

Pattern of Head Injuries among Unhelmeted Motorcycle Riders involved in Fatal Road Traffic Accidents: A Three-Year Retrospective Autopsy-based Study in a Tertiary Care Centre of Karnataka

Yogesh G¹, Chaitanya R², Ravishankar MG³

^{1,2,3}Department of Forensic Medicine, BMCRC, Ballari

Corresponding Author: Dr. Yogesh G

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ABSTRACT

Background: Motorcycle-related road traffic accidents are an important cause of traumatic injuries and mortality, particularly among unhelmeted riders. Head injuries, including skull fractures and intracranial haemorrhages, contribute substantially to mortality following motorcycle crashes. Characterizing these injuries through medico-legal autopsy findings can help establish the patterns of fatal cranial trauma.

Objectives: To describe the patterns of head injuries, including the anatomical distribution and types of skull fractures, intracranial haemorrhages, and causes of death, among unhelmeted motorcycle riders involved in fatal road traffic accidents.

Materials and Methods: A retrospective, descriptive, autopsy-based study was conducted at BMCRC Super Specialty Hospital, Ballari, Karnataka, India, covering the period from January 2023 to December 2025. A total of 202 fatal road traffic accident cases involving unhelmeted motorcycle riders were included. Data were extracted from inquest reports, postmortem examination reports, and available hospital records. The recorded variables included age, location and type of skull fracture, pattern of intracranial haemorrhage, and cause of death. Data were analysed using Jamovi software, version 2.3. Categorical variables were summarized as frequencies and percentages.

Results: The highest proportion of cases occurred among individuals aged 21–30 years (33.1%), followed by those aged 31–40 years (31.1%). Fractures involving both the cranial vault and base were observed in 152 cases (75.24%), representing the most frequent anatomical fracture pattern. Combined comminuted and linear skull fractures were identified in 88 cases (43.56%), followed by depressed and linear fractures in 58 cases (28.71%). The predominant intracranial haemorrhage pattern was the combination of subarachnoid and subdural haemorrhages, observed in 150 cases (74.25%). Head injury was documented as the cause of death in 172 cases (85.14%).

Conclusion: Head injury was the predominant cause of death among unhelmeted motorcycle riders in this autopsy-based study. Combined cranial vault and skull base fractures, complex skull fracture patterns, and concurrent subarachnoid and subdural haemorrhages were the principal findings. These observations underscore the importance of helmet use and comprehensive road safety measures to reduce fatal motorcycle-related injuries.

Keywords: Unhelmeted motorcyclists; skull fracture; intracranial hemorrhage; craniocerebral trauma; road traffic accidents; autopsy study.

INTRODUCTION

Motorcycles are a common mode of transport in low- and middle-income countries. ^[1] Two-wheelers (motorcycle and scooters) make up roughly 75% of all registered motor vehicles in India. Two-wheelers and motorcycles account for 44.8% to 46.2% of all road traffic accidents and fatalities in India, representing the largest share among all vehicle types. Nearly two out of every three road traffic deaths in India involve two-wheeler riders or pedestrians. Wearing a standard motorcycle helmet reduces the risk of death by more than six fold and the risk of brain injury by up to 74%. ^[2] Motorcyclists are commonly involved in accidents resulting from turning into the path of an approaching vehicle from either side, head-on collisions with another motorcycle or a motor vehicle, or head-on collisions with stationary objects located on or off the roadway, and the person is thrown violently to the ground or on to some other object or on to the car. The classical fatal injury in rider is fracture of the skull, usually from secondary impact with ground. Crash helmet reduces the friction of head against the ground, and makes the deceleration less drastic by allowing the protected head to skid across the ground prevent fracture of thin skull bones present in the sides of cranial vault. The absence of helmet protection increases the transmission of impact energy to the skull base, predisposing to Transverse fractures of the skull base. Even though the helmets do not completely eliminate the risk of mortality in extreme high-velocity impacts; they fundamentally alter the anatomical distribution, type, and severity of cranio-cerebral trauma. ^[3] Compared to operators of other types of vehicles on the road, motorcycle riders have a 34-fold higher risk of death following a crash. ^[4] Riders using motorized two and three-wheeled bikes comprise 28% of those deaths, Furthermore, head injuries are a

leading cause of death and trauma for these riders. ^[5] In Bengaluru Metropolitan Region, overall, 23% of motorcyclists used any type of helmets, only 10% recorded correct helmet use. ^[6] Injury to the head is the commonest cause of mortality and morbidity in motor cyclists following two wheeler crashes and the most common location of skull fractures was frontal (47.5 %), followed by parietal (20.4 %) ^[7]. In a journey of a mile, riders of motorbikes are about five times more at risk to encounter and get injured in a road crash than a person travelling in a car. ^[8] Motor cyclists are about twenty-five times more likely than passenger car occupants to die in traffic crashes. ^[9] Motorcycle fatalities were overwhelmingly concentrated in low- and middle-income nations (94%). ^[10]

MATERIALS & METHODS

Study Design and Setting

A retrospective, descriptive, autopsy-based study was conducted at BMCRC Super Specialty Hospital, Ballari, Karnataka, India. The study aimed to characterize the patterns of head injuries among unhelmeted motorcycle riders who died in road traffic accidents. The study covered a three-year period from January 2023 to December 2025.

Study Objectives

The primary objective was to describe the patterns of head injuries identified during medico-legal autopsies of unhelmeted motorcycle riders involved in fatal road traffic accidents. The specific objectives were to identify the types of head injuries, including skull fractures, intracranial haemorrhages, and brain injuries; describe the anatomical distribution of skull fractures; examine the recorded distribution of primary impact injuries over the head; and determine the principal causes of death among the study cases.

Data Sources and Data Collection

Data were retrospectively extracted from medico-legal records, including inquest reports, postmortem examination reports, and available hospital records. The records were reviewed to obtain relevant demographic and injury-related information for each eligible case.

The variables recorded included age group, location and type of skull fracture, presence and pattern of intracranial haemorrhage, brain injuries such as contusions and lacerations, and documented cause of death. Skull fractures were categorized according to their anatomical location and morphological type. Intracranial haemorrhages were classified according to the types documented in the postmortem records, including extradural haemorrhage (EDH), subdural haemorrhage (SDH), subarachnoid haemorrhage (SAH), and intraventricular haemorrhage (IVH). The recorded cause of death was categorized as head injury or a cause other than head injury.

Inclusion and Exclusion Criteria

Cases were included if they involved confirmed motorcycle riders who were not wearing helmets at the time of the accident and had complete autopsy records available for review.

The exclusion criteria comprised motorcycle riders who were wearing helmets, pillion riders, victims of road traffic accidents involving vehicles other than motorcycles, decomposed bodies in which the findings could not be reliably established, and cases with incomplete or missing records.

Ethical Considerations

The study was conducted after obtaining approval from the Institutional Ethics Committee of BMCRC [Approval No. IEC/BMCRC/06/04/26/(A)]. As the study involved retrospective analysis of medico-legal and autopsy records, the data were reviewed for the purposes of the stated research objectives. Any additional procedures relating to confidentiality,

anonymization, or consent should be described in accordance with the measures actually implemented and the conditions specified in the ethics approval.

Statistical Analysis

The data were entered into a Microsoft Excel spreadsheet and analysed using Jamovi software, version 2.3. Descriptive statistical methods were used to summarize the demographic characteristics and injury patterns of the study population. Categorical variables, including age groups, anatomical location and type of skull fractures, patterns of intracranial haemorrhage, and cause of death, were expressed as frequencies and percentages. Percentages were calculated using the total number of eligible cases ($n = 202$) as the denominator, unless otherwise specified. The results were summarized in tables to facilitate the descriptive comparison of injury patterns across the recorded categories. No inferential statistical tests were reported in the original analysis.

RESULT

A total of 202 cases of fatal road traffic accidents involving unhelmeted motorcycle riders were included in this study. The cases were analysed with respect to age distribution, location and type of skull fractures, frequency of intracranial haemorrhage, and cause of death.

Table 1: Distribution of study cases among the age group (n=202)

Category (in years)	Unhelmeted Rider No. (%)
01 to 10	00 (00)
11 to 20	11 (5.5%)
21 to 30	67 (33.1%)
31 to 40	63 (31.1%)
41 to 50	25 (12.4%)
51 to 60	21 (10.4%)
>60	15 (7.5%)

The highest number of cases was observed in the 21–30 years age group, accounting for 67 cases (33.1%), followed by the 31–40 years age group, with 63 cases (31.1%). Together, these two age groups constituted

64.2% of the study population. The 41–50 years age group accounted for 25 cases (12.4%), while 21 cases (10.4%) belonged to the 51–60 years age group. Fifteen cases (7.5%) were aged above 60 years, and 11 cases (5.5%) were in the 11–20 years age

group. No cases were recorded in the 1–10 years age group. These findings indicate that fatal motorcycle accidents in the study population predominantly involved young and middle-aged adults (table 1).

Table 2: Location of skull fracture (n=202)

Location	Unhelmeted Rider No. (%)
In Vault	29 (14.36%)
In Base	05 (02.48%)
In both Vault & Base	152 (75.24%)
No Fracture found	16 (07.92%)

Fractures involving both the cranial vault and base were the most frequently observed pattern, accounting for 152 cases (75.24%). Fractures confined to the cranial vault were observed in 29 cases (14.36%), whereas fractures involving only the base of the skull

were identified in 5 cases (2.48%). No skull fracture was detected in 16 cases (7.92%). Thus, involvement of both the cranial vault and base constituted the predominant fracture pattern among the study cases (table 2).

Table 3: Frequency of Type of skull Fracture (n=202)

Type of skull Fractures	Unhelmeted Rider No. (%)
Linear Fracture only	14 (6.93%)
Comminuted Fracture only	17 (8.41%)
Depressed Fracture only	01 (0.5%)
Diastatic Fracture only	00 (00)
Comminuted + Linear	88 (43.56%)
Depressed + Linear	58 (28.71%)
Diastatic + Linear	08 (3.96%)
No skull Fracture found	16 (07.92%)

The most common fracture pattern was a combination of comminuted and linear fractures, observed in 88 cases (43.56%). Depressed fractures associated with linear fractures were identified in 58 cases (28.71%). Comminuted fractures without another recorded fracture type were observed in 17 cases (8.41%), while linear fractures alone were present in 14 cases

(6.93%). Diastatic fractures associated with linear fractures were found in 8 cases (3.96%). An isolated depressed fracture was recorded in 1 case (0.5%), and no isolated diastatic fractures were reported. Sixteen cases (7.92%) showed no skull fracture. Overall, combined fracture patterns were more frequently recorded than isolated fracture types (table 3).

Table 4: Frequency of Type of intracranial Hemorrhages(n=202)

Particulars	Unhelmeted Rider No. (%)
SAH + SDH	150 (74.25%)
SAH + SDH + EDH	27 (13.36%)
SAH + SDH + EDH + IVH	05 (2.47%)
SAH Only	12 (5.94%)
None	08 (03.96%)

EDH= Extra Dural hemorrhage, SDH=Sub Dural hemorrhage, SAH= Sub arachnoid hemorrhage, IVH= Intra ventricular hemorrhage.

The most frequently observed pattern of intracranial haemorrhage was the combination of subarachnoid haemorrhage (SAH) and subdural haemorrhage (SDH), accounting for 150 cases (74.25%). A combination of SAH, SDH and extradural haemorrhage (EDH) was observed in 27 cases (13.36%). SAH alone was identified in 12 cases (5.94%), whereas the

combination of SAH, SDH, EDH and intraventricular haemorrhage (IVH) was recorded in 5 cases (2.47%). No intracranial haemorrhage was identified in 8 cases (3.96%). The findings demonstrate that combined intracranial haemorrhages, particularly SAH with SDH, were the predominant patterns in the study population (table 4).

Table 5: Cause of death among the study cases (n=202)

Particulars	Unhelmeted Rider No. (%)
Head injury	172 (85.14%)
Other than Head injury	30(14.86%)

Head injury was identified as the cause of death in 172 cases (85.14%), making it the predominant cause of death in the study population. In the remaining 30 cases (14.86%), death was attributed to causes other than head injury. These findings indicate that head injury constituted the principal cause of death in the majority of fatal motorcycle road traffic accident cases included in this study (table 5).

DISCUSSION

The highest number of cases was observed in the 21–30 years age group, accounting for 67 cases (33.1%), followed by the 31–40 years age group, with 63 cases (31.1%). Together, these two age groups constituted 64.2% of the study population, and these findings are similar with the findings of Prasannan K et al. [11] where highest number of cases was observed in the 20 to 29 years age group, accounting for 55 cases (40.74%), and Ravikumar R [12] where highest number of cases was observed in the 20 to 29 years age group, accounting for 90 cases (48.1%), and Takalkar Y et al. [13] where highest number of cases was observed in the 21–30 years age group, accounting for 54 cases (32.1%) and 55 cases (32.7%) in 31 to 40 years age group, and Wankhade T D et al. [14] where highest number of cases was observed in the 21–30 years age group, accounting for 17 cases (29.3%).

Fractures involving both the cranial vault & base were the most frequently observed

pattern, accounting for 152 cases (75.24%), and these findings are similar with the findings of Ravikumar R [12] where Fractures involving both the cranial Basal & vertex accounting for 44 cases (23.5).

The most common skull fracture pattern was a combination of comminuted and linear fracture, observed in 88 cases (43.56%), but these findings are contrast with the findings of Prasannan K et al. [11] where most common fracture pattern was Fissure Fracture Vault observed in 29.76%, Comminuted Fracture Base observed in 23.81%, and findings of Asangi I L et al. [15], where most common skull fracture pattern was Linear Fracture observed in 37 cases (46.25%) and Comminuted Fracture observed in 17 cases (21.25%), and findings of Wankhade T D et al. [14] where most common skull fracture pattern was Comminuted fracture observed in 19 cases (32.8%) and Linear fracture observed in 17 cases (29.3%).

The most frequently observed pattern of intracranial haemorrhage was the combination of subarachnoid (SAH) and subdural haemorrhage (SDH), accounting for 150 cases (74.25%), and these findings are similar with the findings of Wankhade T D et al. [14] where the most frequently observed pattern of intracranial haemorrhage was the SDH + SAH together 35 (60.3%), and also with the findings of Ravikumar R [12] where SDH + SAH together 96 (76.8%), but our findings are contrast with the findings of Prasannan K et

al. [11] where the most frequently observed pattern of intracranial haemorrhage was the SAH observed in 67.86% cases, and SDH observed in 30%, and also with findings of Takalkar Y et al. [13] where SAH observed in 31 cases (30.4%) and SDH observed in 26 cases (25.5%).

Head injury was identified as the cause of death in 172 cases (85.14%), making it the predominant cause of death in the study population.

CONCLUSION

The present autopsy-based study of 202 fatal motorcycle road traffic accident cases demonstrated that head injury was the predominant cause of death, accounting for 85.14% of cases. Young and middle-aged adults, particularly those aged 21–40 years, constituted the majority of the study population.

Fractures involving both the cranial vault and base were the most frequently observed skull fracture pattern. Combined comminuted and linear fractures were the most common fracture type. Among intracranial haemorrhages, the combination of subarachnoid and subdural haemorrhage was predominant.

The findings highlight the substantial contribution of severe cranial trauma to mortality among motorcycle riders involved in fatal road traffic accidents. Strengthening road safety measures, promoting consistent use of appropriate protective helmets, enforcing traffic regulations, and improving timely trauma care may help reduce the burden of fatal motorcycle-related injuries.

Declaration by Authors

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