

HEAD AND NECK INJURIES TO CAR OCCUPANTS
WEARING SAFETY BELTS IN FRONTAL COLLISIONS

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It is widely recognised that restraint systems for car occupants should be designed to protect at least three important areas of the body - the head, the chest, and the legs. As yet, however, there are no generally agreed injury criteria in terms of physical quantities (e.g. force or acceleration) which, when measured on representative dummies protected by restraint systems, should not be exceeded under specified test conditions. The most important suggestions for such criteria were embodied in the proposed American Federal Motor Vehicle Safety Standard No 208 and its amendments, and because of their probable world-wide influence if finally confirmed, they have been extensively tried out in vehicle crash tests, and, perhaps in modified form, are likely to form the basis for future European as well as American regulations. For head injury, with which this paper is concerned, the proposed American criteria are expressed in terms of resultant accelerations, measured in the heads of dummies, in 30 mile/h frontal barrier tests; these accelerations must not be exceeded, even when no impact of the head with the interior of the car occurs.

However, experience of the performance of 3 point lap-and-diagonal safety belts in real accidents has raised doubts as to whether the risk of head injury without head impact is great enough to justify the application of a head injury criterion in such cases; indeed, any such requirement may actually retard the development of systems designed to be effective at higher impact speeds than 30 mile/h. In the present note, the injuries suffered by a sample of belt wearers in frontal impacts are described, and the results are discussed with special reference to the probability of head and neck injury.

In an earlier paper by the author⁽¹⁾ an analysis was made of injuries to belt wearers in about 750 accidents; nearly 90 per cent of the belts were of the 3 point lap-and-diagonal type. For the present note, special attention has been paid to the data on frontal impacts described in the reports which formed the basis of the earlier paper, and to about 100 later reports. All these reports were returned to the safety belt manufacturer by motorists who had been wearing safety belts in accidents. Rough estimates of velocity change were made for all the frontal impacts which resulted in injury to a belt wearer, making use of the reported circumstances of the

accidents, the weights and speeds of the vehicles, and the extent of the damage to the cars. In many of the more serious accidents the original reports were supplemented by more lengthy accounts obtained by correspondence. In no case, however, was it possible to examine vehicles or accident sites.

The estimated velocity changes ranged from 10 to 45 mile/h (16 to 72km/h), and in Tables 1 and 2 the results have been divided into those above and below 30 mile/h (48km/h).

The injuries to the belt wearers were classified in accordance with TRRL note LF130 (Issue 3). There was sometimes difficulty in distinguishing between the three categories of injury to the head and face; for example, all concussions were classed as moderate injuries, whereas some might have been more correctly classed as minor or severe; similarly, almost all lacerated faces and heads were classed as minor, when some might more accurately have been placed in the moderate class. None of the conclusions of the paper are affected by this blurring of the boundaries; and the difficulty did not arise for other parts of the body.

Table 1 summarises the injuries to the different regions of the body, in terms of minor, moderate, and severe injuries. There was only one death, of a passenger. Injury accrued to one or both front seat occupants wearing 3 point lap-and diagonal belts in 182 frontal impacts; 131 were judged to have occurred at velocity changes between 10 and 29 mile/h (16 and 47km/h) and 51 between 30 and 45 mile/h (48 and 72km/h). In the 182 impacts there were 76 head injuries, 18 of which were judged to be of greater than minor severity. As might be expected, the proportion of the more serious injuries was greater at velocity changes above 30 mile/h than below.

The head injuries are considered in more detail in Table 2, in which descriptions are given of head injuries of greater than minor severity and in Table 3, which gives details of accidents in which concussion occurred without accompanying head injuries such as cuts and bruises. In the 51 accidents which occurred at velocity changes over 30 mile/h, there were, of course, 51 drivers and, in addition, 27 front seat passengers, all wearing 3 point lap-and-diagonal belts. 28 drivers had head injuries, 10 of which were judged to be of greater than minor severity; of these more serious head injuries 8 included concussion; every case of concussion was accompanied by other injuries (cuts, bruises etc) to head or face, indicating that the head had struck some object in front of the driver, probably part of the steering wheel. Only 4 of the 27 front seat passengers had head injuries, including one case of concussion without any other head injury. This occurred in a very severe collision (see Table 3, case No 335), in which the passenger sustained a fractured spine as well as concussion, both

attributed to frontal intrusion into the passenger compartment.

In the 131 impacts at velocity changes judged to be below 30 mile/h, 129 of the 131 drivers wore belts; they were accompanied by 70 front seat passengers wearing belts. 31 drivers had head injuries of which 3 were judged to be of greater than minor severity; only one of these (see Table 3, case No 514) involved concussion without other head injury, and this was reported as due to impact with the side window. The 70 front seat passengers also had 3 head injuries judged to be of greater than minor severity - all instances of concussion without other head injury. In 2 of the 3 cases the reports suggest that concussion was the result of impact of the head against a solid object. Case No 276 was a low speed intersection accident (velocity change about 10 mile/h) in which the car probably rotated, resulting in concussion due to collision of heads, as reported; in case No 697, an accident at a higher velocity change, both belted occupants were likely to have been loaded from behind by the two passengers in the rear seat, giving rise to facial and knee injuries to the driver, and causing breakage of the shoulder strap of the passenger's belt, with resulting injuries from jackknifing over the lap strap. Only an case No 559 was no explanation of the concussion given in the report or suggested by the account of the accident, although it is worth noting that the driver was uninjured. It is significant that no neck injuries, even slight ones, were mentioned in any of the cases described in Table 3, and it would appear very unlikely that concussion due to a jerk from a safety belt could occur without any sign of neck injury.

To sum up, in all 182 frontal impacts, involving 277 car occupants wearing safety belts, there were 13 cases of concussion, and only in one case is there any probability that concussion might have occurred without head impact.

There was only one neck injury of greater than minor severity, - a broken neck, probably caused by impact from the passenger in the rear seat, who was killed. Stiff or strained necks were reported in 21 instances; and none of these neck injuries was associated with a head injury. It appears that one finds either neck injuries or head injuries, but very rarely both together. Neck injuries probably only occur when the restraint system of belt and car work correctly together to restrain the occupant without head contact; when head contact occurs the decelerating forces which the neck is capable of exerting are not brought fully into play.

In Table 1 the numbers of head and face injuries are given separately for the driver and the front seat passenger. If injuries of all severities are counted, drivers suffered 59 and passengers 17 head and face injuries. Since the numbers of drivers and passengers at risk were respectively 180 and 97,

the head injuries per occupant were 0.33 for the driver and 0.18 for the passenger - a significant difference. This tendency for the driver to be injured more often is also shown by the figures for greater than minor head and face injury, - 14 for the driver and 4 for the passenger.

The obvious difference between the surroundings of the driver and front seat passenger is the presence of the steering assembly in front of the driver, and many of the reports mention the steering wheel as the object which caused the driver's head injury. Whether the presence of the wheel is enough in itself to account for the greater frequency of head injury in the driver, or whether the whole steering assembly, by limiting the forward movement at the hip, produces a greater tendency to jackknife in the driver than the passenger is a question to which the present investigation does not provide an answer.

It might perhaps be expected that the steering assembly would also increase the frequency of chest and rib injury. The figures in Table 1, however, suggest that if there is any effect at all, it is in the opposite direction. For injuries of all severities, the injuries per driver were 0.26 and for the passenger 0.32; for greater than minor injuries the injuries per occupant were respectively 0.07 and 0.14, but the difference is not significant at the 5 per cent level.

Finally, it is emphasised that no deductions as to the overall efficiency of safety belts should be made from the data given in this paper, since all the impacts considered were ones which resulted in injury to one or more belted front seat occupants. The numerous investigations which have been made of the efficiency of safety belts in preventing injury almost all show that substantial reductions in injury, particularly in serious injury, result when belts are worn.

Conclusions

1. This survey of 182 frontal impacts suggests that when a car occupant wearing a 3 point lap-and-diagonal safety belt suffers concussion in an accident of this type, it is almost always the result of impact of the head with the inside of the car.

2. There was also evidence that the neck injuries that occur in such impacts are infrequent and usually minor ones, and are unlikely to be accompanied by head injury.

3. The results do not provide any support for a head injury criterion for wearers of safety belts of the type considered, except in cases where the head strikes the inside of the vehicle.

Acknowledgements

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References

1. Grime, G. 'Accidents and injuries to car occupants wearing safety belts'. Automobile Engineer 1968 (July).

Table 1.

Injuries to wearers of seat belts in frontal impacts.

Velocity change (mile/h)	Number of impacts	Severity of injury	PARTS INJURED										
			Head and face	Neck	Shoulder	Chest and ribs	Internal organs	Arms	Legs and knees	Cuts, bruises and belt bruises			
10-29 (16-47 km/h)	131	Severe	0	0	0	0	0	0	0	0	0	0	0
		Moderate	6(3/3)*	0	3	14(6/8)*	2	4	7	0	0		
		Minor	38(28/10)	16	6	33(22/11)	0	13	72	60(30/30)			
30-45 (48-72 km/h)	51	Severe	3(3/0)	1	0	4(1/3) ⁺	3 ⁺	0	3	0			
		Moderate	9(8/1)	0	7	9(6/3)	0	7	6	0			
		Minor	20(17/3)	5	2	18(12/6)	0	10	32	25(15/10)			
10-45 (16-72 km/h)	182	Severe	3(3/0)	1	0	4 (1/3)	3	0	3	0			
		Moderate	15(11/4)	0	10	23(12/11)	2	11	13	0			
		Minor	58(45/13)	21	8	51(34/17)	0	23	104	85(45/40)			

* (3/3) etc. denote (Driver/Passenger) injuries
 + One passenger killed

Table 2.
Head injuries of greater than minor severity

Velocity change (mile/h)	Number of impacts causing injury	Number of injuries of greater than minor severity	Case No.	Injuries	
				Driver	Front seat passenger
10-29 (16-47 km/h)	131	32	185	Lost several teeth; chest bruises.	Broken left clavicle; chest bruises.
			276	Uninjured	Concussion; bruised left shoulder; seat belt cuts.
			437	Lost front teeth; cut chin.	
			559	Uninjured.	Slight concussion.
30-45 (48-72 km/h)	51	30	697	Facial lacerations; bruised knees.	Concussion and severe bruising.
			514	Concussion; injured sternum; spinal injuries.	
			169	Facial lacerations and concussion.	Facial lacerations.
			282	Concussion; broken teeth; cuts and abrasions to scalp and knees; bruised hands, arms and ribs; cracked bone in left hand.	
			302	Severe facial injuries and broken nose.	
			335	Fractured clavicle; grazed leg.	Concussion and fractured spine.

Table 2. (continued)

Velocity change (mile/h)	Number of impacts causing injury	Number of injuries of greater than minor severity	Case No.	Injuries	
				Driver	Front seat passenger
30-45 (cont.)			390	Concussion and lacerations.	
			401	Cut head; slight concussion; injured left knee.	Belt bruises.
			409	Facial injuries; slight concussion; severe chest bruising.	Broken clavicle and wrist.
			644	Head injury; unconscious.	
			1012	Facial injuries to jaw and teeth; right leg broken in 3 places.	Injuries to jaw and teeth; fractured clavicle and ankle.
			1016	Facial bruising and concussion; broken right thigh & left shin.	Black eye; bruised knees.
			1019	Fractured jaw; damaged teeth; cut chin; concussion; cut right knee.	Bruised.

Table 3.

Accidents in which concussion was reported without other head injuries.

Case No.	Vehicles	Description of accident	Injuries	
			Driver	Front seat passenger
276	1965 Triumph Herald 1200. Car.	Other car crossing traffic lights at red was hit by Triumph at reported speed of 20 mile/h.	Uninjured.	Bruised left shoulder; seat belt cuts; concussion due to collision of heads.
559	Morris Mini 1964. Car.	Head-on collision to offside front; estimated velocity change 20-29mile/h.	Uninjured.	Slight concussion, No explanation.
697	Renault 10 1966. Jaguar.	Jaguar swerved round a parked car, lost control and hit Renault head-on; estimated velocity change 20-29mile/h. Two passengers in rear seats.	Facial lacerations; bruised knees.	Concussion; severe bruising. Seat belt failed at top anchorage.
514	Vauxhall Viva 1965.	Viva skidded and hit some object (unknown) on front offside, and then 'spun'; estimated velocity change 20-29mile/h.	Concussion-'by spinning towards offside front window sternum injured by steering assembly; spinal injury.	

Table 3. (continued)

Case No.	Vehicles	Description of accident	Injuries	
			Driver	Front seat passenger
335	Austin Mini 1964. Car.	Oncoming car swerved over centre line and hit Mini head-on; estimated velocity change 40-45mile/h.	Fractured clavicle; grazed leg.	Concussion and fractured spine; both attributed to frontal intrusion.