ORIGINAL ARTICLE

Injury patterns and forensic report classification in motorcycle accidents: A large-scale retrospective study

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ABSTRACT

BACKGROUND: Motorcycle accidents represent a significant public health and forensic medicine issue due to their high morbidity and mortality rates. This study aimed to evaluate the demographic, clinical, and forensic characteristics of motorcycle accidents.

METHODS: A retrospective analysis was conducted on 2,445 motorcycle accident cases referred to the Department of Forensic Medicine at Eskişehir Osmangazi University Faculty of Medicine for forensic evaluation between 2020 and 2024. Demographic data, accident characteristics, helmet and alcohol use, injury patterns, Injury Severity Score (ISS) values, and forensic report classifications according to Turkish Penal Code (TCK) No. 5237 were analyzed.

RESULTS: Of these cases, 91.7% were male, with an average age of 31.8 years; the most commonly affected age group was 20–29 years. Most accidents occurred within city limits (68.1%), and the most frequent accident mechanism was collision with another vehicle (59.8%). Helmet use was reported in 36.0% of cases, while 47.0% were not wearing a helmet at the time of the accident. The most common injuries involved the lower (44.4%) and upper extremities (38.7%). Fractures most frequently affected the tibia/fibula, wrist-hand bones, and ribs. The average ISS was 9.1±4.8; injuries were classified as mild in 59.3% of cases, moderate in 30.0%, and severe in 10.7%. According to the TCK, 66.0% of injuries were classified as "treatable with simple medical intervention."

CONCLUSION: Motorcycle accidents are particularly common among young men, and helmet use remains low. Injuries predominantly affect the extremities, and forensic classification based on the TCK provides a distinctive contribution to forensic medicine practice. Increasing the use of protective equipment, preventing driving under the influence of alcohol, and strengthening traffic safety measures are essential.

Keywords: Motorcycle accident; injury pattern; helmet use; Injury Severity Score (ISS); Turkish Penal Code; forensic report.

INTRODUCTION

Traffic accidents continue to be one of the leading causes of death and disability worldwide and constitute a significant public health problem, particularly in low- and middle-income countries.[1] According to the World Health Organization (WHO) 2018 report, approximately 1.35 million people die each year as a result of traffic accidents, while millions more are injured or sustain permanent disabilities.[1]

Motorcycle users are among the highest-risk groups in road traffic accidents, with deaths in this group accounting for approximately 28% of global traffic accident-related fatalities.[1] According to WHO data, mortality rates among motorcycle riders are particularly high in regions such as Southeast Asia and Africa.[1] In developing countries, the widespread use of motorcycles for economic reasons has led to an increase in accidents and traumatic injuries associated with these vehicles.[2]

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Due to their structure, motorcycle accidents expose riders and passengers to environmental trauma, resulting in a high likelihood of non-fatal but serious injuries.[3] Studies have shown that head, lower and upper extremity, and thoracic injuries are prominent in these accidents, and that the majority of fractures occur in the leg bones, wrist and hand bones, ribs, and shoulder region.[4,5]

The Injury Severity Score (ISS), one of the parameters frequently used to assess injury severity in motorcycle accidents, allows for evaluation of the patient's overall condition by considering the type of trauma, injury location, and the presence of multiple injuries.[6] In this context, significant associations have been demonstrated between ISS scores and variables such as injury patterns, use of protective equipment, and the need for surgical intervention.[6-8]

In Türkiye, a total of 1,444,260 traffic accidents occurred in 2024; 266,854 of these were fatal or injury-causing accidents. In these accidents, 6,351 people lost their lives and 385,117 people were injured.[9] In 2024, 31.5% of vehicles involved in fatal or injury-causing accidents were motorcycles. A total of 1,228 people died and 109,832 were injured, highlighting the significant traffic safety risks faced by motorcycle users.[9]

The literature reports that injury patterns associated with motorcycle accidents are more severe in developing countries; protective equipment usage rates are low, and most emergency department visits are related to lower extremity, head, and thoracic trauma.[3-5] The limited number of studies conducted on motorcycle accidents in Türkiye necessitates a more detailed and comprehensive evaluation of this issue from a forensic medicine perspective. This study aims to analyze the traumatic injury profiles of individuals involved in motorcycle accidents, including protective equipment use, hospital admissions, surgery rates, ISS scores, and forensic report evaluations using multidimensional parameters.

MATERIALS AND METHODS

This study was designed as a retrospective, descriptive research. Within the scope of the study, forensic examination reports of individuals involved in motorcycle accidents who were referred to the Department of Forensic Medicine, Faculty of Medicine, Eskişehir Osmangazi University for forensic evaluation between January 1, 2020 and December 31, 2024, were retrospectively reviewed.

Only individuals who survived the motorcycle accident and underwent forensic examination were included in the study. Data were obtained from information contained in the forensic reports. Cases with missing data, illegible records, or trauma sources other than motorcycle accidents were excluded from the study.

The data were obtained from the reports using a standardized data collection form. The variables examined included age, gender, anatomical location of the injury, presence of bone fractures, soft tissue injuries (ecchymosis, abrasion, laceration), number of affected body areas, and severity of trauma. Trauma severity was assessed based on clinical criteria such as hospitalization, need for surgical intervention, or the presence of permanent damage, if any.

Ethical approval for the study was obtained from the Non-Interventional Clinical Research Ethics Committee of Eskişehir Osmangazi University (Decision No: 20, Date: 26.06.2025). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Data analysis was performed using SPSS (Statistical Package for the Social Sciences, version 27.0; IBM Corp., Armonk, NY, USA). Descriptive statistics were presented as frequency, percentage, mean, and standard deviation. No comparative statistical tests were applied in this study.

RESULTS

In this study, a total of 2,445 cases who applied to the Department of Forensic Medicine at Eskişehir Osmangazi University Faculty of Medicine for a forensic report between 2020 and 2024 and were involved in motorcycle accidents were retrospectively evaluated. Of the cases, 91.7% (n=2,243) were male and 8.3% (n=202) were female. The mean age was 31.8±10.6 years, with ages ranging from 16 to 74 years. The most common age group was 20–29 years (41.2%), followed by 30–39 years (28.7%) (Table 1).

Of the accidents, 68.1% (n=1,666) occurred in urban areas, 21.3% (n=522) on interurban roads, and 10.6% (n=257) in rural areas. The most common type of accident was vehicle collisions, accounting for 59.8% (n=1,463) of cases. This was followed by single-vehicle accidents (27.1%; n=663), collisions with stationary objects (8.9%; n=217), and collisions with pedestrians (4.2%; n=102) (Table 1).

When examining the use of protective equipment, it was determined that among the 2,029 cases with known helmet-use data, 36.0% (n=880) were wearing helmets, while 47.0% (n=1,149) were not. Helmet-use information could not be obtained for 17.0% of cases. Of the 1,724 cases with available data on alcohol use, 111 were found to be positive for alcohol. No information on alcohol use was available for the remaining 721 cases (29.4%) (Table 1).

In the assessment of traumatic findings, no injuries were identified in 27.5% of cases (n=671). When the 1,056 cases (43.2%) with only superficial soft tissue injuries (ecchymosis, abrasion, superficial laceration) and no fractures or internal organ damage were included in the evaluation, a total of 70.7% of cases had either no traumatic findings or only superficial injuries. In contrast, bone fractures and/or internal organ injuries were detected in 718 cases (29.3%). Regarding injury location, the lower extremities (44.4%) and upper extremities (38.7%) were most commonly affected, followed by the head (26.0%), face (21.6%), thorax (11.2%), and abdomen-pelvis (5.4%). In cases involving multiple regions, each affected region was counted separately (Table 1).

Table 1. Distribution of demographic, accident-related, and clinical characteristics of the cases

	Number (#)	Percentage (%)
Age, Mean±SD	31.8±10.6	
≤19	123	5.0
20-29	1,007	41.2
30-39	701	28.7
40-49	385	15.7
50-59	156	6.4
≥60	73	3.0
Sex		
Male	2,243	91.7
Female	202	8.3
Helmet Use		
Helmeted	880	36.0
Not helmeted	1,149	47
Unknown	416	17.0
Alcohol Use (Ethanol)		
Positive	111	4.5
Negative	1,613	65.9
Unknown	721	29.4
Accident Location		
Urban area	1,666	68.1
Interurban road	522	21.3
Rural area	257	10.6
Type of Accident		
Single-vehicle accident	663	27.1
Vehicle collision	1,463	59.8
Collision with a stationary object	217	8.9
Collision with a pedestrian	102	4.2
Traumatic Findings		
No injury	671	27.5
Superficial soft tissue injury	1,056	43.2
Bone fracture and/or internal organ injury	718	29.3
Injury Location*		
Lower extremities	788	44.4
Upper extremities	687	38.7
Head	461	26.0
Face	383	21.6
Thorax	199	11.2
Abdomen-pelvis	96	5.4
Hospitalization Required	934	38.2
Intensive care unit	215	23.0
General ward	719	77.0
ISS, Mean±SD	9.1±4.8	
≤8	1,449	59.3
9-15	733	30.0
≥16	263	10.7
Forensic Report Classification		
Injury treatable with simple medical intervention	1,615	66.0
Life-threatening injury	613	25.1
Permanent disability	128	5.2
Surgical intervention		
Yes	357	14.6
No	2,088	85.4
Functional Outcome		
Functional impairment	91	3.7
Loss of function	37	1.5

*In cases involving more than one injured body region, each region was counted separately.

A total of 582 cases (23.8%) had bone fractures, with the most common involving the tibia/fibula (7.5%; n=183), wrist and hand (5.3%; n=129), ribs (3.2%; n=79), clavicle (2.5%; n=61), pelvis (2.4%; n=58), humerus (1.8%; n=45), and radius/ulna (1.7%; n=42). Less frequent fractures included those of the femur (1.6%; n=39), foot bones (1.4%; n=35), skull (0.9%; n=22), and scapula (0.4%; n=11) (Table 2).

Additionally, 28 cases (1.1%) had extremity dislocation, and 11 cases (0.5%) had partial or complete amputation.

A total of 934 cases (38.2%) required hospitalization, of whom 77.0% (n=719) were treated in the ward and 23.0% (n=215) in the intensive care unit. The average length of hospital stay was 5.2±3.6 days among the 821 cases with available data (Table 1). Surgical intervention was performed in 357 cases (14.6%), including orthopedic internal fixation procedures, interventions for visceral organ injuries, and cranial operations.

The Injury Severity Score was calculated for all cases, and the average ISS was 9.1±4.8. When the ISS distribution was evaluated, 59.3% (n=1,449) of cases had mild injuries (ISS ≤8), 30.0% (n=733) had moderate injuries (ISS 9–15), and 10.7% (n=263) had severe injuries (ISS ≥16) (Table 1). The ISS score was positive only in cases with anatomical injury, whereas ISS=0 was defined for cases without traumatic findings.

Among the cases evaluated for sequelae, a total of 128 cases (5.2%) had sensory or anatomical dysfunction. In 91 cases (3.7%), a sensory organ or anatomical structure suffered permanent functional impairment, while in 37 cases (1.5%), complete loss of function developed. According to the forensic report classification, 66.0% (n=1,615) of cases were reported as "recoverable with simple medical intervention," while 25.1% (n=613) were assessed as "life-threatening" (Table 1).

Table 2. Distribution of bone fractures by anatomical location

Fracture Location	Number (#)	Percentage (%)
Tibia and fibula	183	7.5
Wrist bones (distal radius, carpal, metacarpal, phalanx)	129	5.3
Clavicle	61	2.5
Humerus	45	1.8
Femur	39	1.6
Pelvis	58	2.4
Radius/ulna (diaphysis)	42	1.7
Foot bones (metatarsal, phalanx, calcaneus)	35	1.4
Scapula	11	0.4
Skull	22	0.9
Rib	79	3.2
Total	582	23.8

This classification was made based on the criteria defined in the relevant articles of the Turkish Criminal Code No. 5237.

DISCUSSION

This study retrospectively examined the demographic, clinical, and forensic characteristics of motorcycle accident cases referred to the Department of Forensic Medicine at Eskişehir Osmangazi University Faculty of Medicine for forensic evaluation between 2020 and 2024. Among the 2,445 cases evaluated, the majority involved young adult males, and most accidents occurred within urban areas and involved vehicle collisions. Helmet use was low, while the rate of alcohol positivity was low. Injury pattern analysis showed a predominance of lower and upper extremity injuries, with bone fractures most commonly involving the tibia/fibula and wrist/hand bones. The average ISS score indicated mild injury severity; however, approximately one-third of the cases had moderate or severe injuries. In forensic report evaluations, a substantial proportion of cases were classified as "treatable with simple medical intervention" according to the Turkish Penal Code No. 5237.

Our data revealed that 91.7% of the cases were male and 8.3% were female. The higher incidence of motorcycle accidents among males is consistent with findings reported both nationally and in the international literature.[1-3,7,8,10,11] The fact that men exhibit riskier driving behaviors and that motorcycle use is more common among men for occupational and transportation purposes is cited as the main factor explaining this situation.[2,7] The average age of the cases was 31.8 years, with the most common age group being 20-29 years. Similarly, studies conducted in different regions, including Ethiopia, Nigeria, and Iran, have reported that young adults are at the highest risk of motorcycle accidents.[4,8,10] This situation is associated with young drivers' lack of experience, tendency to drive at high speeds, and inadequate compliance with traffic rules.[7,11]

The analysis showed that 68.1% of accidents occurred in urban areas, 21.3% on interurban roads, and 10.6% in rural areas. The high proportion of urban accidents is particularly associated with heavy traffic, increased motorcycle usage, and complex road conditions.[9,11,12] Regarding accident types, vehicle collisions were the most common (59.8%), followed by single-vehicle accidents (27.1%), collisions with stationary objects (8.9%), and collisions with pedestrians (4.2%). Similarly, a study conducted in Thailand identified vehicle collisions as the primary cause of motorcycle accidents, and data from the Turkish Statistical Institute also indicate that vehicle collisions are the leading accident mechanism in Türkiye.[9,12] A significant proportion of single-vehicle accidents can be attributed to driver errors, speeding, road surface defects, and adverse weather conditions.[13]

In this study, the helmet usage rate was found to be 36.0%, with 47.0% of cases not wearing a helmet at the time of the accident, while helmet-use information was unavailable for 17.0% of cases. The World Health Organization data indicate that properly worn helmets reduce the risk of death among motorcycle riders by approximately 40% and the risk of serious head injury by 70%.[1] However, helmet usage rates in low- and middle-income countries are generally below 50%, and in some regions, they have been reported to be below 10%.[14,15] In Türkiye, helmet usage rates vary by region, and this rate decreases significantly, particularly during short-distance urban travel.[9] The low helmet usage rate identified in our study suggests that, despite the proven effectiveness of helmets in reducing injury severity,[14,15] there are shortcomings in the enforcement of legal regulations and public awareness campaigns related to helmet use.

When evaluating the distribution of injury sites, the lower extremities (44.4%) and upper extremities (38.7%) were most frequently affected, followed by the head (26.0%), face (21.6%), thorax (11.2%), and abdomen-pelvis (5.4%) regions. The literature similarly indicates that lower extremity injuries are the most common type of trauma in motorcycle accidents, which is related to the structural characteristics of motorcycles and the direct exposure of the rider's lower limbs during impact.[3,4,7,8,10,11] The prevalence of head and face injuries is directly related to helmet use and is significantly higher among riders who do not wear helmets.[14,15] Jeffers et al.[5] reported that lower extremity injuries, particularly those involving the foot and ankle, play a critical role in fatal accidents, while Rebollo-Soria et al.[16] emphasized that head and face injuries are equally critical in such incidents. In our study, fractures were most commonly observed in the tibia/fibula, wrist and hand bones, and ribs, which is consistent with fracture locations reported in previous studies.[4,5,8,10]

In our study, the mean ISS was 9.1±4.8, with 59.3% of cases

classified as mild (ISS ≤8), 30.0% as moderate (ISS 9-15), and 10.7% as severe (ISS ≥16) injuries. These findings are consistent with similar studies conducted in developing countries.[7,8,11] The ISS is a scoring system that objectively assesses injury severity and is closely related to prognosis.[6] Hoseinian et al.[8] reported a severe injury rate of 12.1%, while Lin and Kraus[7] demonstrated that ISS values are significantly associated with injury mechanism, protective equipment use, and the presence of multiple injuries. In our study, the relatively low rate of severe injury may be attributed to the fact that most cases involved only superficial injuries and that the majority of fractures were limited to the extremities.

When examining forensic report classifications, 66.0% of cases were categorized as injuries treatable with simple medical intervention, 25.1% were classified as life-threatening, and 5.2% were classified as resulting in permanent anatomical or sensory impairment or loss. This classification was based on the criteria defined in Articles 86 and 87 of the Turkish Penal Code (TCK) No. 5237. Similarly, Sataloğlu et al.[17] reported that a substantial proportion of injuries in bicycle and motorcycle accidents were classified as minor. The forensic report classification of motorcycle accidents according to TCK criteria has rarely been addressed in the literature, highlighting the distinctive value of our study from a forensic medicine perspective. In studies conducted abroad, forensic reporting processes are generally evaluated based on injury severity scores or trauma patterns, and legal classifications vary according to national legislation.[8,11,16] In this context, examining TCK-based forensic report classifications, which directly affect legal processes in Türkiye, in a large sample of motorcycle accident cases makes an important contribution to both forensic medicine practice and traffic safety policies.

One of the most important strengths of this study is its large sample size, which includes 2,445 motorcycle accident cases referred to the forensic medicine unit over a five-year period. Additionally, collecting data from a single center ensured that records were evaluated using the same standard procedures and increased classification consistency. Another valuable contribution of the study, from both forensic medicine and traffic safety perspectives, is the classification of injuries according to the criteria of the Turkish Penal Code No. 5237. However, the retrospective design of the study led to information loss due to record deficiencies, particularly resulting in a high "unknown" rate for variables such as helmet use, alcohol status, and accident mechanism. Furthermore, due to its single-center nature, the generalizability of the findings to the entire country is limited. Prospective, multicenter studies are recommended to more thoroughly elucidate injury patterns and the effectiveness of protective measures.

The findings indicate that motorcycle accidents continue to be a significant public health issue in terms of serious injuries and fatal outcomes. Our study sheds light on both forensic medicine practice and the development of traffic safety policies by detailing injury types, affected body regions, helmet and alcohol use, and forensic report classifications. In particular, forensic report classification based on the Turkish Penal Code is of critical importance, as it serves as evidence in legal proceedings. Therefore, legal regulations, awareness campaigns, and strengthened control mechanisms are needed to increase protective equipment use among motorcycle users. Additionally, effective enforcement of existing penalties for driving under the influence of alcohol and infrastructure improvements to prevent accidents will reduce injury severity as well as the burden on forensic processes.

CONCLUSION

Motorcycle accidents continue to be a significant legal and public health issue in Türkiye due to the high risk of injury and mortality. Using a large sample, our study detailed injury types, helmet and alcohol use, and legal report classifications based on the Turkish Penal Code. The findings emphasize the need to promote protective equipment use, prevent driving under the influence of alcohol, and strengthen traffic safety measures. Furthermore, multicenter and prospective studies are recommended to comprehensively evaluate injury patterns and the effectiveness of protective measures.

Ethics Committee Approval: This study was approved by the Eskişehir Osmangazi University Non-Interventional Clinical Research Ethics Committee (Date: 26.06.2025, Decision No: 20).

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ORİJİNAL ÇALIŞMA - *ÖZ*

Motosiklet kazalarında yaralanma paternleri ve adli rapor sınıflandırması: Geniş ölçekli retrospektif bir çalışma

AMAÇ: Motosiklet kazaları, yüksek morbidite ve mortalite oranları nedeniyle önemli bir halk sağlığı ve adli tıp sorunudur. Bu çalışma, motosiklet kazalarının demografik, klinik ve adli özelliklerini değerlendirmeyi amaçlamaktadır.

GEREÇ VE YÖNTEM: 2020-2024 yılları arasında Eskişehir Osmangazi Üniversitesi Tıp Fakültesi Adli Tıp Anabilim Dalı'na adli değerlendirme amacıyla sevk edilen 2.445 motosiklet kazası olgusu retrospektif olarak incelendi. Demografik veriler, kaza özellikleri, kask ve alkol kullanımı, yaralanma paternleri, ISS skorları ve 5237 sayılı Türk Ceza Kanunu'na (TCK) göre adli rapor sınıflandırmaları değerlendirildi.

BULGULAR: Olguların %91.7'si erkek olup, ortalama yaş 31.8 idi; en sık etkilenen yaş grubu 20-29 yaş aralığıydı. Kazaların %68.1'i şehir içinde meydana gelmiş, en sık mekanizma araçla çarpışma (%59.8) olarak bulunmuştur. Kask kullanım oranı %36.0 olup, %47.0'ı kaza sırasında kask takmamıştı. En sık yaralanmalar alt (%44.4) ve üst ekstremitelerde (%38.7) görülmüş; kırıklar en çok tibia/fibula, el-bilek kemikleri ve kaburgalarda saptanmıştır. Ortalama ISS skoru 9.1±4.8 olup, olguların %59.3'ü hafif, %30.0'ı orta, %10.7'si ağır yaralanma grubunda yer almaktadır. TCK'ya göre yaralanmaların %66.0'sı "basit tıbbi müdahale ile giderilebilir" olarak sınıflandırılmıştır.

SONUÇ: Motosiklet kazaları özellikle genç erkeklerde yaygındır ve kask kullanımı düşük düzeydedir. Yaralanmalar çoğunlukla ekstremitelerde yoğunlaşmakta olup, TCK'ya göre yapılan adli sınıflandırma adli tıp uygulamalarına özgün bir katkı sağlamaktadır. Koruyucu ekipman kullanımının artırılması, alkol etkisi altında araç kullanımının önlenmesi ve trafik güvenliği önlemlerinin güçlendirilmesi gerekmektedir.

Anahtar sözcükler: Adli rapor; ISS; kask kullanımı; motosiklet kazası; Türk Ceza Kanunu; yaralanma paterni.

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