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C38 Head Injuries in Lower Speed Collinear Collisions: An Analysis of the National Automotive Sampling System Database

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After attending this presentation, attendees can expect to learn about the types and severity of head injuries that may occur in low speed

front and rear impact collisions. This information will be beneficial in assessing claims of injury or head impact in such collision.

This presentation will impact the forensic science community by describing how delta V corresponds with head injury in lower speed collisions, and demonstrates a lack of a lower threshold for injuries such as concussions and other closed head injuries.

Introduction: Occupants with head injuries following lower speed frontal or rear collisions will occasionally claim to have struck their head on a steering wheel or even windshield despite the use of a restraint. The claims defy common clinical and biomechanical experience and are thus sometimes doubted. The goal was to evaluate the potential validity of such claims by searching the NASS for cases of head injury associated with lower speed collinear collisions.

Methods: Individual counts and weighted data were obtained from the NASS-CDS for the years 1997-2007 for all collinear crashes in which there was a single front, single rear, or rear and then front impact collision with a delta V of 20 mph or less and in which a head injury was coded. A collinear impact was considered to be one with a principle direction of force making an angle of 15 degrees or less with the long axis of the vehicle. Rollovers and ejections were excluded from the analysis. Parameters evaluated were injury type and severity, delta V, restraint use, airbag deployment, and injury contact source.

The National Automotive Sampling System-Crashworthiness Data System database for the years 1997-2007 inclusive was queried per the parameters described above. The Crashworthiness Data System (CDS) collects detailed information on an annual sample of approximately 5,000 Police Accident Reports involving at least one towed vehicle, and includes cars, vans, or trucks with less than 10,000 pounds GVWR. The NASS reports both raw data counts and weighted counts, with the latter intended to indicate the likely number of real world cases represented by each NASS case.

Results: The query yielded 947 injuries among 711 occupants, and a weighted value of 365,732 crashes. There were 787 frontal crashes ranging from 5-20 mph in delta V, 166 rear impact collisions ranging from 7-20 mph delta V, and 75 rear-front impact collisions at 7-20 mph delta V. There were three injury groups; superficial (scalp) injuries (488), brain concussion (348 injuries), and AIS \geq 3 injuries (127). Seatbelt presence played the largest role in AIS \geq 3 frontal collisions (24.4% of injuries in belted occupants versus 47.9% and 45.3% of concussion and scalp injuries, respectively). In contrast, most injuries seen in the rear impact collisions occurred in belted occupants (75.8, 80.8, and 100% of scalp, concussion, and AIS \geq 3 injuries, respectively). Airbag deployment was indirectly related to injury severity in frontal collisions; 41.6% of scalp injuries involved an airbag deployment, whereas 36.6% of concussions and 31.2% of AIS \geq 3 injuries occurred in crashes with an airbag deployment (See Table 1).

Among the frontal crash concussion cases with three point seatbelt use 15 of the injuries occurred without head contact, 21 resulted from a strike against the steering wheel rim, six involved a head strike to the windshield, and two struck the roof and A-pillar each. Average speed change was the same among belted and unbelted occupants; 14 mph. A concussion occurred in one restrained occupant at 5 mph.

In the rear impact concussion cases there were an equal number of head restraint/seat contact and no head contact injuries. Five of the concussions resulted from rebound movement and contact with the steering wheel or mirror despite the use of a three point seat belt.

In the frontal crash AIS \geq 3 cases there were 28 skull fractures, 11 in belted occupants. The injuries resulted from contact with a variety of frontal structures. A skull fracture occurred at 7 mph in an unrestrained occupant. There were 4 AIS \geq 3 injuries resulting from a rear impact collision, all in restrained occupants.

Discussion: It is apparent that head injuries such as concussion, intracranial bleeding, and even skull fracture can and do occur in restrained occupants in lower speed rear and frontal collisions, including those with speed changes below 10 mph. Because of the bias of the NASS-CDS toward more severe collisions it is difficult to estimate a

lower threshold for any of these injuries, even skull fractures. The fact that a fracture was observed at 7 mph in the NASS's higher crash severity-biased sample suggests that in the general population of real-world crashes such injuries may occur at even lower speeds. It is concluded from this, *inter alia*, that there is a small but real possibility that a restrained occupant can strike the windshield in a <10 mph delta V



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frontal collision, or that a rear impact collision of can cause a belted occupant to rebound and to strike the steering wheel and sustain a concussion.

It is likely that the lack of non-tow away crashes in the NASS had the effect of greatly understating the number of concussion associated with rear impact collisions. Since more than half of the concussions were attributed to either no head contact or contact with a head restraint and occurred at speed changes as low as 7 mph it is reasonable to infer similar injury mechanisms at lower speed changes.

Conclusions: These results may be some of the first to indicate significant head injuries can and do occur in lower speed frontal and rear impact collisions, with and without head contact, regardless of restraint use.

Crash Type	Crash Type	Injury Count	Weight	% not belted	% belted	Delta V	% Occupant
Scalp Injury	Front	300	1,122,711	44	56	4.6	5.0
	Rear	43	29,214	75	25	0	3.0
	Rear-front	44	33,522	70	30	1.2	3.0
Concussion*	Front	573	2,117,966	21	79	1.6	5.0
	Rear	36	26,074	83	17	0	3.0
	Rear-front	23	4,171	87	13	1.2	3.0
Yellow tape†	Front	110	2,132,722	24	76	1.3	4.0
	Rear	4	548	100	0	0	0.1
	Rear-front	17	4,607	11	89	0.3	3.0
	Total	107	29,880				

1. All but 2 of the scalp injuries were AIS 1 severity, which consisted of contusions, abrasions, and lacerations.
2. Concussion was accompanied by loss of consciousness in 84.8% of frontal impacts, 7.7% of rear impacts, and 52.6% of rear-front collisions.
3. Delta V for the rear-front collisions is the total for both rear and frontal impact.

Lower Speed, Collinear, Collisions