A fatal crash against guardrail. Report of a case and considerations about safety of roadway barriers in Italy

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Abstract: There are three types of motorcycle accidents: crashes against a fixed non-vehicular object; crashes between motorcycle and another motor vehicle; other harmful action. Crashes against guardrails are included in the first crash category. Guardrails are roadside barriers erected to restrain vehicles whose driver has lost control in order to reduce the severity of collisions with off-road fixed objects. Despite such measures, guardrails may still be inadequate to reduce mortality related to motorcycle crashes. The present authors report a case of a man who died after a collision against a guardrail near an Italian city (L'Aquila). The crash against the pole of the guardrail determined a right angle dent of the upper part of the helmet. This dent led to a fatal fracture of the skull. The authors report this case to underline the necessity to modify crash barrier homologation criteria in Italy, because they may actually fail to protect motorcyclists and be responsible for specific, and sometimes even lethal, lesions.

Key Words: motorcycle accidents, mortality, skull fracture, helmet, roadside guardrails homologation.

In developed countries, motorcycle crashes are becoming a widespread road safety problem [1], there is an increasing number of annual traffic-related fatalities and today they represent more than 10 percent of all traffic-related deaths [2]. Motorcycle accidents can be grouped into three categories: crashes against a fixed non-vehicular object; crashes between motorcycle and another motor vehicle; other harmful action [3]. The use of guardrail can prevent vehicles from colliding against roadside infrastructure and this can reduce injury severity [4]. Guardrails are roadside barriers erected to restrain vehicles out of the rider’s control and to reduce the severity of collisions with offroad fixed objects. They are widely used, and generally consist of one or two parallel, continuous metal beams with a W-shaped section, to absorb the kinetic energy of impacts. The beams are screwed - directly or through metal distancers - to vertical steel posts of various geometric shapes, generally rectangular or circular sections [5] (Fig. 1). Guardrail systems are designed to protect travellers from hazards at the side of the road, such as poles, trees, drains or cliffs [1]. Hazards at the roadside need to be shielded with guardrails. In these case, the guardrail must be of adequate length and size, in order to protect vehicles from impact roadside hazards in the event of going beyond the barrier [4]. However, the use of guardrail may not be sufficient for reduce mortality by motorcycle crashes: as reported by EuroRAP in 2008, 8–16% of motorcycle deaths in Europe are due to hitting a safety barrier. The survey revealed that motorcycle riders are 15 times more likely to be killed, than car drivers, when crashing into a roadside barrier [6]. In fact, guardrails put up in Europe must meet the EN 1317 standard [7]. However, this standard was developed to protect car occupants,
but not motorcyclists [8]: this explains the higher fatality risk for motorcycle accidents with guardrail impacts [9]. The motorcycling community has become aware that roadway barriers can be a significant safety hazard [10]. The best protection for motorcyclists is provided by the energy-absorbing characteristics of the roadside infrastructure. The required length of a guardrail was considered the length that reduces vehicle speed at a maximum theoretically possible deceleration of 0.3 g behind the barrier based on real-life road departure speed [4]. There are, however, many other factors that contribute to the extent of the motorcyclist’s injuries: age and experience of the motorcyclist, the use of alcohol or illicit drugs, speed of the motorcycle at the time of the impact, time of year and of the day, road conditions and environment, risk taking behavior, and use of the helmet [11]. For example, the probability of crashes increase if the motorcyclist drive under the influence of alcohol [3] or goes over the speed limit [12], while decrease if he wears a helmet [2]. As demonstrated by Nunn et al., rural areas have a higher relative risk of fatality than urban areas [3]. The age of the rider is another factor that increases the risk of fatality. This may be because older riders have less physical resilience to injuries and they have slower reaction time and reduced sensory ability to avoid lethal crashes [13, 14].

Motorcycle crashes against guardrails involve two impact event: first, a collision with the ground and, secondly, sliding into the barrier [15]. In these cases, the question arises whether the most harmful event is caused by impact with the ground or from collision with the barrier [16]. Certainly, both events contribute to the extent of injury, and the motorcyclist will already have received fatal injuries from the ground collision prior to sliding toward and hitting into the barrier [16].

CASE REPORT

The authors report a case of a Caucasian, 50 years old man who died after a fatal crash against a guardrail near the Campotosto lake, L’Aquila, in the Abruzzo region, Italy. The victim wore the helmet, but as photos show, the presence of a post in the guardrail determined an angle dent of the upper of the helmet (Figs 1-2). This dent led to a fatal fracture of the skull (Fig. 3). A blood alcohol concentration (BAC) was analyzed, and resulted negative. Traumatic injuries were given a score for severity using the Abbreviated Injury Scale (AIS). A numerical score between 1 (mild) and 6 (unsurvivable) is assigned to individual injuries [17]. As suggested by Wright and Robertson, the authors compared the crash site (defined as the point at which the vehicle left the roadway) with a point one mile distant from the crash site, in the direction from which the vehicle had come, on the same road [18]. The crash site had a curvature of 19°. The degree of the

Figure 1. A typical Italian guardrail: it consists of two parallel, continuous metal beams with a W-shaped section screwed to vertical steel posts across metal distancers. The lack of a deformable under-run that reaches down to the road surface can lead to a fatal motorcycle crash.

Figure 2. The upper of the helmet, after the crash: the presence of a post in the guardrail determined a right angle dent of the helmet.

Figure 3. The fatal fracture of the skull, caused by the crash against the post of the guardrail.
bend in the road at the crash site is very important in determining the causes of the crash. Another important factor in determining the crash is the speed at which the motorcycle was travelling at the point of the collision, but this is a very difficult evaluation. Some studies reported the determination of “critical curve speeds” [1]: these speeds are calculated using engineering formulae, after which an experienced police officer rides a motorcycle along the road at the maximum possible speed.

The accident occurred on Sunday afternoon. This is confirmed in the article of Hussein et al., which observed an high frequency of fatalities at weekend. These studies explain that driving as a recreational activity is a contributory factor of crashes [1]. This case demonstrated the relevant role of Forensic Medicine in evaluation of mortality, disability, and social cost of road accidents.

**DISCUSSION**

The motorcycle is a dangerous means of transport, relative to four-wheels vehicles, because riders are exposed to a greater threat of death or injury: in 1994, Nunn et al. demonstrated that riders are 11 times more to be involved in fatal collisions, compared to passenger cars [3]. The type of injury is determined by severe blunt force trauma, that lead to head, neck, thoracic, and other axial–skeletal injuries [19, 20]. The Fatal Accident Reporting System proposed a classification that divided injury severity into five categories: property damage only, possible injury, evident injury, disabling injury, and fatality [12]. Common cause of mortality are injuries to the head. The use of helmets should protect against these injuries, even if helmets decrease the rider’s field of visual and increases neck injuries [2]. Despite this, observational studies demonstrate that, in case of motorcycle accidents, the use of helmets reduce head injuries by 69% and death by 42% [21]. The percentage of cases where helmets fail to protect are due to behavioral and technical factors, such as the “Peltzman hypothesis”, which suggests that compensating changes (e.g., speed and braking distance) in risky driving behavior can actually reduce the benefits of helmet use; moreover, because the rest of the motorcyclist’s body are exposed, the use of the helmet can’t prevent injuries in serious crashes; furthermore, it is possible that the vision and reaction time of motorcyclists may be reduced by the use of helmets, thus increasing the severity of injuries; finally, the weight of a helmet can exacerbate certain injuries (i.e., injuries of the neck) in the event of a crash [2]. However, it is always desirable to wear a helmet: studies by Evans and Frick in 1988 demonstrated that helmets reduced fatality risks by 28 percent [22] and, more recently, in 2004, Deutermann et al. demonstrated that use of a helmet reduced fatality risks by 37 percent [23]. During a motorcycle accident, injuries are generally determined by collisions with other vehicles [3] or with different types of objects, such as trees, lampposts, road signs, and guardrails. Guardrails are the second most frequent collision objects [8]. Guardrails are designed to protect occupants of a vehicle from hazards that may be encountered during a crash, such as poles or trees. However, they are not safe for motorcyclists: Gabler et al. reported that there were 1,189 fatal crashes and 35,000 injurious crashes into guardrails take place in the US in 2005 (24). In Europe, due to the lack of any EU action, the use of “motorcycle friendly” guardrails depends on the awareness of any single nation. For example, in Portugal, France, the Netherlands, Germany [8] and Spain [25] new barriers were installed which feature a deformable under-run that reaches down to the road surface, shielding the posts. In Italy, the only requirement is that barriers complies EN 1317 criteria. Therefore, only some areas in Italy, currently, have motorcyclist-friendly guardrails. For this reason, it is necessary to pass new regulations in Italy in order to modify crash barrier homologation criteria, because they may actually fail to protect motorcyclists [5], as demonstrated in this case report. The hazard of guardrails is accurately described in the article of Daniello, who showed that collisions with guardrail, rather than collisions with the ground, have a greater fatality risk for motorcyclists, and is 7 times more likely to be fatal [16]. The work of Gabler et al. also analyzed all guardrail crashes which occurred in the United States in the period 2000-2005: it was observed that motorcycles were involved in less than 1% of all guardrail crashes, but accounted for over 30% of guardrail crash fatalities. The same article demonstrated that motorcycle fatalities in guardrail collisions is a growing problem: in fact, the number of fatally-injured motorcyclists increased by 73% - from 129 in 2001 to 224 fatalities in 2005, compared to car occupant fatalities, that was reduced by 31% from 251 deaths in 2001 to 171 deaths in 2005 [24]. There is a variety of injury type in death by motorcycle. A study of 59 motorcycle crashes in Scotland revealed these fatal lesions: decapitation, liver destruction, ruptured ventricle, brainstem laceration, skull fracture, spinal cord transection, and various transections of the thoracic aorta [20].

**CONCLUSION**

In conclusion, even if guardrails provide protection against other roadside objects, they are not safe for motorcyclists because, on average, the collision between motorcyclist and guardrail is more harmful than a collision between motorcyclist and ground. The design of guardrails must be reviewed with a focus on the safety of motorcyclists [26], because of their potentially important function in protecting riders from crashes with off-road objects [1]. It is necessary to study high-risk locations in which guardrails must be erected.
along all the sections of roadway, while it is possible to minimize these in low-risk areas [17]. As the collision speed is an important parameter used in the design of protective devices, it is suggested that the government should have a lower tolerance toward motorcycles traveling at higher speeds [3] and that it is necessary to reach a slower deceleration by making barriers more flexible [27]. The forensic discipline must have a role in identifying dangerous behavior and in promoting the adoption of measures to improve rider safety [28]. A plan of written and practical tests should also be established in order to evaluate motorcyclist’s skills, this could reveal any deterioration in response and control capabilities in elderly riders. Refresher courses for riders are necessary to explain the behavior is better to adopt in the case of emergency: for example, they should be aware that, from an injury prevention perspective, it might be better, if possible, to leave free the motorcycle to avoid sliding and striking any objects [3].

References