C36 The Effect of Restraint Use on Skull Vault Fractures in Rollover Crashes

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After attending this presentation, attendees will understand the relationship between roof crush, restraint use, and risk of skull vault fracture in rollover crashes.

This presentation will impact the forensic science community by discussing the belief that this analysis is the first population-based study to evaluate a specific injury type (skull vault fracture) and associate it with a specific injury mechanism (contact with a crushed roof) in rollover crashes. These research findings lead to a rejection of the crash test dummy-based "diving" theory as the primary cause of head injury in rollover collisions with roof crush.

Introduction: Skull vault fractures (SVF) are a serious complication of rollover crashes and there is a question as to whether they result from roof crush or "diving" kinematics of the occupant toward the roof. Based on the effect of three point restraints in limiting occupant movement in rollovers we hypothesized that progressively greater crush would result in a relatively greater increase in the rate of skull vault fractures in unbelted occupants if diving was the mechanism, and a greater increase in belted occupants if roof crush was the injury mechanism.

Methods: A search was conducted of the National Automotive Sampling System-Crashworthiness Data System (NASS-CDS) of the United States National Highway Traffic Safety Administration (NHTSA) for the years 1997 through 2005, inclusive (9 years total) for rollover crashes with at least two one quarter turns and in which an occupant sustained a head or neck injury of some degree as a result of roof, windshield headliner, or side rail contact (as opposed to ejection). A case was only included for analysis if the degree of roof, windshield headliner, or side rail intrusion at the position of the occupant was recorded and correlated to the head injury, as well as the restraint use status of the occupant. Both raw and weighted counts of injuries as well as occupants were recorded by NASS injury code, and also the number of occupants with head and neck injuries by injury severity rank was recorded. The ratio of skull vault fractures versus other injuries by roof crush severity was calculated for restrained and unrestrained occupants and tabulated.

Results: A total of 2,120 injuries were recorded in the NASS given the above parameters for 558 restrained occupants (330,056 weighted),

and 1,261 injuries were recorded for 288 unrestrained occupants (143,389 weighted).

Although belt use decreased the rate of serious head injury among restrained occupants relative to unbelted occupants in all crashes except those with >61 cm of roof crush, the efficacy of seatbelts was inversely related to the degree of intrusion (see Figure 1). At 3-8 cm of roof crush belted occupants sustained a reduction of serious or greater head injuries of 45%, at 8-15 cm serious injury was reduced 40%, at 15-30 cm serious injury was only reduced 23%, and at 30-46 cm and 46-61 cm serious injury was reduced 15% in each category in belted vs. unbelted occupants.

A risk ratio assessment of the effect of belt use vs. roof crush was performed. Among restrained occupants SVF comprised 11.9% of serious and greater (AIS≥3) head/neck injuries (6.4% of all head/neck injuries), and thus only 0.8% of all injuries at the lowest level of roof crush (3-8 cm). At 8-15 cm of crush the risk was 1.9 times the lowest level, at 15-30 cm it was 2.5 times greater, at 30-46 cm of crush the risk it was 3.5 times greater, at 46-61 cm of crush it was 8.4 times greater, and at more than 61 cm the risk was 6.6 times greater. Among unrestrained occupants at the lowest level of roof crush SVF accounted for 20.6% of all AIS≥3 injuries (10.9% of all injuries in this category were serious), and thus 2.2% of all injuries. Risk ratios, relative to the lowest level, were as follows: 8-15 cm, 0.7; 15-30 cm, 0.9; 30-46 cm, 1; 46-61 cm, 1.8; and at >61 cm, 1.6.

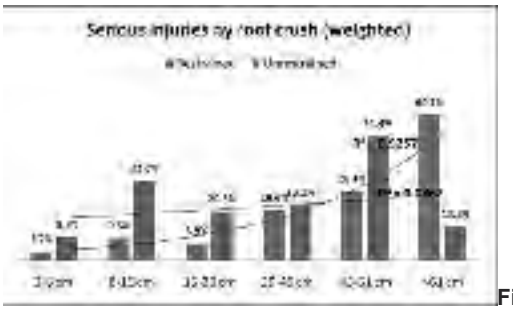

Figure 1

 ** Presenting Author*

Discussion: At the lowest levels of roof crush SVF occurred 175% more often in unrestrained occupants. In contrast, SVF occurred 22%, 68%, and 47% more often among restrained occupants in rollover crashes with 30-46, 46-61, and more than 61 cm of crush, respectively. The explanation for this finding is that SVF results from sudden forceful loading associated with the higher head accelerations resulting from increased roof crush, and a relatively less mobile restrained occupant is more likely sustain a head impact from a collapsing roof, relative to an unrestrained occupant. Additionally, higher speed rollovers are theoretically more likely to result more violent occupant kinematics, leading to a higher probability of displacement of unbelted occupants in rollovers away from a crushing roof, and thus the observed relatively lower frequency of SVF. This finding is the opposite of what would be expected if the injury mechanism was diving.

Conclusions: As a general rule the use of passive restraints reduces injury frequency, although are specific exceptions to this rule. We have identified one of these exceptions; skull vault fracture risk in rollover crashes with 30 cm or more of roof crush. Increased roof strength would likely reduce the frequency of these injuries.

Skull, Vault, Fracture

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