e-ISSN: 0976-822X, p-ISSN:2961-6042

Available online on http://www.ijcpr.com/

International Journal of Current Pharmaceutical Review and Research 2026; 18(2); 2063-2072

Original Research Article

Pattern of Skull Fractures in Fatal Two-wheeler Road Traffic Accidents: A Cross-sectional Study

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Received: 16-12-2025 / Revised: 16-01-2026 / Accepted: 26-02-2026

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Conflict of interest: Nil

Abstract

Background: Two-wheeler riders and pillion riders are highly vulnerable road users because of limited external protection during road traffic accidents. Head injury is one of the most common causes of death in fatal two-wheeler accidents, and skull fracture patterns provide important medicolegal information regarding the site, direction, and severity of impact. Detailed analysis of skull fractures and associated intracranial injuries helps in understanding injury mechanisms and strengthening preventive strategies.

Aim: To study the pattern of skull fractures in fatal two-wheeler road traffic accidents brought for medicolegal autopsy at a tertiary care hospital.

Materials and Methods: This cross-sectional study included 150 fatal two-wheeler road traffic accident cases with skull fractures. Riders and pillion riders of motorcycles and scooters were included. Data regarding age, sex, type of victim, helmet use, type of vehicle, place and time of accident, type of collision, survival period, skull fracture pattern, anatomical site of fracture, cranial fossa involvement, intracranial injuries, and associated external injuries were collected using a structured proforma. Complete medico legal autopsy was performed in all cases. Data were entered in Microsoft Excel and analyzed using IBM SPSS Statistics version 27.0. Categorical variables were expressed as frequencies and percentages. Chi-square test or Fisher's exact test was applied where appropriate, and p-value <0.05 was considered statistically significant.

Results: The majority of victims belonged to the 21–40 years age group (46.67%), and males predominated (80.00%). Riders constituted 70.00% of cases, and helmet non-use was observed in 81.33%. Spot death occurred in 42.67% of cases. Motorcycles were involved in 74.67% of accidents, and the most common accident time was 6 PM–12 AM (42.67%). Linear/fissured fracture was the most common skull fracture pattern (48.00%), followed by comminuted fracture (20.00%). The temporal bone was the most commonly involved site (28.00%), followed by the parietal bone (24.00%). Helmet non-use showed significant association with severe fracture patterns, multiple cranial bone/base involvement, and multiple intracranial lesions. Subarachnoid hemorrhage (68.00%), subdural hemorrhage (64.00%), brain contusion (52.00%), and scalp laceration (69.33%) were common associated findings.

Conclusion: Fatal skull fractures in two-wheeler accidents were common among young adult males, riders, and non-helmet users. Linear fractures and temporal bone involvement were predominant. Strict helmet use, road safety enforcement, and timely trauma care are essential to reduce fatal head injuries.

Keywords: Skull Fracture; Two-Wheeler Accident; Road Traffic Accident; Helmet Use; Medicolegal Autopsy.

DOI: 10.25258/ijcpr.18.2.341

Introduction

Road traffic accidents (RTAs) remain a major global public health problem and are among the leading causes of death and disability, particularly in low- and middle-income countries. According to the World Health Organization, approximately 1.19 million people die annually due to road traffic injuries, with motorcyclists and other vulnerable road users

accounting for a substantial proportion of these fatalities [1]. In India, the rapid increase in motorization, especially the widespread use of two-wheelers, has significantly contributed to the burden of fatal road traffic injuries. Two-wheelers constitute the most commonly used mode of personal transportation because of their affordability and convenience; however, they also expose riders and pillion passengers to a higher risk of severe trauma during collisions [2]. Head injury is recognized as the principal cause of death in fatal two-wheeler accidents, with skull fractures representing one of the most important indicators of the severity and mechanism of cranio-cerebral trauma. The pattern of skull fractures often reflects the magnitude, direction, and nature of impact and can provide valuable medicolegal insights regarding the dynamics of the accident [3]. Recent autopsy-based studies have highlighted the predominance of young adult males among fatal two-wheeler accident victims. Similarly, Debnath et al. (2025) observed that two-wheeler riders represented the largest category of fatal road traffic victims and that head injury was involved in more than 80% of death [4]. These findings underscore the persistent burden of fatal cranial trauma among motorcyclists despite improvements in road safety regulations and trauma care services. Factors such as excessive speed, alcohol consumption, poor road conditions, non-compliance with helmet use, and use of substandard helmets have been identified as major contributors to fatal head injuries among two-wheeler users [5]. Talukdar et al. (2025) observed that fractures involving the frontal and temporal bones, as well as the middle cranial fossa, were particularly common in fatal RTAs, indicating the predominance of high-velocity frontal and lateral impacts in two-wheeler crashes [6].

Aim & Objectives

Aim: To analyze the pattern of skull fractures and associated intracranial injuries in fatal two-wheeler road traffic accident (RTA) cases, and to evaluate their association with sociodemographic factors, accident characteristics, and helmet use.

Objectives

- To study the sociodemographic profile (age, gender, type of victim) of fatal two-wheeler RTA cases.
- To assess the accident-related parameters including type of vehicle, place, time, and mode of collision.
- To evaluate the morphological pattern and anatomical distribution of skull fractures.
- To determine the association between helmet use and severity of skull fractures and intracranial injuries.
- To analyze the pattern of intracranial hemorrhages, brain injuries, and external injuries in fatal cases.
- To identify the survival period and its relation to severity of injury in fatal two-wheeler accidents.

Materials & Methods

Study Design: This was a hospital-based, cross-sectional observational study conducted to evaluate the pattern of skull fractures in fatal two-wheeler road traffic accidents.

Study Place: The study was carried out in the Department of Forensic Medicine and Toxicology (FMT), Patna Medical College & Hospital, Patna, Bihar, India. The institution receives medicolegal autopsy cases from urban, semi-urban, and rural regions, ensuring a diverse case mix and representative injury patterns.

Study Population: The study population comprised deceased individuals who were riders or pillion riders of two-wheelers and had sustained fatal head injuries resulting in skull fractures following road traffic accidents.

Study Period: The study was conducted over a period of Nine Months from March 2025 to November 2025, during which all eligible medicolegal autopsy cases were included consecutively until the required sample size was achieved.

Sample Size: A total of 150 cases fulfilling the inclusion criteria were included in the study.

Ethical Considerations: The study was conducted after obtaining approval from the Institutional Ethics Committee. As the study involved deceased individuals and medicolegal autopsy records, informed consent was waived. Confidentiality and anonymity of all cases were strictly maintained, and data were used solely for research purposes in accordance with ethical guidelines.

Inclusion Criteria: Fatal two-wheeler road traffic accident cases with confirmed skull fractures on autopsy involving riders or pillion riders of motorcycles, scooters, or other motorized two-wheelers, and having complete medicolegal records, autopsy findings, and documented accident history were included in the study.

Exclusion Criteria: Cases involving non–two-wheeler accidents, pedestrian injuries, railway accidents, falls from height, assault-related head injuries, decomposed bodies where skull fracture assessment was not feasible, incomplete records, unknown circumstances of injury, or deaths not directly attributable to road traffic accident injuries were excluded.

Methodology

Data were collected using a predesigned structured proforma from multiple sources, including police inquest reports, hospital medical records, eyewitness accounts (where available), and treatment history prior to death.

Demographic and accident-related variables recorded included age, sex, type of victim (rider/pillion rider), helmet use, type of two-wheeler, place and time of accident, type of collision, position of the victim at impact, survival period, and associated external injuries.

Autopsy Procedure: A complete medicolegal autopsy was performed in all cases following standard protocols.

External Examination

- Documentation of abrasions, contusions, lacerations, and patterned injuries
- Recording of distribution and severity of external injuries

Internal Examination

- Reflection of scalp to identify scalp hemorrhage
- Removal of calvarium for examination of skull vault
- Detailed assessment of skull base

Skull fractures were analyzed systematically for type, anatomical location, direction, extent, and number.

Fracture Classification: Fractures were classified anatomically into frontal, parietal, temporal, occipital, multiple cranial bones, and base of skull.

Morphologically, they were categorized as linear (fissured), depressed, comminuted, diastatic, sutural, and basilar fractures. Basal fractures were further classified based on involvement of the anterior, middle, and posterior cranial fossae.

Intracranial Injury Assessment: Associated intracranial injuries—including extradural, subdural, subarachnoid, and intracerebral hemorrhages, as well as brain contusions, lacerations, cerebral edema, and herniation—were recorded and correlation between skull fracture patterns and intracranial injuries was performed.

Investigations: Relevant ante-mortem investigations, where available, including radiological imaging findings (CT scan and skull X-ray), clinical records documenting neurological status, and details of emergency and inpatient treatment, were reviewed.

These findings were correlated with autopsy observations.

Outcome Measures

Primary Outcome

- Pattern and type of skull fractures in fatal two-wheeler accidents

Secondary Outcomes

- Distribution of fractures by anatomical site
- Association between helmet use and fracture pattern
- Correlation between skull fractures and intracranial injuries
- Relationship between demographic/accident variables and injury patterns

Statistical Analysis: Data were entered in Microsoft Excel and analyzed using IBM SPSS Statistics version 27.0 (IBM Corp., Armonk, NY, USA). Categorical variables were expressed as frequency and percentage, while continuous variables were presented as mean ± standard deviation or median with interquartile range/range, as appropriate. Associations between categorical variables were assessed using the Chi-square test or Fisher's exact test. Continuous variables were compared using the independent t-test or Mann–Whitney U test. A p-value <0.05 was considered statistically significant.

Result

In the present study, a total of 150 fatal two-wheeler road traffic accident cases with skull fractures were analyzed [Table 1]. The majority of victims belonged to the 21–40 years age group, comprising 70 cases (46.67%), followed by 41–60 years with 40 cases (26.67%). Victims aged more than 60 years accounted for 25 cases (16.67%), while those aged ≤20 years formed the smallest group with 15 cases (10.00%). The distribution of cases according to age group was statistically significant ($p = 0.032$), indicating that young and middle-aged adults were more commonly involved in fatal two-wheeler accidents with skull fractures.

Table 1: Sociodemographic Profile and Victim Characteristics among Fatal Two-Wheeler RTA Cases (n = 150)

Variable	Category	Frequency (n)	Percentage (%)	p-value
Age Group	≤20 years	15	10.00	0.032*
	21–40 years	70	46.67	
	41–60 years	40	26.67	
	>60 years	25	16.67	
Gender	Male	120	80.00	<0.001*
	Female	30	20.00	
Type of Victim	Rider	105	70.00	<0.001*
	Pillion rider	45	30.00	
Helmet Use	Present	28	18.67	<0.001*
	Absent	122	81.33	
Survival Period	Spot death	64	42.67	0.018*
	<6 hours	46	30.67	
	6–24 hours	25	16.67	
	>24 hours	15	10.00	

*p-value <0.05 was considered statistically significant

Male predominance was observed in the study, with 120 cases (80.00%) being males and 30 cases (20.00%) being females. This sex-wise difference was statistically significant ($p < 0.001$). Riders constituted the majority of victims, accounting for 105 cases (70.00%), while pillion riders accounted for 45 cases (30.00%). The higher involvement of riders was also statistically significant ($p < 0.001$). Helmet use was documented in only 28 cases (18.67%), whereas 122 victims (81.33%) were not wearing helmets at the time of the accident. This difference was statistically significant ($p < 0.001$), showing a marked predominance of fatal skull fracture cases among non-helmet users.

Regarding survival period, 64 victims (42.67%) died on the spot, while 46 victims (30.67%) survived for less than 6 hours after the accident. A survival period of 6–24 hours was observed in 25 cases (16.67%), and only 15 cases (10.00%) survived for more than 24 hours. The distribution of survival period was statistically significant ($p = 0.018$), suggesting that most fatal cases had severe injuries leading to immediate or early death.

Table 2: Accident-Related Parameters among Fatal Two-Wheeler RTA Cases (n = 150)

Variable	Category	Frequency (n)	Percentage (%)	p-value
Type of Two-Wheeler	Motorcycle	112	74.67	<0.001*
	Scooter	38	25.33	
Place of Accident	Urban road	68	45.33	0.041*
	Semi-urban road	50	33.33	
	Rural road	32	21.33	
Time of Accident	6 AM–12 PM	24	16.00	0.026*
	12 PM–6 PM	35	23.33	
	6 PM–12 AM	64	42.67	
	12 AM–6 AM	27	18.00	
Type of Collision	Two-wheeler vs heavy vehicle	58	38.67	0.009*
	Two-wheeler vs four-wheeler	42	28.00	
	Skid/fall	32	21.33	
	Two-wheeler vs fixed object	18	12.00	
Position after Impact	On road surface	96	64.00	0.003*
	Roadside/shoulder	38	25.33	
	Under vehicle	16	10.67	

*p-value <0.05 was considered statistically significant

Table 2 show that in relation to accident-related parameters, motorcycles were involved in 112 cases (74.67%), whereas scooters were involved in 38 cases (25.33%). This difference was statistically significant ($p < 0.001$). Most accidents occurred on urban roads, accounting for 68 cases (45.33%), followed by semi-urban

roads in 50 cases (33.33%) and rural roads in 32 cases (21.33%). The place of accident showed a statistically significant distribution (p = 0.041), with urban roads being the most common location. The maximum number of accidents occurred between 6 PM and 12 AM, involving 64 cases (42.67%). This was followed by 35 cases (23.33%) between 12 PM and 6 PM, 27 cases (18.00%) between 12 AM and 6 AM, and 24 cases (16.00%) between 6 AM and 12 PM. The association with time of accident was statistically significant (p = 0.026), indicating evening and night hours as the most common period for fatal two-wheeler accidents. Regarding collision type, two-wheeler collision with heavy vehicles was the most common, seen in 58 cases (38.67%), followed by collision with four-wheelers in 42 cases (28.00%), skid or fall in 32 cases (21.33%), and collision with fixed objects in 18 cases (12.00%). This distribution was statistically significant (p = 0.009).

After impact, 96 victims (64.00%) were found on the road surface, 38 (25.33%) on the roadside or shoulder, and 16 (10.67%) under the vehicle, with a statistically significant difference (p = 0.003).

Table 3: Morphological Pattern and Anatomical Site of Skull Fractures (n = 150)

Variable	Category	Frequency (n)	Percentage (%)	p-value
Type of Skull Fracture	Linear/fissured	72	48.00	0.012*
	Depressed	24	16.00	
	Comminuted	30	20.00	
	Basilar	18	12.00	
	Diastatic (sutural separation)	6	4.00	
Number of Fractures	Single	82	54.67	0.034*
	Multiple	68	45.33	
Anatomical Site	Frontal bone	18	12.00	0.029*
	Parietal bone	36	24.00	
	Temporal bone	42	28.00	
	Occipital bone	12	8.00	
	Multiple cranial bones	30	20.00	
	Base of skull	12	8.00	
Cranial Fossa Involvement	Anterior cranial fossa	16	10.67	0.046*
	Middle cranial fossa	24	16.00	
	Posterior cranial fossa	10	6.67	
	No basal fossa involvement	100	66.67	

*p-value <0.05 was considered statistically significant

With respect to skull fracture pattern [Table 3], linear or fissured fractures were the most common type, observed in 72 cases (48.00%). Comminuted fractures were present in 30 cases (20.00%), depressed fractures in 24 cases (16.00%), basilar fractures in 18 cases (12.00%), and diastatic or sutural separation fractures in 6 cases (4.00%). The distribution of fracture types was statistically significant (p = 0.012). Single skull fractures were observed in 82 cases (54.67%), while multiple fractures were present in 68 cases (45.33%), showing a statistically significant difference (p = 0.034). Anatomically, the temporal bone was the most frequently involved site, seen in 42 cases (28.00%), followed by parietal bone in 36 cases (24.00%) and multiple cranial bones in 30 cases (20.00%). Frontal bone fractures were seen in 18 cases (12.00%), while occipital bone and base of skull fractures were each observed in 12 cases (8.00%). The distribution of fracture sites was statistically significant (p = 0.029). Cranial fossa involvement was absent in 100 cases (66.67%). Among cases with basal involvement, the middle cranial fossa was most commonly affected, seen in 24 cases (16.00%), followed by anterior cranial fossa in 16 cases (10.67%) and posterior cranial fossa in 10 cases (6.67%). This distribution was statistically significant (p = 0.046).

Table 4 and figure I, show that helmet use showed a significant association with skull fracture pattern (p = 0.021). Among helmet users, linear or fissured fractures were the most common, seen in 18 cases (64.29%), whereas among non-helmet users they were seen in 54 cases (44.26%). More severe fracture patterns, such as depressed and comminuted fractures, were proportionately higher among non-helmet users. Depressed fractures were seen in 21 non-helmet users (17.21%) compared with 3 helmet users (10.71%), while comminuted fractures were seen in 27 non-helmet users (22.13%) compared with 3 helmet users (10.71%). The site

of fracture also showed a statistically significant association with helmet use (p = 0.038). Single cranial bone fractures were more common among helmet users, seen in 22 cases (78.57%), compared with 86 cases (70.49%) among non-helmet users. Multiple cranial bone or base of skull fractures were proportionately higher among non-helmet users, observed in 36 cases (29.51%), compared with 6 cases (21.43%) among helmet users. Intracranial injury severity was also significantly associated with helmet use (p = 0.014). Multiple intracranial lesions were observed in 80 non-helmet users (65.57%) compared with 11 helmet users (39.29%), indicating greater severity among those not wearing helmets.

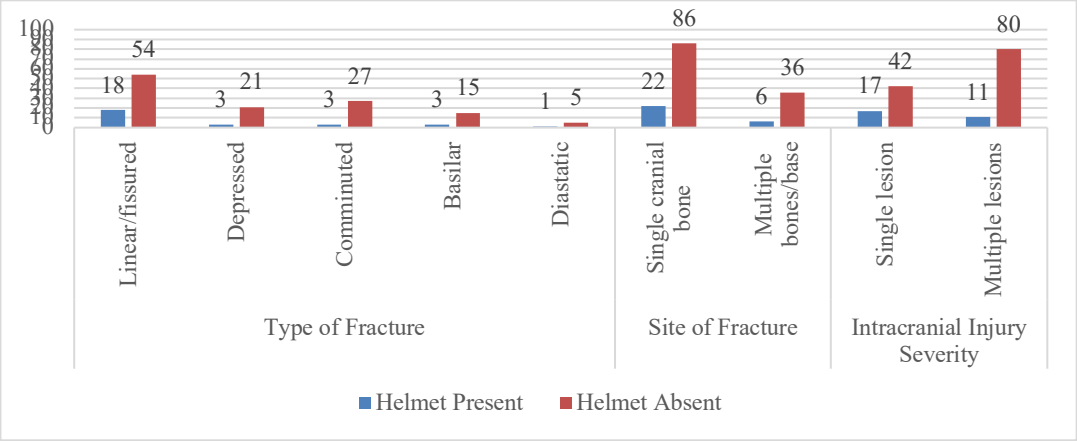

Figure 1: Association of Helmet Use with Skull Fracture Pattern and Intracranial Injury

Table 4: Association of Helmet Use with Skull Fracture Pattern and Intracranial Injury (n = 150)

Variable	Category	Helmet Present n (%)	Helmet Absent n (%)	Total n (%)	p-value
Type of Fracture	Linear/fissured	18 (64.29)	54 (44.26)	72 (48.00)	0.021*
	Depressed	3 (10.71)	21 (17.21)	24 (16.00)	
	Comminuted	3 (10.71)	27 (22.13)	30 (20.00)	
	Basilar	3 (10.71)	15 (12.30)	18 (12.00)	
	Diastatic	1 (3.57)	5 (4.10)	6 (4.00)	
Site of Fracture	Single cranial bone	22 (78.57)	86 (70.49)	108 (72.00)	0.038*
	Multiple bones/base	6 (21.43)	36 (29.51)	42 (28.00)	
Intracranial Injury Severity	Single lesion	17 (60.71)	42 (34.43)	59 (39.33)	0.014*
	Multiple lesions	11 (39.29)	80 (65.57)	91 (60.67)	

Table 5: Intracranial and Associated External Injuries in Skull Fracture Cases (n = 150)

Variable	Category	Frequency (n)	Percentage (%)	p-value
Intracranial Hemorrhage	Subarachnoid hemorrhage	102	68.00	0.011*
	Subdural hemorrhage	96	64.00	
	Intracerebral hemorrhage	48	32.00	
	Extradural hemorrhage	36	24.00	
Brain Injury	Brain contusion	78	52.00	0.019*
	Cerebral edema	66	44.00	
	Brain laceration	30	20.00	
	Brain herniation	22	14.67	
External Injuries	Scalp laceration	104	69.33	0.008*
	Abrasion	98	65.33	
	Contusion	76	50.67	
	Facial injury	62	41.33	
Associated Body Injury	Chest injury	44	29.33	0.047*
	Limb fracture	38	25.33	
	Abdominal injury	20	13.33	
	Spinal injury	12	8.00	

*p-value <0.05 was considered statistically significant

Table 5 demonstrate, among intracranial hemorrhages, subarachnoid hemorrhage was the most common, present in 102 cases (68.00%), followed by subdural hemorrhage in 96 cases (64.00%). Intracerebral hemorrhage was observed in 48 cases (32.00%), while extradural hemorrhage was found in 36 cases (24.00%). The distribution of intracranial hemorrhages was statistically significant (p = 0.011). Among brain injuries, brain contusion was the most frequent finding, seen in 78 cases (52.00%), followed by cerebral edema in 66 cases (44.00%), brain laceration in 30 cases (20.00%), and brain herniation in 22 cases (14.67%). This distribution was statistically significant (p = 0.019). External injuries were commonly associated with skull fractures. Scalp laceration was the most frequent external injury, observed in 104 cases (69.33%), followed by abrasions in 98 cases (65.33%), contusions in 76 cases (50.67%), and facial injuries in 62 cases (41.33%). The distribution of external injuries was statistically significant (p = 0.008). Associated body injuries were also documented, with chest injuries present in 44 cases (29.33%), limb fractures in 38 cases (25.33%), abdominal injuries in 20 cases (13.33%), and spinal injuries in 12 cases (8.00%). This distribution was statistically significant (p = 0.047).

Discussion

In the present study, the maximum number of fatal two-wheeler RTA cases with skull fractures belonged to the 21–40 years age group, comprising 70 cases (46.67%), followed by 41–60 years in 40 cases (26.67%), and the age-wise distribution was statistically significant (p=0.032). This indicates that young and economically active adults were the most affected group. Kumar et al. (2020), in an autopsy-based study of 312 fatal two-wheeler RTA cases in Uttar Pradesh, also observed the highest mortality in the 21–30 years age group, accounting for 28.50%, followed by 31–40 years at 26.00%. In the same study, males formed 63.50% of cases, whereas the present study showed a still higher male predominance of 120 cases (80.00%), with a significant sex-wise difference (p<0.001). Thus, both studies show that fatal two-wheeler head injuries are more common among young adult males, probably due to greater outdoor activity, occupational travel, and higher exposure to road traffic [7].

In the present study, riders constituted 105 cases (70.00%) and pillion riders constituted 45 cases (30.00%), with a statistically significant difference (p<0.001). This finding is comparable with Ravikumar et al. (2014), who studied 245 fatal two-wheeler accident cases and reported riders in 187 cases (76.33%) and pillion riders in 58 cases (23.67%). Male predominance was also similar, as Ravikumar et al. reported males in 87.75% of cases compared with 80.00% in the present study. Helmet non-use was very common in the present study, as 122 victims (81.33%) were not wearing helmets, whereas Ravikumar et al. reported that 35.83% of riders were not wearing helmets and none of the pillion riders were helmeted. The higher proportion of non-helmeted victims in the present study supports the role of poor helmet compliance in fatal skull fracture case [8].

In the present study, 64 victims (42.67%) died on the spot and 46 victims (30.67%) died within 6 hours, showing that nearly three-fourths of deaths occurred either immediately or very early after the accident. This survival-period distribution was statistically significant (p=0.018) and reflects the severity of cranio-cerebral trauma. Kakeri et al. (2014), in a study of 150 RTA victims, reported 57 deaths on the spot (38.00%), 75 deaths in hospital (50.00%), and 18 deaths while being shifted to hospital (12.00%). Their findings are close to the present study regarding spot deaths, although hospital deaths were more frequent in their series. They also observed that 74.00% of victims were not wearing helmets, while helmet non-use in the present study was 81.33%, again emphasizing the association between lack of head protection and fatal outcome [9].

In the present study, most accidents occurred on urban roads, accounting for 68 cases (45.33%), followed by semi-urban roads in 50 cases (33.33%) and rural roads in 32 cases (21.33%), with a significant association (p=0.041). The most common time of accident was 6 PM–12 AM, seen in 64 cases (42.67%), followed by 12 PM–6 PM in 35 cases (23.33%), and this distribution was statistically significant (p=0.026). Das et al. (2020), in an autopsy study of 328 RTA head injury cases from Kamrup district, similarly reported that the maximum number of accidents occurred between 6 PM and 12 midnight, with 134 cases (40.85%), and urban accidents were more common than rural accidents, accounting for 60.98% and 39.02%, respectively. The close similarity in evening-hour predominance suggests that poor visibility, fatigue after work, increased traffic density, and movement of heavy vehicles may contribute to

fatal two-wheeler accidents during this period [10].

In the present study, motorcycles were involved in 112 cases (74.67%), whereas scooters were involved in 38 cases (25.33%), with a statistically significant difference ($p<0.001$). Collision with heavy vehicles was the most common mechanism, seen in 58 cases (38.67%), followed by collision with four-wheelers in 42 cases (28.00%), skid/fall in 32 cases (21.33%), and collision with fixed objects in 18 cases (12.00%). Sukumar et al. (2019), in a retrospective autopsy-based study of 100 fatal motorized two-wheeler riders, reported motorcycles in 72.00%, mopeds in 21.00%, and scooters in only 7.00% of cases; the most common mode of injury was collision with another two-wheeler in 26.00%, followed by impact with a car in 23.00% and skid/fall in 22.00%. The present study had a higher proportion of heavy-vehicle collisions, which may explain the greater severity of skull fractures and the high number of spot deaths [11]. In the present study, linear/fissured fracture was the most common skull fracture pattern, observed in 72 cases (48.00%), followed by comminuted fracture in 30 cases (20.00%), depressed fracture in 24 cases (16.00%), basilar fracture in 18 cases (12.00%), and diastatic fracture in 6 cases (4.00%); the distribution was statistically significant ($p=0.012$). Barman et al. (2024), in a cross-sectional study on fatal two-wheeler RTAs, also found fissured fracture as the most common type, seen in 64 out of 103 skull fracture cases (62.14%), followed by depressed fracture in 19 cases (18.45%) and comminuted fracture in 12 cases (11.65%). The present study had a lower percentage of linear fractures but a higher proportion of comminuted fractures, suggesting comparatively greater impact force in the present series [12].

In the present study, the temporal bone was the most commonly fractured skull bone, involved in 42 cases (28.00%), followed by parietal bone in 36 cases (24.00%) and multiple cranial bones in 30 cases (20.00%); the anatomical distribution was statistically significant ($p=0.029$). Soni et al. (2016), in a study of fatal RTA victims, reported skull fracture in 57.00% of cases and found linear fracture as the most common pattern. However, they observed frontal bone involvement as the most frequent site, seen in 46 cases (40.35%), followed by temporal bone in 33 cases (28.94%) [13]. Thus, while the present study agrees with Soni et al. regarding the predominance of linear fracture, it differs in anatomical distribution, as temporal bone was the commonest site in the present study. This difference may be due to variation in direction of impact, type of vehicle collision, and whether the victim fell sideways or forward [13].

In the present study, cranial fossa involvement was absent in 100 cases (66.67%), while middle cranial fossa involvement was the most common among basal fractures, seen in 24 cases (16.00%), followed by anterior cranial fossa in 16 cases (10.67%) and posterior cranial fossa in 10 cases (6.67%). Deepak et al. (2021), in a study on skull fracture distribution in RTAs, reported fissured fracture as the most frequent type in 59.80% of cases and temporal bone as the most commonly involved bone, seen in 100 cases (21.00%). They also reported that fractures extending to the base of skull were common, with middle cranial fossa involvement being highest at 23.10%, followed by posterior cranial fossa at 15.00% and anterior cranial fossa at 8.28%. This is broadly comparable with the present study, where the middle cranial fossa was also the most commonly involved basal region [14].

In the present study, helmet use showed a significant association with fracture pattern ($p=0.021$), site of fracture ($p=0.038$), and intracranial injury severity ($p=0.014$). Multiple intracranial lesions were more common among non-helmet users, seen in 80 cases (65.57%), compared with 11 cases (39.29%) among helmet users. Subarachnoid hemorrhage was the most common intracranial hemorrhage in the present study, seen in 102 cases (68.00%), followed by subdural hemorrhage in 96 cases (64.00%). Rizwi et al. (2023), in a study of 100 fatal two-wheeler RTA cases, reported that 91.00% of victims had not used helmets and only 9.00% had used helmets. They also observed that linear fracture was the most common vault fracture, followed by comminuted fracture, and that abrasions and lacerations were the commonest injuries to the face and head. These findings support the present study, where non-helmet users had more severe skull fracture patterns and multiple intracranial lesions, while scalp laceration (69.33%) and abrasion (65.33%) were the most frequent external injuries [15].

Limitations of the Study

- Cross-sectional design limits causal inference between risk factors and outcomes.
- Single-centre, autopsy-based data may reduce generalizability.

- Limited sample size (n = 150) may affect subgroup analysis.
- Selection bias due to inclusion of only fatal skull fracture cases.
- Detailed helmet-related information was unavailable.
- Important confounding factors such as alcohol use, vehicle speed, road conditions, and pre-hospital care were not assessed.
- Reliance on police and medico-legal records may introduce documentation bias.

Conclusion

The present study highlights that fatal two-wheeler road traffic accidents with skull fractures predominantly involve young adult males, with riders and non-helmet users being more commonly affected than pillion riders. A significant proportion of victims were not wearing helmets, emphasizing poor compliance with safety measures. Motorcycles were the most frequently involved vehicles, and accidents occurred more commonly on urban roads, particularly during evening and night hours. Collisions with heavy vehicles were the leading cause, and most victims died either on the spot or within a few hours, indicating high-impact trauma. Linear skull fractures were the most common pattern; however, more severe fractures (depressed and comminuted) and multiple cranial bone involvement were significantly higher among non-helmet users. Helmet use was associated with less severe fracture patterns, fewer intracranial lesions, and better outcomes, demonstrating its protective effect. The temporal bone was the most frequently involved site, and middle cranial fossa was the most commonly affected basal region. Among intracranial injuries, subarachnoid and subdural hemorrhages were predominant, with brain contusions being the most common parenchymal injury. External injuries such as scalp lacerations and abrasions were frequently associated. Overall, the study underscores the critical importance of helmet use in reducing the severity of skull fractures and intracranial injuries. Strengthening road safety enforcement, public awareness, and strict helmet compliance is essential to reduce mortality in two-wheeler accidents.

Acknowledgement

The authors sincerely thank the Department of Forensic Medicine and Toxicology, Patna Medical College & Hospital, for providing the necessary facilities and support for this study. We are especially grateful to Dr. Pankaj Kumar for his constant guidance, valuable suggestions, encouragement, and academic support throughout the study. We also acknowledge the cooperation of the faculty members, postgraduate students, technical staff, hospital administration, and medico-legal authorities for their assistance during data collection and autopsy examinations.

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