A STUDY OF MOTORCYCLIST CASUALTIES WITH PARTICULAR REFERENCE TO HEAD INJURIES

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ABSTRACT

Details from a sample of fatal and non-fatal motorcyclist casualties are presented using data from several hospitals and police districts. The methodology is described with the following data elements being considered:-

Injury information with particular reference to the head, accident details including probable collision speed and impact direction, principal points of contact for both the machine and rider and also detailed examination of the helmet worn at the time of the accident.

A high proportion of the sample were in the 17-19 year age group. Of the 116 casualties in the sample, eighty-three were wearing full-face helmets and the remaining thirty-three wore open-face or 'jet' types. Of particular interest was the correlation between the location of helmet impact and the underlying head injury. In the full-face helmet sub-set the majority of blows were to the frontal and temporal regions with virtually none to the helmet crown. It was particularly noticed that blows to the helmet facebar and sides gave rise to serious and fatal head injuries often involving the base of the skull. Fractures to this area were sometimes caused through an indirect blow via the mandible.

The open-face helmet provided little facial protection and, as the majority of impacts were to this region of the head, they frequently resulted in serious and sometimes fatal injuries.

Injury severity is force-related but the study suggests that the location of head impact could be a key factor. Such forces could not be determined from the accident data but must be measured from reconstructed impacts under controlled conditions. It is suggested that attention is given to critical aspects highlighted by the study.

Future work in this area should extend the existing study, in particular to the very serious head injury casualties in order to confirm the above findings. The injury/accident studies must be linked with crash reconstruction and helmet impact work in order to produce realistic head injury criteria levels.

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INTRODUCTION

The study was based on a hospital sample of motorcyclist casualties, drivers and pillion passengers, who attended one of five different hospitals in close proximity to TRRL. Fatalities in the same geographical area were also included whether a head injury was the cause of death or not. In all cases the helmet worn at the time of the accident was retained for examination; this included noting the areas of contact to the outer shell, any linear damage and taking photographs. Accident data was noted and probable speeds of impact were estimated from information obtained from police sources. A visual examination of the vehicles involved was carried out for the majority of the cases together with photographic evidence of the damage. The trajectory of the rider together with the primary and secondary points of body contact were also deduced where possible. Clinical information on injuries was obtained from hospital notes and post-mortem reports.

RESULTS

A total of 116 casualties, driver and pillion passengers, have been reported in this study. Age distribution is shown in Table 1 and motorcycle engine size with related fatality involvement in Table 2. The types of helmet worn in the accidents are given in Table 3.

Table 1. Age distribution, drivers (+ pillion passengers)

Age (yrs) / Severity	16	17	18	19	20	21	22	23	24	25	26-30	> 30	Total
Fatalities	4	11	9	6(1)	3	5(3)	3	4	3	4	4	7	63(4)
All Severities	9(1)	20(2)	19	8	4(1)	5(4)	6(1)	5	3	3	17	17(1)	106(10)

Table 2. Distribution of motorcycle engine size and fatalities involved (Driver and pillion)

Engine size (cc)	50	51-125	126-200	201-400	> 400	Total
Fatalities (F)	5	6	11	25	20	67
N. (All severities)	14	13	16	36	36	115
F/N (%)	(36)	(46)	(63)	(69)	(56)	N/A

Table 3. Helmet worn at time of accident

Helmet type	Full-face (FF)	Open-face (OF)
Polycarbonate	41	31
Glass reinforced plastic (GRP)	42	2
Total	83	33

Evidence on helmet disposition at the precise moment of impact is one of the more difficult areas of investigation in this type of study. There is never any way of precisely determining how tight the rider had pulled the strap or whether emergency services or others had touched or removed the helmet, although some evidence of the latter subsequently comes to light. The precise fit of the helmet on the rider's head is another unknown factor and secondhand helmets passed on from other riders is yet another area of concern. Factors relating to this area of the study are given in Table 4. The groupings are not necessarily connected or mutually exclusive sub-sets. There were occasions when the strap was done up but the helmet wrenched off during impact, sometimes after it had protected the head in the principal impact. On other occasions the strap might have broken and the helmet stayed on the head.

Table 4. Helmet malfunction etc N(% of each group)

Helmet type	Not retained in accident	Strap/fixing broken	Strap undone
OF(N=33)	6(18)	2(6)	1(3)
FF(N=83)	12(14)	8(10)	4(5)

Examination of the helmets and vehicles involved in the accidents and relating these to accident circumstances where applicable, gave an indication of the objects or surfaces impacting the helmet. These are given in Table 5 and refer only to the main impact damage. The location of principal damage to the helmet in the cases where the helmet remained on the head is given in Table 6.

Table 5. Object struck by helmet causing principal damage

(Slightly damaged helmets excluded)

Road	Road + vehicle	Glass	Veh. body edge	Deformable panel/fence	Lampost /Tree	Earth	Wall/ solid	Kerb edge	Other	Total
32	8	2	8	7	7	5	3	1	5	78

Table 6. On-helmet location of principal contact

Location / Type	L or R facebar	Centre facebar	Frontal excluding facebar*	FACE only	Sides	Back	Top	NK Ø	Totals
OF	–	–	5	10	9	3	0	6	33
FF	6	8	18	–	31	14	1	6	83

*Contact to the forehead portion of the helmet. Ø Includes helmet not retained in accident.

The distribution of head injury severity using the Abbreviated Injury Scale is shown in Table 7. Use has been made of autopsy information where available. However the former may be deficient if a visual assessment of brain injury only is given in the post-mortem report.

Table 7. Head injury severity related to overall severity

Head injury severity / Overall severity	AIS 0	AIS 1	AIS 2	AIS 3	AIS 4 – 6	Totals
Fatal	3	5	1	14	42	66
Non-fatal	9	12	21	6	1	49
Total	12	17	22	20	44	115

The locations of principal helmet contact when the helmet was retained in the accident, are given in Table 8 (full-face helmets) and Table 9 (open-face helmets).

Table 8. Location of principal helmet contact related to head injury severity - full-face retained helmets

Impact location / Severity	L or R facebar	Centre facebar	Frontal excluding facebar	Sides	Back	Top	Totals
All fatals (HI severity AIS 3-6)	5	7	11	13	4	0	40
All fatals with basal # (HI severity AIS 3-6)	3	5	7	7	4	0	26
All severities (HI severity AIS 1-6)	7	8	15	26	11	1	68

Table 9. Location of principal helmet/face contact related to head injury severity - open-face retained helmets

Inpact location / Severity	Helmet front	FACE only	Sides	Back	Top	Totals
All fatals (HI severity AIS 3-6)	2	6	5	1	0	14
All fatals with basal # (HI severity AIS 3-6)	2	5	2	1	0	10
All severities (HI severity AIS 1-6)	2	13	6	5	0	26

DISCUSSION

Previous studies have highlighted features of head injury and the degree of protection required. Much of this was summarised with references in the Proceedings of a Symposium on the State of Art in Head Protection[1]. At that meeting Pedder referred to previous field accident studies[2,3] and the need to precisely identify the source of the head injury.

Table 1 shows that a high proportion of the casualties are under the age of 21 years which relates to national trends and supports other findings[2,3]. The larger size machine is over-represented in the sample and, although this factor cannot be taken in isolation, there is an increase in the fatality involvement for the larger type of machine. The majority of the casualties in the sample were wearing full-face helmets with an even distribution on the latter between polycarbonate and GRP. A proportion of both types came off in the accident but, as previously noted, the reason for this is always difficult to establish and may well require further study using more refined techniques. It is hoped that improvements to the British Standards test for helmet retention is reducing the number of crash helmets coming off before impacts.

In most of the cases the rider's helmeted head struck the road, which is an unyielding surface. Contact with different vehicle structures also featured highly as collisions were principally with other vehicles, usually saloon cars. Despite the protection of the helmet, a high proportion of fatalities involved a fatal head injury. It is interesting to note that principal points of contact fall within a band extending from one side of the helmet, across the front to the other side. Very few contacts were to the back of the helmet and there is only one contact recorded to the helmet top. Although the latter was a fatal case, it was concluded that the head injury component of this fatality was negligible.

In the case of the full-face helmets, although there was protection for most of the head, serious and fatal head injuries still occurred. Injury is force-related but the study suggests that the location of head impact is also a key factor. It was particularly noticed that impacts to the helmet facebar and sides (principally the temple area) gave rise to serious and fatal head injuries, often involving the base of the skull. Fractures to this area were sometimes caused by an indirect blow via the mandible.

Although the sub-set was smaller, data for the open-face helmet showed a similar trend. Direct blows to the unprotected face gave rise to both serious and fatal injuries, the latter invariably involving extensive skull fractures.

CONCLUDING REMARKS

Although the motorcycle helmet continues to give protection, the following points were highlighted by the current study:

The majority of head contacts leading to serious injury were to unyielding surfaces and structures and therefore the helmet has to play the major part in head protection.

The majority of impacts were to the front and sides so helmets should be impact-tested to those zones. It also shows that the open-face helmets give minimal protection in the majority of frontal impacts.

Although impact severity is fore-related, the study suggests that the location and direction of force is also a key factor. The actual forces giving rise to head injury will have to be estimated from reconstructed impacts similar to the real accidents investigated. However it is suggested that special attention is given to protecting the vulnerable areas indicated above. It is also suggested that a suitable head form be developed for test purposes whose structure is more analogous to the human skull with particular reference to the skull base.

The ability to examine all the circumstances of the accident and injury in some detail, bringing all elements together to form the total picture has been identified. It is hoped that this paper has gone a little further along the path to improve our knowledge.

Future work is planned to extend the existing study, in particular the very serious head injury casualties in order to confirm the above findings. The injury/accident studies will be linked with crash reconstruction and helmet impact work in order to produce realistic head injury criteria levels.

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