Low Speed Impacts

Effective Use of Biomedical Engineers

By David L. Gushue, Michael L. Markushewski, Ronald J. Fijalkowski and Thomas F. Jennings

It is important to understand the details of cases where testimony has been excluded, and how a properly conducted biomechanical injury causation analysis addresses those rulings.

Many difficult claims involve soft tissue injuries that are alleged to have occurred during a low speed automobile impact. Biomedical engineering integrates traditional engineering principles with fundamental knowledge of the anatomy and physiology of the human body. As a scientific subdiscipline of biomedical engineering, biomechanical engineering applies the laws of physics and the tools and approaches of mechanical engineering to the joints and tissues of the human body. More specifically, biomechanical engineers investigate the response of the human body to the application of mechanical forces to determine the potential for failure or injury to the human body.

Biomechanical analyses and associated testimony have been shown to be an effective tool for the analysis of the low speed impact case. This article explains the discipline of biomechanics, and how a properly trained biomechanical engineer evaluates the potential for a causal relationship between claimed injuries and a specific incident, through a systematic investigation of both the magnitude and the direction of the forces applied to the claimant during the incident. In addition, we will address admissibility of biomechanical testimony within the context of commonly cited court cases.

■ David L. Gushue, Ph.D., Biomedical Engineering is Director of Biomechanical Engineering, ARCCA, Inc.; Michael L. Markushewski, Chief Engineer and Chief Technical Officer, ARCCA Inc.; Ronald J. Fijalkowski, PhD, Biomedical Engineering, Sr. Biomedical Engineer, ARCCA, Inc; Thomas F. Jennings, V.P., ARCCA, Inc. ARCCA is a Biomechanical, Forensic Engineering and Litigation Consulting firm (http://www.arcca.com/) with offices in Florida, Illinois, Massachusetts, Pennsylvania and Washington state and is a corporate member of DRI.

Biomechanical Engineer vs. Medical Doctor

Determination of a causal relationship between claimed injuries and a specific event requires thorough analyses of the subject incident, an understanding of the unique tolerance level of the individual in question, and a biomechanical analysis of the associated injury mechanisms and force magnitudes. Unfortunately, this task is often incorrectly given to a treating physician who is ill-equipped to properly analyze the subject incident. Although treating physicians may have knowledge of the diagnosed injuries, they lack information, expertise, and a sufficient technical basis to evaluate the nature of the collision environment which is necessary to provide an opinion regarding injury causation. Evaluations of incident severity, as well as the associated kinematics (*i.e.*, motions) of the occupant are required to properly assess injury mechanisms, associated force magnitudes and the potential for injury causation.

Therefore, a biomechanical engineer trained in applying the concepts and methods of mechanical engineering and the physical sciences to the joints and tissues of the human body is needed to determine the potential for a causal relationship between claimed injuries and a specific incident. Typical injuries investigated by a biomechanical engineer in a low speed impact include, but are not limited to, intervertebral disc bulges/herniations within the cervical, thoracic or lumbar spine, rotator cuff and labrum tears, carpal tunnel syndrome, meniscus and ligament tears within the knee joint, temporomandibular joint injuries, or closed head injuries.

A common misconception by many attorneys and judges is that the analyses and opinions proffered by a biomechanical engineer are diagnostic, and in direct contrast to the diagnosed injuries noted by the treating physicians. However, biomechanical engineers do not proffer opinions regarding the presence, or lack thereof, of a diagnosed injury. Rather, the role of the biomechanical engineer is to evaluate *causation*, *i.e.*, determine whether a causal relationship exists between a claimed injury and a specific incident, through a scientific investigation of the motions and forces applied to an occupant. Determining causation is precisely the role of a biomechanical engineer. Attorneys and judges must understand that medical doctors are trained to *diagnose and treat* injuries; they are not qualified or trained to evaluate causation.

Biomechanical Injury Causation Analysis

The method used to conduct a biomechanical injury causation analysis is well defined and accepted in the biomechanical engineering community and is an established approach to assessing injury causation documented in the technical literature. Within the context of a specific incident, a proper analysis approach consists of the following steps:

- Identify the diagnosed injuries alleged by the claimant to have been caused by the incident;
- Define the mechanisms/loads that cause such injuries;
- Quantify the nature of the incident in terms of forces, accelerations, and changes in velocity of the vehicle occupied by the claimant;
- Define the kinematics (movement) of the claimant's body within the vehicle as a result of the incident and any interaction between their body and interior components of the vehicle;
- Determine whether the interaction between the claimant and the vehicle during the incident created any of the mechanisms/loads known to cause the injuries they attribute to the incident.

If the incident creates the acceleration forces and motions necessary to create the mechanisms/loads that cause the claimed injuries, a causal link between the injuries and the event cannot be ruled out. If, however, the incident did not create the injury mechanisms/loads, then no causal link between the injuries and the incident can be drawn.

A biomechanical engineering analysis of a low speed impact begins through the review of pertinent file material. Although all of the following material may not be necessary for a specific case, typical file materials include medical records pertaining to the claimant (pre- and post-incident if available), police or operator's reports, itemized repair estimates and photographs of the vehicles involved, statements, deposition testimony, and relevant legal pleadings. Based upon a review of the available medical records and supporting documents, the biomechanical engineer identifies the diagnosed injuries alleged by the claimant to have been caused by the incident.

The mechanisms known and required to cause the claimed injuries are then identified and referenced from data published in peer-reviewed technical literature and learned treatises. For an event to create a particular injury mechanism, two conditions must be satisfied:

- Loads must be applied to the tissue in the manner required to cause the defined damage (injury). For example, the accepted mechanism for acute intervertebral disc bulge/herniation involves a combination of bending (flexion/extension and lateral) together with an application of a sudden compressive load.
- Loads must be applied with sufficient magnitude to exceed the tolerance or strength of the tissue.

Typically, the vehicles involved in a low speed impact have been repaired prior to the involvement of a biomechanical engineer, thereby preventing the ability to inspect the vehicle(s) to assess the associated damage. Therefore, to evaluate the forces, accelerations, and changes in velocity of the vehicle occupied by the claimant, a biomechanical engineer uses scientific and engineering methodologies generally accepted in the automotive industry. Essentially, these methods recognize that there is a direct relationship between the amount of crush damage sustained by a vehicle in a crash and the force applied to the vehicle during the impact. By comparing the calculated crush damage associated with a given change in velocity, or Delta-V, to the actual crush damage sustained by the incident vehicle a maximum impact severity can be determined.

> **To evaluate** the forces, accelerations, and changes in velocity of the vehicle occupied by the claimant, a biomechanical engineer uses scientific and engineering methodologies generally accepted in the automotive industry.

One example of determining the severity of the incident is to analyze the available statements and/or testimony, as well as photographs and the itemized repair estimates of the vehicles in question in accordance with accepted engineering analysis methodologies. The analysis reveals the primary points of impact to the subject vehicles as shown in the figures below. Likewise, review of the available photographs and the itemized repair estimates of the subject vehicles are helpful in using an energy-based crush analysis to determine impact force severity.

Energy-based crush analyses have been shown to represent valid and accurate methods for determining the severity of automobile collisions. Using stiffness data applicable to the incident vehicle, this analytical methodology calculates the amount of crush damage that would occur to a vehicle given various impact speeds. By comparing the predicted crush damage to the actual crush damage sustained by the incident vehicle, a maximum impact severity can be determined and acceleration forces or g's can be calculated.

After quantifying the nature of the collision in terms of accelerations and changes in velocity of the vehicle, the next step in the biomechanical injury causation analysis is to define the kinematics (movement) of the claimant's body within the vehicle as a result of the collision and any interaction between their body and interior components of the vehicle. The manner in which occupants move during a vehicular collision is dictated by a number of factors, including the laws of physics, the nature of the crash, and the use, or lack of use of a seat belt. As a general rule of thumb, in a low speed impact an occupant's body moves toward the point of impact. For example, during a low speed rear impact an occupant of the struck vehicle would move rearward relative to the interior of the vehicle and the resulting motion would be well-controlled by the seatback.

The final step of a biomechanical injury causation analysis is to determine whether the interaction between the claimant and the vehicle during the incident created any of the mechanisms/loads known to cause the injuries they attribute to the incident. The biomechanical engineer analyzes the forces, accelerations or g's, and motions of the occupant in relation to the personal tolerance levels of the occupant and the injury mechanism that is required for *causation* of the alleged injury.

Personal Tolerance Levels and Preexisting Conditions

Injury mechanisms and associated failure loads of the joints and tissues of the human body have been extensively studied and published in peer-reviewed scientific literature and learned treatises. However, a properly trained biomechanical engineer does not simply extrapolate the results of these scientific studies to a specific incident or individual to provide an opinion regarding the causation, or lack thereof, of an alleged injury in a low speed impact. Rather, the biomechanical engineer's evaluation regarding the potential for a causal relationship between an alleged injury and a specific incident uses thorough analyses of the forces and accelerations during the incident, an understanding of the unique tolerance level of the claimant's body, and a biomechanical analysis of the associated injury mechanisms and force magnitudes. Peer-reviewed scientific literature and learned treatises are then used to support the results of the biomechanical engineer's independent analysis regarding the incident and the alleged injuries.

Certainly the presence of significant preexisting degenerative conditions may change the tolerance of a specific individual's joints or tissues to applied forces, which is precisely why a properly trained biomechanical engineer evaluates the personal tolerance levels of the claimant. Through a technical analysis of the claimant's job duties and activities of daily living, a biomechanical engineer can calculate the magnitude and direction of forces applied to specific joints or tissues of their body. This analysis provides data that the biomechanical engineer can use to gain a baseline understanding of the claimant's personal tolerance levels and expected response to forces in a low speed impact. In addition, when extensive preexisting degenerative conditions exist, an analysis of the personal tolerance levels of the claimant provides unique insight into the force levels experienced on a day-to-day basis (in the presence of the preexisting conditions), which affords the biomechanical engineer the ability to evaluate the potential for acute injuries as well as for exacerbation of prior injuries.

Testimony and Admissibility

Challenges to biomechanical engineering testimony and admissibility can come from a variety of directions based upon the facts of the case, the scientific methodologies utilized (or lack thereof), venue, improper or inaccurate assumptions made by others, and judicial bias to name a few. However, the testimony of a properly trained and qualified biomechanical engineer has been shown to be an effective tool for the

Figure 1. Photographs depicting the damage sustained to the rear of a Nissan Altima as a result of a low speed impact.

analysis of injury causation in low speed impacts. Nevertheless, court decisions precluding the testimony of biomechanical engineers exist and it is important to understand the details of those cases and how a properly conducted biomechanical injury causation analysis addresses those rulings.

In *Clemente v. Blumenberg*, 183 Misc. 2d 923, 705 N.Y.S.2d 792 (N.Y. Supp., 2000), the expert was qualified as an expert in the field of biomechanics, but the trial court found that the expert's methodology was not reliable and not presentable to the jury and the court of appeal affirmed the trial judge's ruling. In this case, the expert simply looked at photographs of the incident vehicle and compared the repair costs in dollars, to a chart entitled "Bumper Performance Repair Costs, 5 mph Crash Tests." Since the repair costs exceeded the average cost of repairs for vehicles driven into a flat barrier at five miles per hour, the engineer concluded that the change in velocity of the incident vehicle was five miles per hour. Merely using repair costs in dollars and photographs as a method for calculating change in velocity of two vehicles at impact is not a generally accepted method in any relevant field of engineering or under the laws of physics. Itemized repair estimates provide important data for the evaluation of crush damage by noting the nature of the repairs and the parts involved; the repair costs in dollars are irrelevant for a technical evaluation of the incident severity. A properly trained biomechanical engineer would use peer-reviewed and accepted scientific methodologies to evaluate the actual crush damage sustained by the incident vehicle as compared to the amount of crush damage that would occur to the vehicle given various impact speeds.

In *Davis v. Martel*, 790 So. 2d 767 (La. App. 3 Cir., 2001, the expert was an ex-police officer who calculated lateral speed during a sideswipe incident on the highway through "his experience" and timing cars during lane changes with a stopwatch. This expert testified that he relied on his personal experience concerning vehicles making lane changes and did not rely on any published studies, data or any other reference material to assist in developing his opinion. Obviously, the inferences and opinions that the expert made in this case did not adhere to formal principles, specific calculations, or to a repeatable and testable "scientific method." This expert failed to use methodologies that were generally accepted in any scientific field. Again, a properly trained biomechanical engineer would use the laws of physics and generally accepted techniques to evaluate the specific incident and the resulting damage to determine the severity of the incident, and would provide support for their analyses and conclusions through peer-reviewed technical literature and learned treatises.

In *Tittsworth v. Robinson*, 252 Va. 151, 475 S.E.2d 261 (Va. 1996), the expert looked at the postcollision photographs of the cars and "assumed half of an inch of permanent crush of the whole width and whole height of the back of the incident vehicle." This expert then used a computer program that calculated the maximum force applied to the rear of the vehicle to be 1.6 Gs. The court criticized the expert's analysis and ruled that it lacked sufficient scientific and evidentiary basis. The analysis of photographs as a basis for the severity of an automotive accident is a generally accepted analytical technique. However, the expert in this case failed to demonstrate that he had sufficient basis for the assumption of a half an inch of crush to the rear of the vehicle. Although a properly trained and qualified biomechanical engineer uses photographs of the incident vehicle after the impact to assess the presence of crush damage, known landmark locations on the vehicle must be compared to geometric measurements of an undamaged vehicle to evaluate the extent of the crush damage. By using a crush depth and landmarks that exceed the damaged portions of the incident vehicle, a biomechanical engineer can determine the change in velocity and associated forces necessary to crush the structure of the vehicle beyond what is observed in the photographs.

In *Hisenaj v. Kuehner*, 194 N.J. 6, 942 A.2d 769 (N.J. 2008), the expert referenced published studies that included live subjects who were subjected to impacts of comparable severity to the claimant and were not significantly injured. However, on appeal the appellate division ruled that the expert made no reference to activities of daily living and made no nexus between the claimant and the acceleration forces experienced by the live subject studies. Although the Supreme Court of New Jersey overturned the ruling of the appellate division and allowed the testimony of the expert, the analysis that was performed contained some inherent flaws. A properly trained biomechanical engineer does not simply extrapolate the results of these scientific studies to a specific incident or individual to provide an opinion regarding the causation, or lack thereof, of an alleged injury in a low speed impact. Rather, the biomechanical engineer's evaluation regarding the potential for a causal relationship between an alleged injury and a specific incident uses thorough analyses of the forces and accelerations during the incident, an understanding of the unique personal tolerance levels of the claimant's body, and a biomechanical analysis of the associated injury mechanisms and force magnitudes. Peer-reviewed scientific literature and learned treatises are then used to support the results of the biomechanical engineer's independent analysis regarding the incident and the alleged injuries.

The presence of significant preexisting degenerative conditions may change the tolerance of a specific individual's joints or tissues to applied forces, which is precisely why a properly trained biomechanical engineer evaluates the personal tolerance levels of the claimant.