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NOTABLE OBSERVATIONS FROM HUMAN SUBJECT CRASH TESTING

Dr. Anthony V. D'Antoni has participated in crash testing through the Spine Research Institute of San Diego (www.srisd.com) and has gained knowledge and expertise in this area of automotive health. In conjunction with the Center for Research into Automotive Safety and Health, the Spine Research Institute of San Diego has sponsored consecutive human-subject crash tests that began with CRASH 1999.

These tests have totaled over 50 individual crashes, with vehicle closing speeds ranging from a little over 2 mph to nearly 50 mph. The outcome of this research has given rise to a number of papers that have appeared in such publications as *Accident Analysis and Prevention* and presentations at the International Whiplash Trauma Conference, the International Research Council on the Biomechanics of Impact (IRCOBI), and the Association for the Advancement of Automotive Medicine Annual Conference.

This article is an overview of some of the more notable observations from these crash tests. While many more could have been mentioned, the following is a brief list of observations of which everyone who deals with whiplash patients should become aware:

1. Occupants may experience significant head accelerations without noticeable vehicle bumper damage.
2. Occupants of (target) vehicles struck from the rear undergo approximately three times the amount of force acting on the cervical spine compared with occupants of striking (bullet) vehicles.
3. Vehicle speed changes are not linearly associated with occupant head accelerations.
4. In rear impact collisions, females (or smaller persons) generally experience greater resultant head acceleration than do males (or larger persons).
5. Most vehicles tested have been able to withstand impacts resulting in delta Vs in excess of 5 mph without noticeable vehicle bumper damage.
6. Occupants who are aware and braced in rear impact collisions experience significantly less head acceleration and less violent neck kinematics than do unaware and unbraced occupants.

The crash tests were carried out in a precise manner, utilizing established engineering protocols, and were IRB approved. The informed and consenting human subjects (male and female) were instrumented with accelerometers, and then individually placed in instrumented crash test vehicles. Occupant accelerations were recorded for the head, thorax, and lumbar spines. Forces and moments were calculated based on head accelerations and the principles of dynamics. Vehicle accelerations, closing velocities, and speed changes were recorded. Volunteers were subjected to rear, frontal and side impact crashes, most of which were conducted in the unaware mode (subjects had no visual clues as to the time of impact and are distracted with loud music played through ear phones). A few that were in the aware mode were allowed to brace for the impact.

One of our major purposes for this crash series was to compare the occupant kinematics and forces between the bullet (striking) and target (struck) vehicles. The same instrumented subjects underwent crash sequences with the same speed changes in the same vehicle under both bullet and target conditions. Based on the recorded data, as well as observation of high-speed video, it is clear that both the occupant kinematics and forces are dramatically different between the two crash conditions—being rear-ended is much more traumatic than rear-ending another vehicle when the subject, vehicle, and speed change are held constant. This also addresses the common question: "How come it's always the guy in the front car who gets hurt?" A good example of this event is evident when comparing one of the crashes that was a frontal impact involving a female subject with a delta V of 7.1 mph and 4.6 g head acceleration, with another crash, a rear impact involving the same female subject with a 6.7 mph delta V and a remarkable 15 g head acceleration.

As previously indicated, speed changes are not linearly associated with occupant head accelerations. For instance, one of the crashes with a 17.1 mph delta V resulted in a 10.3 g head acceleration, while in another crash, the subject experienced a more significant head acceleration of 12.5 g at only 5.2 mph delta V. The higher speed crash test resulted in very significant crush damage to both crash test vehicles. This increased the duration of the high-speed crash test and the resulting head acceleration to the driver of the bullet vehicle was relatively lower. This information would be vital to present to claims adjusters and juries in certain real world cases.

Another interesting finding is that multiple crash sequences can be performed within the crash metrics corridor of which the upper boundary is generally held to be above the level which could produce injuries to human subjects (i.e., 5 mph delta V), without causing significant damage to the test vehicles. This is consistent with most of the other reported crash testing in the literature. Several of these non-damaging crash sequences are at closing speeds of nearly 10 mph. These observations are significant in light of the common myth that one can predict occupant injury from examining the vehicle damage, or that the absence of property damage is a reliable indication that the crash speeds must have been below the published bumper ratings. As a matter of fact, we exceeded these bumper ratings in nearly every test.

Another valuable bit of information is that volunteers frequently reported that their head did not make contact with the head restraint, usually after the first run, and sometimes even after the second, even though the head does make contact, which is quite obvious to the onlookers. It's not clear at this point why this rather abrupt contact is not registered by the volunteers. This phenomenon is also frequent among whiplash patients, and defense experts often use the argument that since the occupant doesn't report (or recall) striking the head restraint, it implies that no contact occurred. If that were the case, this logic goes, the collision would have been at a very low speed. Following this line of reasoning, the neck would not have been exposed to injurious forces.

Rear impact crashes involving females demonstrated that they react more violently with the seat back than males do. One of the crashes involving a female volunteer demonstrated the highest head acceleration of any that were carried out in this series of crash tests. Research done by Siegmund et al. (1) found similar kinematic differences between female and male volunteers.

Finally, when comparing head accelerations of crashes involving unaware and unbraced volunteers, with a crash involving a braced volunteer, the volunteer who was aware and braced for the impact resulted in considerably less head acceleration. Awareness and bracing obviously have a significant effect on head and neck kinematics in rear-end collisions. A number of other researchers have found that injury is less likely when occupants in rear-impact collisions are braced. Ryan et al. (2) found that unaware patients were 15 times more likely to have long-term pain. Consequently, this would be an important detail to gather from a whiplash victim during the interview.

REFERENCES

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