ABSTRACT:

One of the main tasks of a forensic biomechanician is to determine the mechanism of injuries and factors influencing the causation of an accident or the failure of an implant. This task, in itself, is analogous to putting together pieces of a puzzle and trying to answer to the questions related to the accident causation or the failure. To achieve this task, one has to perform a detailed analysis of an after-the-fact or to execute a “Reverse Bioengineering” process. Similar to many other inverse problems, the reverse bioengineering may not have a unique solution. However, the expertise and experience of a forensic biomechanician help to provide a rather unique solution that is logical and appealing.

In this paper, the author, from his own experiences in forensic biomechanics, presents factors influencing the inverse process of three cases. In particular, reverse bioengineering is employed and the causation of bodily injuries, specifically cervical spine injuries, of the three cases presented here are discussed. Note that while the title of the paper has not been changed, the materials presented in the abstract have been expanded to cover a wider spectrum of forensic biomechanics. Therefore, the title of this paper does not fully reflect the content of the paper.

INTRODUCTION:

In an accident or an incident where parts of a human body comes in contact with machine parts or rigid objects a biomechanics expert is called to investigate and to explain the causation, the mechanism, of the injuries or the failure of the equipment. This is analogous to an inverse engineering problem where through the solution one tries to define the boundary or the initial conditions of the problem. In this paper, similar to the numerical solution of an inverse problem, an iterative process is employed to find the initial and boundary conditions of the event that led to the injury.

THE REVERSE ENGINEERING PROCESS.

A biomechanics expert can be called upon at any stages of the discovery process of a litigation case. We assume that the biomechanics expert is involved when all the facts on the case are available. The following flow chart, depicted in Figure 1, describes the reverse process for in a forensic biomechanics case.

Starting with the depositions of a case, the facts about the case should be gathered from the testimonies give by the parties involved in the case or the witnesses. These testimonies will be used to describe the initial and boundary conditions of the problem and can be included or disregarded as it fit to the creation of scenarios of the accident. Physical evidence such as photographs, police reports, or other reports that are based on the hard facts have to be gathered.
and analyzed. These facts are used as the basis of the problem definition. Medical records, specifically the operation reports and radiology reports are used to establish the basis for the injuries. In fact, these records are the most important part of the reverse process and fact finding since the expert can deduce type of impact or the loading, which led to the injury. The reports concerning the independent examination of the patient by physicians are also important in deducing some facts. The expert personal inspection of the site of the accident or the device is extremely important in establishing a framework for an expert opinion. The inspection always includes measurements, photographing, laboratory testing and analyzing of the evidence.

Based on these facts, the biomechanics expert defines the first iteration of the problem. Utilizing the engineering principles, the expert analyzes the problem. The solution of the defined problem may lead to one or more scenarios. In each scenarios one has to reexamine the hard facts presented in the depositions, medical records, and the inspection. The first solution to the problem must be reiterated and checked against the inspections, medical records and physical evidence. The expert opinion would be the most likely scenario of the incident or the injury, which justifies the uniqueness of the final solution.

The following three examples show the inverse process explained above. These examples will be fully described and discussed at the presentation.

Neck injury
The plaintiff of this case alleged that as soon as she walked into the hotel room the ceiling tile and a section of the aluminum track of the suspended ceiling fell on her head. As a result of this impact she allegedly sustained injuries. After careful review of the depositions and the medical record, the accident site was inspected and the tile weight and size were measured. The engineering mechanics principles were employed and the total force that was exerted to the plaintiff’s head was calculated to be tenth of a pound. Three scenarios were assumed and it was determined that only one of the scenarios was a likely candidate. After some iteration process it was concluded that with a reasonable degree of biomechanics certainty the impact was not sever enough to have caused permanent injuries and it is very unlikely that the accident happened the way it was reflected in the reviewed documents.

Automotive rear impact
The plaintiff was the driver of a Jeep and had come to a complete stop when the defendant was unable to control his vehicle, failed to stop in a timely manner, and the front of his car impacted the rear bumper of the Jeep. The plaintiff’s vehicle was pushed forward a few feet and almost hit the vehicle in front of him. At the time of the accident, it was snowing and the road was covered by 1 to 3 inches of snow and ice. The road had 2.5% downhill slope. As a result of the accident the plaintiff allegedly sustained cervical and lumbar spine injuries. In particular he was diagnosed as having discs herniations at C5-C6 and C6-C7 and later discs bulging at L3/L4 and L4/L5 both of which produced lateral recessed stenosis. Later a surgery was performed on his lower back. After careful review of the depositions and the evidence both cars were inspected and the damaged to the vehicles were assessed. The principle of linear momentum and energy conservation were used and the velocity of the vehicles were determined. Unlike the testimony of the defendant the damage to his vehicle was extensive and his speed at the time of the impact was determined to be more than what was claimed. Based on the deformation of the Jeep’s fender an inverse engineering problem was solved and the impact
velocity (Delta-V) was determined. After proposing two scenarios the most likely scenario was selected. Because of the stiffer structure of the Jeep, the Jeep did not absorb the energy of the impact and almost all of the impact was transmitted to the plaintiff’s head and neck and his lower back. Therefore, it was determined that, with a reasonable biomechanics certainty, the type of the speed and the impact were such that they would create sufficient force to cause herniated cervical discs and bulging discs in the lower back of the plaintiff.

Automotive seatbelt neck injury

The plaintiff was a rear seat passenger of a Chevy Blazer traveling about 25 MPH on a road having descending slope with patches of ices. The Blazer began to slide “fish tailing” at the ice patch. The driver lost control of the car and slid across the road and went into a ditch. Finally, the Blazer hit the mountain and came to rest. At the time of the accident, the plaintiff was not wearing his seat belt. As a result of the impact, the plaintiff, who was unrestrained, was ejected upward from his seat and his head hit the roll bar on the roof of the Blazer. In the rebound, the plaintiff came in contact with interior passenger side of the vehicle. The plaintiff was taken to the hospital and the initial x-ray indicated that he sustained a cervical spine and right mandible fractures. The depositions and the medical records were carefully reviewed. The Blazer was inspected and the interior dimensions of the rear seat with respect to the roll bar were measured. To calculate the force that was exerted to the plaintiff’s head and neck, the height and the weight of the plaintiff were assessed and the rate of change of momentum and engineering mechanics principles were utilized. It was determined that the compressive load was 441.6 lb. This high force is severe enough to fracture his cervical spine. If the plaintiff was restrained, the lap seat belt would have prevented his lower extremity to move forward or would have restrained his body from separating from the seat. Specifically, his head and upper torso would not have moved 26 inches (measured at the inspection) diagonally forward and would not have come in contact with the roll bar. It was concluded that, within a reasonable degree of biomechanics certainty, the plaintiff would not have sustained the injuries if he had his seatbelt on.

Figure 1: Flowchart of the Reverse Bioengineering process