACTURES

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Abstract

Background: *Skull base fractures account for roughly 4% of head injuries, and post-traumatic cerebrospinal fluid (CSF) rhinorrhea is among their most consequential complications because of the substantial risk of bacterial meningitis. Pakistani incidence estimates vary widely, from 3% to over 60%, leaving local clinicians without a reliable reference figure.*

Objectives: *To determine the 30-day cumulative incidence of post-traumatic CSF rhinorrhea among adults with skull base fractures sustained in road traffic accidents.*

Methods: *This prospective observational cohort study was conducted at the Department of Neurosurgery, Punjab Institute of Neurosciences, Lahore, from August 2024 to February 2025. Using non-probability consecutive sampling, 150 adults (≥ 18 years) with CT-confirmed skull base fractures from road traffic accidents were enrolled. CSF rhinorrhea was confirmed by combined bedside testing (halo sign, reservoir sign, glucose strip) and radiological evaluation, with 30-day follow-up. Data were analysed in IBM SPSS version 26 using descriptive statistics, Pearson chi-square, and Fisher's exact tests; $p \leq 0.05$ was considered significant.*

Results: *The 30-day cumulative incidence was 38.67% (58/150; 95% CI 31.25–46.65%). Mean age was 41.64 ± 5.38 years; 69.33% were male and 80% involved motorcycle collisions. Anterior cranial fossa fracture ($p=0.010$), raccoon eyes ($p<0.001$), and pneumocephalus ($p<0.001$) emerged as significant predictors. Conservative management succeeded in 81.03% of cases; the remaining 18.97% required surgery, predominantly trans-nasal endoscopic (72.73%).*

Conclusions: *A standardised local 30-day incidence of 38.67% provides a reference to guide clinical counselling and resource planning in Pakistani neurosurgical practice.*

INTRODUCTION

Skull base fractures (SBF) involve the frontal, ethmoid, sphenoid, temporal, or occipital bones of the cranial floor and most often result from high-velocity blunt trauma. Globally, SBF account for around 4% of head injuries and up to 21% of all skull fractures, with road traffic accidents responsible for 80–85% of cases [1, 2]. Cerebrospinal fluid (CSF) rhinorrhea, the leakage of CSF through the nose via abnormal communication between the subarachnoid space and the sinonasal cavity, is among the most

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consequential complications of SBF, owing to the firm dural adherence to the anterior cranial fossa floor [3, 4].

Reported incidence varies widely, from 4% in a large institutional cohort [5] to 17.5–20.95% in Indian series [6, 7] and up to 30% in older reports, reflecting differences in diagnostic criteria, CT sensitivity, observation duration, and trauma severity [1, 5, 6]. Approximately half of leaks present within 48 hours of injury and up to 95% within three months, with delayed leaks following resolution of cerebral oedema, dissolution of haematoma plugs, or mucosal herniation [3, 4, 8]. Untreated leaks carry a meningitis risk of up to 25.7% and have caused fatal meningoencephalitis years after trauma [7, 8]. Management is initially conservative bed rest, head elevation, stool softeners, avoidance of straining, and CSF diversion when required with a 7- to 30-day trial before considering trans-nasal endoscopic or trans-cranial repair [9].

Robust prospective Pakistani data remain scarce, and existing figures are strikingly inconsistent: 3.2% within a 48-hour window (Qazi et al. [10]), 10% in a Karachi cross-sectional cohort (Qureshi et al. [11]), while Mahmood et al. focused on conservative-management outcomes without population-level incidence [12]. None have employed a prospective design with a standardised adult cohort and a clinically meaningful observation window capturing both immediate and delayed leaks. Pakistani surveillance further shows that road traffic injuries account for over half of traumatic brain injury admissions, with motorbike impacts disproportionately affecting young adult males, a risk profile that may differ from higher-income cohorts [13]. The result is a clinically important blind spot, with current Pakistani estimates ranging from 3% to over 60% too wide to support evidence-based bedside or institutional decisions.

The present study was therefore designed to generate a defensible local incidence estimate of CSF rhinorrhea in a homogeneous adult post-traumatic cohort observed prospectively over a clinically meaningful 30-day window, and to simultaneously document the patterns of conservative and surgical management employed at a major Pakistani tertiary-care neurosurgical centre. The findings are intended to inform institutional protocols, guide observation and resource planning, and provide the foundation for future multi-centre work that can ultimately translate into context-specific national guidelines.

MATERIALS AND METHODS

This prospective observational cohort study was conducted at the Department of Neurosurgery, Punjab Institute of Neurosciences (PINS), Lahore, from August 2024 to February 2025.

The study population comprised adult patients (≥ 18 years of either sex) presenting for the first time to the emergency or neurosurgical outpatient department of PINS with a post-traumatic skull base fracture after a road traffic accident and confirmed by computed tomography. Non-probability consecutive sampling was used to enrol every eligible patient presenting during the study period until the target was achieved.

Patients were excluded if the CSF leak was non-traumatic (spontaneous, tumour-related, or congenital), iatrogenic following prior surgery, if there was a history of previous skull base surgery, if consent was declined, or if follow-up was lost before completion of the 30-day window.

Skull base fracture was defined as a radiologically confirmed discontinuity of one or more cranial-base bones (frontal, ethmoid, sphenoid, temporal, or occipital) on non-contrast HRCT with thin-section bone-window reconstructions, classified by fossa involved [1, 5]. CSF rhinorrhea was defined as leakage of CSF through the nose via abnormal communication between the subarachnoid space and sinonasal cavity, presenting as clear watery nasal discharge [3, 4]. Onset was classified as immediate (≤ 48 hours) or delayed (> 48 hours within the 30-day window) [3, 4, 8].

Conservative management was first-line, continued for up to 30 days per the protocol of Tajelsir et al., comprising bed rest with head elevation (15–30°), stool softeners, avoidance of straining, and diuretics where indicated [9]. Surgical management was undertaken for leaks persisting beyond 30 days, recurrent leak, meningitis, tension pneumocephalus, or large (> 1 cm) defects with herniation [9, 14]. Approach was

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guided by defect site: trans-nasal endoscopic endonasal for cribriform plate, fovea ethmoidalis, ethmoid roof and sphenoid sinus defects; trans-cranial bifrontal craniotomy for posterior frontal-sinus wall, large or comminuted anterior fossa floor fractures, laterally inaccessible defects, or when concomitant pathology required open exposure [9, 14].

All adult patients presenting with a history of head trauma underwent non-contrast high-resolution computed tomography (HRCT) of the head with bone-window reconstruction (slice thickness ≤ 1 mm) as part of the standard institutional trauma workup. Patients in whom HRCT confirmed a skull base fracture and who fulfilled the eligibility criteria were enrolled prospectively. At enrolment, baseline data were recorded on a pre-designed structured proforma, including age, gender, mechanism of injury (with road traffic accidents further sub-categorised by colliding parties as motorcycle-versus-motorcycle, motorcycle-versus-auto-rickshaw, motorcycle-versus-car, motorcycle-versus-animal-drawn cart, car-versus-car, and car-versus-auto-rickshaw collisions), Glasgow Coma Scale at admission, and the anatomical site of the fracture. Clinical signs of skull base fracture namely Battle's sign (mastoid ecchymosis), raccoon eyes (periorbital ecchymosis), and CSF otorrhea were recorded. Associated intracranial injuries (extradural haematoma, subdural haematoma, intracerebral haematoma, cerebral contusion, traumatic subarachnoid haemorrhage, and pneumocephalus) and associated extracranial injuries (cervical spine injury, maxillofacial fractures, and other systemic injuries) were also documented.

Clinical suspicion of CSF rhinorrhea was raised by clear, watery nasal discharge with or without a salty postnasal drip. Beta-2 transferrin assay and computed tomography cisternography were unavailable; diagnosis was therefore established using a stepwise approach. Bedside testing comprised the halo (double-ring) test and reservoir sign, with a glucose strip on the discharge supportive at ≥ 30 mg/dL. Radiological confirmation used HRCT of the skull base, computed tomography of the paranasal sinuses with functional endoscopic sinus surgery protocol (CT-FESS), and magnetic resonance imaging (MRI) with a dedicated CSF rhinorrhea protocol (heavily T2-weighted thin-section coronal and sagittal sequences) to localise the leak and identify any meningoencephalocele. Diagnosis was confirmed when clinical suspicion was supported by at least one positive bedside test and corroborative CT-FESS or MRI evidence.

Confirmed cases were managed per the institutional protocol described above. Lumbar drain placement was used as a conservative adjunct for persistent or high-volume leaks (maintained 5–7 days, drainage ~10 mL/hour) and post-operatively after large-defect repairs. Meningitis suspected on fever, headache, neck stiffness, photophobia, or altered consciousness was confirmed by lumbar puncture and CSF analysis, and managed with empirical broad-spectrum intravenous antibiotics (third-generation cephalosporin with vancomycin) de-escalated by culture; documented meningitis with persistent leak was an absolute indication for surgical repair. Small non-tension pneumocephalus was managed conservatively (bed rest, head-end elevation, 100% oxygen via non-rebreather mask); tension pneumocephalus with mass effect or clinical deterioration prompted urgent surgical decompression and dural repair.

All patients irrespective of whether they were managed conservatively or surgically were followed for 30 days after discharge, with scheduled clinical assessments on day 7, day 14, and day 30 post-discharge. Patients unable to attend in-person follow-up were contacted telephonically on the corresponding dates. Patients who could not be reached after three documented attempts at any scheduled timepoint were classified as lost to follow-up and excluded from the final analysis.

Data were collected by direct clinical examination, imaging and operative-record review, and telephonic interview where required, and analysed in IBM SPSS Statistics version 26. Continuous variables (age, Glasgow Coma Scale) were summarised as mean ± SD with range, and categorical variables as frequencies and percentages. The 30-day incidence of CSF rhinorrhea was expressed as a percentage with 95% confidence interval. Bivariate associations

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with age group, gender, fracture site, clinical signs, and associated intracranial injuries were assessed using the Pearson chi-square test, with Fisher's exact test substituted where any expected cell count was below 5. A p-value ≤ 0.05 was considered statistically significant.

RESULTS

A total of 150 adults with post-traumatic skull base fractures from road traffic accidents were enrolled and followed for 30 days. Mean age was 41.64 ± 5.38 years (range 27–53); 108 patients (72.00%) were aged 31–45, 39 (26.00%) 46–60, and 3 (2.00%) 18–30. The cohort was 69.33% male (M:F ≈2.3:1). Motorcycle collisions accounted for 120 patients (80.00%), led by motorcycle-versus-car (28.00%), motorcycle-versus-motorcycle (25.33%), and motorcycle-versus-auto-rickshaw (16.00%). On HRCT, the anterior cranial fossa was the most frequent fracture site (50.00%), followed by middle (25.33%), multiple fossae (16.67%), and posterior (8.00%). Raccoon eyes were noted in 45 patients (30.00%) and Battle's sign in 15 (10.00%). Admission pneumocephalus was the most frequent associated intracranial finding (50.00%), followed by cerebral contusion (30.00%); other injuries are listed in Table 1.

Cerebrospinal fluid rhinorrhea was identified in 58 of 150 patients, corresponding to a 30-day cumulative incidence of 38.67% (95% CI 31.25-46.65%) (Figure 1), while 92 patients (61.33%) showed no evidence of CSF leak during the observation period. The detailed distribution of CSF rhinorrhea across baseline variables is summarised in Table 1.

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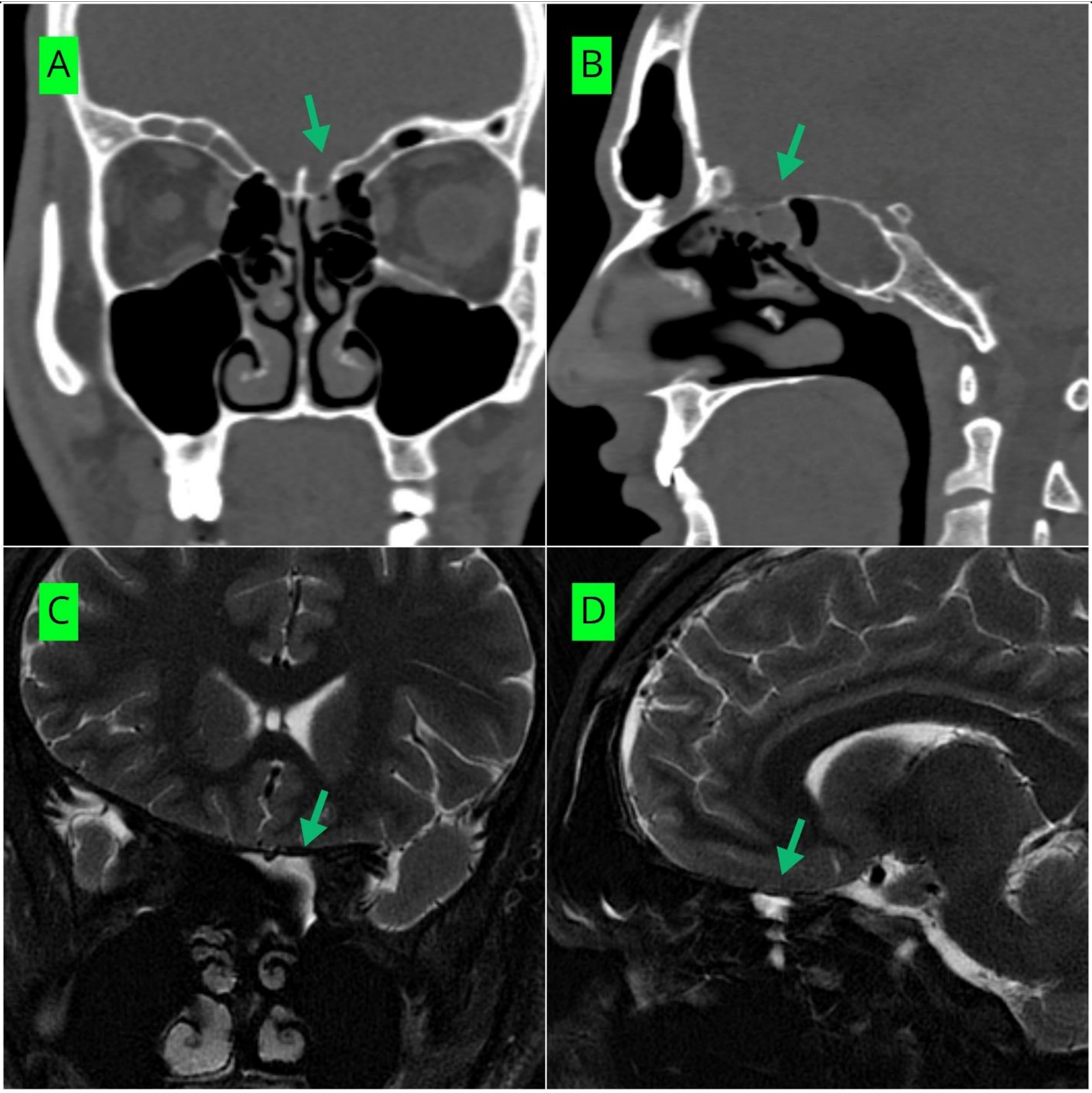

Figure 1: High-resolution CT and MRI demonstrating a post-traumatic anterior skull base defect with active CSF leak into the nasal cavity. Panels A (coronal) and B (sagittal) demonstrate the bony defect in the left half of the cribriform plate (green arrows). Panels C (coronal) and D (sagittal) show CSF leak into the nasal cavity (green arrows).

Three variables were significant predictors on bivariate analysis (Table 1): fracture site (χ^2 = 11.32, p = 0.010), with multiple-fossa (52.00%) and anterior cranial fossa (46.67%) fractures together accounting for 82.76% of leaks; raccoon eyes (χ^2 = 15.04, $p < 0.001$; 62.22% vs 28.57%); and admission pneumocephalus (χ^2 = 13.61, $p < 0.001$; 53.33% vs 24.00%). Age group, gender, mechanism of injury, Battle's sign, and cerebral contusion were not significantly associated (all $p > 0.05$).

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Table 1. Demographic, mechanism, fracture-site, and clinical characteristics of the cohort and their association with CSF rhinorrhea (n = 150).

Variable	Category	Total n (%)	CSF Rhinorrhea Present, n (%)	CSF Rhinorrhea Absent, n (%)	p-value*
Total cohort		150 (100.00)	58 (38.67)	92 (61.33)	-
Age group (years)	18–30	3 (2.00)	1 (33.33)	2 (66.67)	0.281
	31–45	108 (72.00)	46 (42.59)	62 (57.41)	
	46–60	39 (26.00)	11 (28.21)	28 (71.79)	
Gender	Male	104 (69.33)	43 (41.35)	61 (58.65)	0.311
	Female	46 (30.67)	15 (32.61)	31 (67.39)	
Mechanism of injury (RTA)	Motorcycle-vs-car	42 (28.00)	18 (42.86)	24 (57.14)	0.850
	Motorcycle-vs-motorcycle	38 (25.33)	15 (39.47)	23 (60.53)	
	Motorcycle-vs-auto-rickshaw	24 (16.00)	9 (37.50)	15 (62.50)	
	Car-vs-car	18 (12.00)	8 (44.44)	10 (55.56)	
	Motorcycle-vs-cart	16 (10.67)	4 (25.00)	12 (75.00)	
	Car-vs-auto-rickshaw	12 (8.00)	4 (33.33)	8 (66.67)	
Fracture site	Anterior cranial fossa	75 (50.00)	35 (46.67)	40 (53.33)	**0.010**
	Middle cranial fossa	38 (25.33)	8 (21.05)	30 (78.95)	
	Multiple fossae	25 (16.67)	13 (52.00)	12 (48.00)	
	Posterior cranial fossa	12 (8.00)	2 (16.67)	10 (83.33)	

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Clinical signs	Raccoon eyes	45 (30.00)	28 (62.22)	17 (37.78)	**<0.001**
	Battle's sign	15 (10.00)	4 (26.67)	11 (73.33)	0.314
Associated injuries	Pneumocephalus (admission)	75 (50.00)	40 (53.33)	35 (46.67)	**<0.001**
	Cerebral contusion	45 (30.00)	22 (48.89)	23 (51.11)	0.092

**Pearson chi-square test of independence; Fisher's exact test was used where any expected cell count was less than 5. †Other associated injuries comprise acute subdural haematoma (38, 25.33%), maxillofacial fractures (42, 28.00%), traumatic subarachnoid haemorrhage (23, 15.33%), extradural haematoma (23, 15.33%), other systemic injuries included limb, chest, abdomen (23, 15.33%), intracerebral haematoma (15, 10.00%), and cervical spine injury (11, 7.33%); counts are non-mutually-exclusive.*

Among the 58 leak patients, 34 (58.62%) were immediate-onset (≤ 48 hours) and 24 (41.38%) delayed. Concurrent extracranial CSF leak was documented in 3 cases (otorrhea 2, oculorrhea 1). Conservative management resolved the leak in 47/58 patients (81.03%); 11 (18.97%) required surgery, mostly for persistent leak. Lumbar drains were used in 19/58 (32.76%) overall (27.66% as conservative adjunct, 54.55% post-operatively). Surgical approach was trans-nasal endoscopic endonasal in 8 (72.73%) and trans-cranial bifrontal craniotomy in 3 (27.27%), guided by defect site as detailed in Methods. The full distribution is in Table 2.

Table 2. Onset and management of CSF rhinorrhea (n = 58).

Variable	Category	n	%
Onset of CSF rhinorrhea	Immediate (≤ 48 hours)	34	58.62
	Delayed (> 48 hours, ≤ 30 days)	24	41.38
Concurrent CSF leak	CSF otorrhea	2	3.45
	CSF oculorrhea	1	1.72
Management arm	Conservative (resolved without surgery)	47	81.03
	Surgical intervention	11	18.97
Lumbar drain placement	As conservative adjunct (n = 47)	13	27.66
	Post-operatively (n = 11)	6	54.55
	Overall (n = 58)	19	32.76
Surgical approach (n = 11)	Trans-nasal endoscopic endonasal	8	72.73
	Trans-cranial bifrontal craniotomy	3	27.27

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DISCUSSION

This prospective Lahore cohort reports a 30-day cumulative incidence of post-traumatic CSF rhinorrhea of 38.67% (95% CI 31.25–46.65%) among 150 adults with road-traffic-accident-related skull base fractures. The male-predominant (69.33%), 31–45-year cohort (72.00%) mirrors the working-age male demographic disproportionately affected by road traffic injury in lower-middle-income settings [6, 13, 15].

Motorcycle-related accidents accounted for 80.00% of cases, consistent with Pakistani neurotrauma surveillance [13] and the Iranian cohort of Seyedmoalemi et al., in which motorcycle collisions accounted for nearly half of all basilar skull fractures with a 19% leak rate [16]. Although per-mechanism leak rates were not statistically significant (p = 0.850), motorcycle-related collisions accounted for 79.31% of all leak cases, underscoring the centrality of two-wheeler injury prevention.

The 30-day incidence of 38.67% is higher than most contemporary figures, which range from 4% (Stopa et al. [5]) and 7.2% (Albalawi et al. [17]) to 17.5–20.95% in Indian cohorts [6, 7], and from 3.2% to 15% across recent Pakistani series [10, 11, 15, 18]. Three methodological factors explain the disparity: (i) restriction to confirmed skull base fractures rather than broader head-injury populations; (ii) a 30-day prospective window with scheduled day 7, 14, and 30 follow-up that captured immediate and delayed presentations [3, 4, 8]; and (iii) exclusively high-energy motorcycle-dominant trauma, which carries a higher inherent risk of dural disruption than mixed-mechanism cohorts.

The strongest finding was the fracture-site association (p = 0.010): anterior cranial fossa involvement (50.00%) and anterior plus multiple-fossa fractures together accounted for 82.76% of leaks, consistent with the firm dural adherence to the cribriform plate and fovea ethmoidalis [3, 4, 7, 18], an association independently confirmed by Albalawi et al. and Sivanandapanicker et al. [6, 17].

Two clinical signs were strongly associated with CSF rhinorrhea (p < 0.001 for both): raccoon eyes (62.22% vs 28.57%) and admission pneumocephalus (53.33% vs 24.00%), the latter a direct marker of dural tear also identified as a key predictor by Mateen et al. [15] and Albalawi et al. [17]. Battle's sign was not significant (p = 0.314), as petrous fractures more commonly produce otorrhea. Concurrent extracranial leakage was documented in 3 of 58 leak cases (otorrhea 2, oculorrhea 1) uncommon but recognised in multi-fossa fractures [3, 4].

Conservative management succeeded in 81.03% of leak cases (18.97% required surgery), aligning with Tajelsir et al.'s Sudanese cohort [9] and the Southeast Asian series of Wong et al. [19]. Surgical approach was trans-nasal endoscopic in 8 (72.73%) and trans-cranial bifrontal craniotomy in 3 (27.27%), mirroring the UK CRANIAL multicentre study by Khan et al. [20]. Lumbar drains were used in 32.76% of leak patients, consistent with Tajelsir et al. [9].

Prophylactic antibiotics remain controversial; the Cochrane review by Ratilal et al. found no evidence supporting routine prophylaxis [21], and our protocol reserved antibiotics for confirmed meningitis. Meningitis risk from persistent leak is substantial up to 25.7% [7], with fatal late-onset cases reported years after injury [8, 22]. Pneumocephalus was managed conservatively for non-tension cases and surgically for tension cases with mass effect [9, 21].

Limitations

Several limitations should be acknowledged. First, this was a single-centre tertiary-care study in Lahore, which may limit generalisability. Second, restriction to road-traffic-accident mechanisms produced a homogeneous cohort but precludes extension to mixed-mechanism populations. Third, beta-2 transferrin assay and CT cisternography were unavailable; diagnosis relied on bedside signs, glucose-strip testing, and HRCT/CT-FESS/MRI, which may have introduced misclassification bias. Fourth, the 30-day window did not capture late-presenting cases. Fifth, small subgroups (18–30-year band, n = 3; posterior fossa, n = 12) limited subgroup power, addressed by Fisher's exact test. Sixth, multivariable logistic regression to isolate independent effects of fracture site, raccoon eyes,

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and pneumocephalus was not performed. Future multi-centre prospective studies with biochemical confirmation, longer follow-up, and multivariable modelling will refine these estimates and inform Pakistani national guidelines.

CONCLUSIONS

This prospective study established a 30-day cumulative incidence of post-traumatic CSF rhinorrhea of 38.67% (95% CI 31.25–46.65%) among adults with road-traffic-accident-related skull base fractures, providing a standardised local estimate that addresses the wide heterogeneity of previously reported Pakistani figures. The findings underscore the substantial burden of this complication in a young, predominantly male, motorcycle-injured population and provide a defensible reference figure for clinical counselling, observation protocols, and resource allocation in Pakistani neurosurgical practice.

REFERENCES

[1] Dreizin D, Sakai O, Champ K, Gandhi D, Aarabi B, Nam AJ et al. CT of skull base fractures: classification systems, complications, and management. Radiographics. 2021 May; 41(3): 762-82. doi: 10.1148/rg.2021200189.

[2] Tang R, Zhang SY, Zhou JY, Gu YL, Mao S, Zhang WT. Clinical characteristics and surgical outcomes between traumatic and nontraumatic cerebrospinal fluid rhinorrhea. World J Otorhinolaryngol Head Neck Surg. 2024 Aug; 11(3): 391-9. doi: 10.1002/wjo2.70000.

[3] Oh JW, Kim SH, Whang K. Traumatic cerebrospinal fluid leak: diagnosis and management. Korean J Neurotrauma. 2017 Oct; 13(2): 63-7. doi: 10.13004/kjnt.2017.13.2.63.

[4] Yadav YR, Parihar V, Janakiram N, Pande S, Bajaj J, Namdev H. Endoscopic management of cerebrospinal fluid rhinorrhea. Asian J Neurosurg. 2016 Jul; 11(3): 183-93. doi: 10.4103/1793-5482.145101.

[5] Stopa BM, Leyva OA, Harper CN, Truman KA, Corrales CE, Smith TR et al. Decreased incidence of CSF leaks after skull base fractures in the 21st century: an institutional report. J Neurol Surg B Skull Base. 2022 Feb; 83(1): 59-65. doi: 10.1055/s-0040-1716689.

[6] Sivanandapanicker J, Nagar M, Kutty R, Sunilkumar BS, Peethambaran A, Rajmohan BP et al. Analysis and clinical importance of skull base fractures in adult patients with traumatic brain injury. J Neurosci Rural Pract. 2018 Jul; 9(3): 370-5. doi: 10.4103/jnrp.jnrp_38_18.

[7] Vattaparambil S, Kannoth P, Abu SU, Kollannur LJ, Areekal B. Cerebrospinal fluid leak in base of skull fractures - incidence and complications. J Clin Diagn Res. 2021 Nov; 15(11): PC33-6. doi: 10.7860/JCDR/2021/51407.15700.

[8] Karki B, Acharya U, Pun B, Shrestha PS. Delayed CSF rhinorrhea presenting as a lethal acute bacterial meningitis 5 years post trauma. Clin Case Rep. 2023 May; 11(5): e7320. doi: 10.1002/ccr3.7320.

[9] Tajelsir M, Elfadil N, Elawad M. Management and outcome of treatment modalities of cerebrospinal fluid rhinorrhea. Pan Arab J Rhinol. 2020; 10(2): 63-8. doi: 10.4103/pajr.pajr_16_19.

[10] Qazi R, Rehman L, Ahmed T, Qazi SA, Afzal A. The frequency of early post traumatic cerebrospinal fluid rhinorrhea in patients with head trauma. Pak J Neurol Surg. 2022; 26(2): 250-7. doi: 10.36552/pjns.v26i2.638.

[11] Qureshi A, Jummani MM, Bhatti T, Ansari AB, Shaukat S, Ayeshah S et al. Association between skull base fracture location and likelihood of developing a traumatic CSF leak. J Health Wellness Community Res. 2025; 3(2): e79. doi: 10.61919/9b601t07.

[12] Mahmood RZ, Lakho MA, Abbas T, Wajid A, Ahmed T, Farooq U et al. Results of conservative management of CSF rhinorrhea in post traumatic patients. Pak J Neurol Surg. 2022; 26(2): 258-62. doi: 10.36552/pjns.v26i2.689.

[13] Barki MT, Filza F, Khattak AF, Khalid OB, Qazi M, Gilani H et al. A survey of traumatic brain injuries from road traffic collisions in a lower middle-income country. Cureus. 2023 Mar; 15(3): e36892. doi: 10.7759/cureus.36892.

[14] Phang SY, Whitehouse K, Lee L, Khalil H, McArdle P, Whitfield PC. Management of CSF leak in base of skull fractures in adults. Br J Neurosurg. 2016 Dec; 30(6): 596-604. doi: 10.1080/02688697.2016.1229746.

[15] Mateen U, Saeed S, Shah IA, Khulsai MS, Ali F, Talreja V et al. Post-traumatic CSF leak in patients presenting with pneumocephalus. Biol Clin Sci Res J. 2024 May; 2024(1): 870. doi: 10.54112/bcsrj.v2024i1.870.

[16] Seyedmoalemi MA, Sheibani Tehrani D, Ahmadi A, Sheikhbahaei A, Kalbasi G, Sourani A. Basilar skull fractures and their complications in patients with traumatic brain injury. Korean J Neurotrauma. 2023 Mar; 19(1): 63-9. doi: 10.13004/kjnt.2023.19.e7.

[17] Albalawi NA, Aldakkan A, Alqurashi WS, Alhumaid AM, Alenezi AM, Alharbi MS et al. Cerebrospinal fluid leak following traumatic skull base fractures: predictors and outcomes. Surg Neurol Int. 2025; 16: 179. doi: 10.25259/SNI_290_2025.

[18] Hameedullah HK, Iqbal N, Khan H. To evaluate the frequencies of post-traumatic cerebrospinal fluid leak in patients presenting with traumatic brain injury. J Popul Ther Clin Pharmacol. 2024; 31(7): 1872-8. doi: 10.53555/jptcp.v31i7.7397.

[19] Wong EHC, Yong DJP, Teh KT, Charn TC, Kong SK, Suhaimi A et al. Management of traumatic and non-traumatic cerebrospinal fluid rhinorrhea - experience from three Southeast Asian countries. Int J Environ Res Public Health. 2022 Oct; 19(21): 13847. doi: 10.3390/ijerph192113847.

[20] Khan DZ, Hanrahan JG, Baldeweg SE, Dorward NL, Stoyanov D, Marcus HJ. CSF rhinorrhoea after endonasal intervention to the skull base (CRANIAL): a multicentre prospective observational study. Front Oncol. 2023 Jan; 12: 1049627. doi: 10.3389/fonc.2022.1049627.

[21] Ratilal BO, Costa J, Pappamikail L, Sampaio C. Antibiotic prophylaxis for preventing meningitis in patients with basilar skull fractures. Cochrane Database Syst Rev. 2015 Apr; 2015(4): CD004884. doi: 10.1002/14651858.CD004884.pub4.

[22] Ozaki A, Iwata T, Terada E, Kajikawa R, Tsuzuki T, Kishima H. Severe delayed-onset meningitis developed one year after a basilar skull fracture without a cerebrospinal fluid leak: a case report. Cureus. 2024 Dec; 16(12): e75261. doi: 10.7759/cureus.75261.