C22 Relationship Between Injury Severity and Vehicle Crush in Rear Impact Collisions

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After attending this presentation, attendees will have a greater understanding of the relationship between crush and injuries in collisions.

This presentation will impact the forensic science community by enabling attendees to more accurately analyze injury mechanisms in rear impact collisions.

The objective of the research reported in this paper was to determine if the magnitude of crush to the rear of a vehicle was indicative of the severity of the collision. The research revealed that a statistically significant correlation between the crush to the vehicle and the Abbreviated Injury Scale (AIS) injury rating was not present. This confirms that injury severity is a function of more than the crush to the vehicle and the change in velocity.

It is well known that the energy available to cause injury is a function of the non-dissipated kinetic energy in a collision. Previously published papers have raised doubts regarding the correlation of the change of velocity experienced by a vehicle in rear impact and the resultant injuries.[1,2] Similarly, research has shown a lack of an established injury threshold based on change of velocity.[1,3-9] Theoretically, the greater the damage to the vehicle, the less energy is available to cause injury at a given speed. However, the energy available to crush a vehicle increases with the square of the velocity while the momentum is a linear function. Previous research has demonstrated an energy threshold value for the onset of damage in a rear impact.[9] This is relevant because at the lower speeds momentum is the critical factor while energy is the critical element at higher speeds.

The National Automotive Sampling System (NASS) is a database of more 100,000 collisions investigated by the National Highway Traffic Safety Administration (NHTSA).[10] The various versions of the database cover well over a decade. The AIS is a measure of the severity of an injury based on lethality.[11] The NASS databases record the injuries to an occupant in terms of type, cause, and severity. The files also report crush measurements, collision sequences, and change in velocity. Two significant limitations of the database deal with the change in velocity and the severity of the injury. Velocities are often calculated using SMASH, a derivative program of CRASH3 which has limited utility in rear impacts.[12] The injuries are based primarily on initial diagnosis and do not capture subsequent diagnoses which often raise the overall severity of the injury. As an example, injuries originally coded as AIS 1 may in reality be AIS 2 or 3. However, the crush to a vehicle is actually physically measured by the investigator. For these reasons, an analysis was performed to determine if the crush to the rear of a vehicle is statistically significant in the prevalence of diagnosed injuries in rear impacts.

The crush to vehicles and the maximum AIS code for a given collision were retrieved by examining a random sample of 198 impacts taken from the NASS case list. In an attempt to obtain an unbiased sample, every 20th case in the database was selected. To be chosen, the collision had to meet certain qualifications. Only rear impacts based on an impact angle of 180° were allowed. In addition, the collision had to be a pure rear end crash with no other sources of damage such as rollover or subsequent contact with other objects. The impact could only involve two vehicles. In addition, the database had to include the injury and AIS code and include the measured crush sustained by the vehicle. If any of these conditions were not met, that case was skipped and the next case was used.

Table 1 provides the results obtained by the research. The table compares the maximum AIS with the magnitude of the measured crush in inches. The number in the table lists the number of collisions in a given range. Figure 1 is a graph of the data with greater crush discrimination. Figure 1 also includes a linear and a quadratic fit to the data.

AIS	0 < crush < 10	10 ≤ crush < 20	20 ≤ crush < 30	30 ≤ crush < 40	40 ≤ crush < 52
1	72	56	32	8	3
2	3	8	2	1	0
3	0	1	1	2	1
4	0	0	0	0	2
5	1	0	2	1	0
6	0	0	0	0	2

Table 1 – Distribution of AIS based on inches of crush

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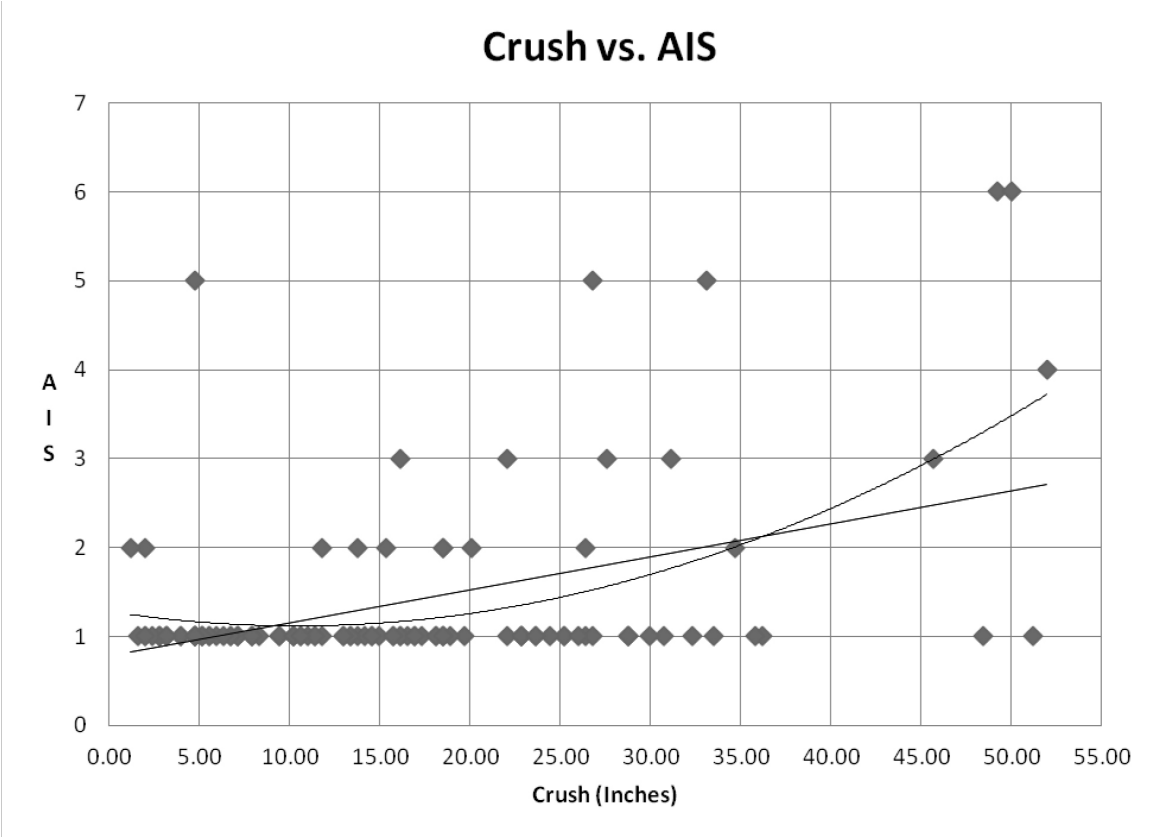

Figure 1 – Crush vs. AIS
Note: Many of the points are duplicates

An analysis was performed to determine if there was a statistically relevant correlation between the amount of crush and the initial injury level. Three tests were run on the data; Chi Squared, correlation, and Student-t. The latter was used to compare individual AIS levels. Additionally, as mentioned previously, a linear and quadratic fit to the data was determined.

Conclusion: The data reviewed demonstrates that for AIS level 1 and 2 injuries, crush to the vehicle is not a reliable indicator of injury potential. Additionally, severe injuries can occur with minimal crush while minor injuries can occur with significant crush.

None of the analysis methods applied to the complete data set resulted in a finding of statistical significance between crush depth and injury severity. The mean crush for each level was determined. A student-t test was applied to each AIS level and resulted in a finding of a statistically significant variation between AIS 1 and 2 versus AIS 3. However, it should be noted that of the 198 random sample cases, only thirteen revealed injury severities of AIS 3 or greater. The data does indicate that it is possible crush is a factor in AIS level 3 and higher injuries.

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Injury, Crush, Damage

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