PATTERN OF HEAD INJURY IN MOTORCYCLE FATALITIES

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ABSTRACT: Head injury contributes to a significant proportion of motorcycle fatalities. The site and pattern of head injury in victims of fatal motorcycle crashes in 1995 were studied retrospectively. The site of impact on the head was determined based on the injuries on the scalp, pattern of skull fractures and injuries of the brain. Of 54 cases, 9 had massive crush injuries. Of the remaining 45 cases, the site of impact was as follows: frontal 21, lateral 14, posterior 4, vertex 1, chin 1 and unascertainable in 4 cases. The majority of injuries occurred on the front and lateral aspects of the skull. Motorcycle helmets are currently tested for impact energy attenuation and penetration test at the vertex. Helmet standards need to take into account site and nature of injury. *(JUMMEC 2000; 1: 33-35)*

KEYWORDS: Head injury, motorcycle fatalities, helmet standards.

Introduction

With control of communicable diseases, injuries are emerging as an important problem in developing countries. Malaysia is no exception and injuries of all types are a major health problem (1). The investigation and reporting of road traffic crashes is carried out by the traffic unit of the Royal Malaysia Police using an adapted software of the Microcomputer Accident Analysis Package of Transport and Road Research Laboratory, United Kingdom. According to police data motorcyclists (riders and passengers) constituted 59.3% of road fatalities in 1998 (2). Head and "multiple" injuries were observed in 49.7% and 33% of victims of motorcycle fatalities respectively (2). "Multiple" injuries includes head injuries in this classification by the police. An earlier autopsy study of motorcycle fatalities at this centre showed that head injuries were present in 60% of victims (3).

The site and pattern of head injuries in motorcycle fatalities was studied to correlate the common sites of injuries with existing standard requirements for motorcycle helmets.

Materials and methods

In Malaysia, all fatalities due to traffic crashes require a post-mortem examination under the provisions of the Criminal Procedure Code (F.M.S. cap. 45). The University of Malaya Medical Centre, Kuala Lumpur serves as a referral centre for almost all victims of road crashes occurring in the adjacent district of Petaling Jaya. From the autopsy register for 1995, reports of motorcyclists were studied and only those with head injuries were included. The injuries on the scalp, skull and brain were charted and tabulated. The site of impact on the head was determined based on the injuries on the scalp, pattern of skull fractures and injuries on the brain. On the face and scalp, the injuries are usually localized at the site on impact. However, in some cases, there were extensive internal head injuries with little or no external injuries. In these cases, the pattern of skull fractures was used to determine the direction of force upon the head. According to Spitz, the fractures of skull usually follow the rule of thumb (4):-

- impact of the face causes fractures of the facial skeleton
- impact of the forehead causes a sagittal fracture of the base of the skull
- impact of the chin may transmit the force through the temporomandibular joints to the base of the skull and cause a "hinge" fracture.
- A side or lateral impact of the head causes similar "hinge" fracture of the base of the skull

The pattern of skull fractures with the scalp and facial injuries were evaluated together with brain injuries. Site of impact was substantiated by internal haemorrhages (extradural, subdural or subarachnoid) and lacerations or contusions on the brain (coup or contrecoup).

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Results

A total of 54 cases of head injuries were extracted from the records. Of these, 9 cases were due to massive crush injuries (e.g. head being run over by a car). The sites of impact in the remaining 45 cases is given in Table 1.

The front of the head and face was by far the most common site of impact. The next most common site was the lateral aspect (including both right and left sides). Only 4 cases were due to impact on the back of the head. Impact on the vertex was observed in only one case and in 4 cases, the direction of the impact could not be ascertained.

In 4 cases of lateral impact, the side of the impact i.e. whether right or left could not be inferred. In these instances, the victims had the classical sagittal ("hinge") fracture of the skull with an apparently uninjured scalp. The internal injuries to the brain were not specific enough. Hence, lateral impact were charted as such without giving the direction of laterality (right or left).

Case studies

Case 1. A 19 year adult male motorcyclist, collided with a stationary lorry parked at the side of the road. He died on the spot. Autopsy examination showed deep lacerations on the face with underlying comminuted fractures of the facial bones and anterior cranial fossae. The frontal lobes of the brain were lacerated. In addition, he had a closed fracture of left humerus.

The impact site was determined to be frontal.

Case 2. A 22 year old adult male motorcyclist, skidded off the road and hit the ground. He was admitted to University Hospital with a serious head injury (Glasgow Coma Scale of 4/15). In view of his condition, he was treated conservatively. He succumbed to his injuries 7 hours later. Autopsy showed laceration of the right occipital region of the head, fracture of the right temporal bone of the skull radiating to the across the middle cranial fossa with contusion of the right temporal lobe of the brain. There was also subdural haemorrhage over the left temporo-parietal lobes of the brain. In addition, there was fracture of the right humerus.

The impact site was determined to be right lateral.

Case 3. A 18 year old motorcyclist, crashed into a car parked at the side of the road and then thrown off onto the road where he was ran over by an army truck. He died on the spot. He sustained extensive comminuted fractures of the skull with the brain grossly lacerated. In addition, he sustained multiple injuries including rupture of the heart.

The mechanism of injury was due to run-over by the truck.

Table 1. Site of impact to the head in 45 motorcycle fatalities, University of Malaya Medical Centre, Kuala Lumpur, 1995.

Site of impact	Number of cases
Frontal	21
Lateral	14
Posterior	4
Vertex	1
Chin	1
Unascertained	4
Total	45

The three cases illustrated the usual mode and pattern of fatal head injuries in motorcyclists.

Discussion

The common sites of impact were the front and sides of the head. Only one case showed evidence of impact to the vertex. Unfortunately, we could not correlate these injuries with the markings on the helmet as the helmet was either not brought with the victim to the hospital or not described in the autopsy report. There was also no mention as to whether the helmet remained in place i.e. on the head or dislodged from the head. Theoretically, the helmet can dislodge if the straps are not tied or are loosely tied or if there is massive force. In a few cases, we could infer that the helmet was worn properly based on the injury (or non-injury) on the scalp and strap marks on the chin. An earlier study showed that a significant proportion of motorcyclists either do not strap their helmets or strap them loosely (5). In these instances, the helmet does not confer any protection.

It is therefore concluded that available evidence points to a need for the frontal and lateral aspects of the head to be protected by the helmet.

Helmets typically have a rigid covering consisting of a stiff outer shell and a crushable liner. The stiff outer shell protects by its ability to spread a concentrated load of energy at its outer surface over a larger area. The crushable liner is a protective padding protects by its capacity to manage impact energy (6).

In some subjects who displayed no scalp injuries but had severe intracranial injuries, it is postulated that the helmet was able to withstand the impact without destruction but transmitted the energy of the impact to the skull resulting in fractures and brain injuries. It can be speculated that the protective liner in such cases was unable to manage the impact energy because it was either too soft (thus becoming flattened during the impact), too hard (thus transmitting energy without adequate absorption)or because it was too thin (thus 'bottoming out' before the energy was adequately absorbed).

Testing of helmets essentially comprises impact energy attenuation, penetration resistance, strength of retention system and effectiveness of retention system ('roll-off') (7). Of these, the two of most interest to this study are the impact energy attenuation test and the penetration resistance test.

Impact energy attenuation testing utilizes an accelerometer to measure the rate of acceleration to the head imparted by the impact. The lower the acceleration reading the better the job being performed by the helmet.

Penetration resistance testing primarily assesses the structural integrity of the helmet. As a secondary benefit, the penetration resistance test assesses the ability of the helmet to protect the head against sharp or pointed objects that might impact the head during an accident. The penetration resistance test utilizes a falling dart to create a very high point loading on the outer surface of the shell. Penetration resistance testing does not assess the ability of the helmet to resist the crushing effects of a vehicle running over the helmet but clearly a helmet that affords penetration resistance would be expected to be somewhat more rigid in this respect than one which offered no penetration resistance.

It is normally the intention of Standards (the Malaysian Standard MS-1-1996 included) that the impact energy attenuating and penetration resisting properties of a helmet be consistent over all parts of the helmet above the test line (a boundary delineating critical areas of the head that are to be protected).

Laboratories in most countries are permitted to vary the location of impact energy attenuation sites anywhere above the test line (provided that minimum distances are observed from previous impact sites on the same specimen). However, testing of helmets in a number of countries, including Malaysia, has typically concentrated penetration resistance testing within the crown area of the helmet (6). This has often been imposed by limitations on the ability of test equipment to reach the sides of the helmet. What this means is that critical areas towards the front and sides of the helmet are in some countries not assessed (8).

Impacts to the vertex of the head are rare while impacts to the front and sides form the bulk of injuries. It is inconsistent therefore that physical testing of helmets be omitted from these areas of the helmet. A good helmet should provide protection to the entire region of the front and sides of the head. Laboratory testing should as far as possible take into account the mechanism of injuries in real crash situations.

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