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A Person and His Bicycle are Struck by a Pickup Truck, but was He Riding or Walking the Bicycle?

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A person and his bicycle are struck by a pickup truck, but was he riding or walking the bicycle?

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ABSTRACT

A pickup truck is leaving a doughnut shop drive-thru. The driver checks the traffic and turns left onto the main roadway. The roadway has two lanes in each direction separated by a double yellow line. At the same time, a person with a bicycle leaves a side road on the opposite side of the main roadway and illegally begins to cross the main roadway, with the intent of getting to the other side. The pickup truck strikes the person and the person and his bicycle are knocked to the ground.

The person claimed that he was walking his bicycle at the time of the collision and that he was well-visible and not moving quickly. Since he was walking his bicycle there was no reason to wear a bicycle helmet. The driver of the pickup truck claimed the person was actually riding his bicycle at high speed without due care and that he should have been wearing a helmet.

Several simulations were conducted using HVE and GATB. There was good evidence as to the rest positions of the person and his bicycle after the collision. By simulating the motion of the person's body after impact and comparing the diagnosed injuries with loading on the human model, it was determined that the person could have been either riding his bicycle or walking it. In both scenarios he would have struck his head forcefully on the hood of the pickup.

THE LITIGANTS

The author was retained by the lawyers for pickup truck driver (the defendant) in this case to investigate this collision from a biomechanical perspective. In particular, the author was asked to determine whether or not the person with the bicycle (the plaintiff) was riding his bicycle at the moment of impact and to approximate his speed if he was riding the bicycle. These factors were to be determined based on the kinematics of the plaintiff's body and its final rest location due to the collision with the pickup truck.

THE INCIDENT

The incident in question occurred on the morning of January 28 in London, Ontario, Canada. The defendant was the seat-belted driver of a 2011 Chevrolet Silverado pickup truck. He was exiting the drive-thru lane of the Tim Horton's coffee shop on the north side of Horton Street. His intention was to turn left and proceed eastbound along Horton. An aerial view is shown in the Figure 1. At that time, the plaintiff was riding or walking a bicycle northbound along Henry Street. This was the wrong way along a one-way street where the traffic travels only southbound. Upon reaching Horton Street, the plaintiff proceeded to cross the lanes of traffic of Horton Street without right of way. Street views are shown in Figures 2 and 3.

At some point during the left-hand turn, the defendant became aware of the plaintiff in his path. He engaged his brakes but was unable to avoid colliding with the plaintiff and his bicycle. The impact was on the dead center front of the pickup truck but resulted in no damage. The bicycle was reportedly damaged, but it was stolen from the scene of the collision soon after the incident. Therefore, there was no physical evidence as to the state of damage to the bicycle. No airbags deployed in the pickup truck.

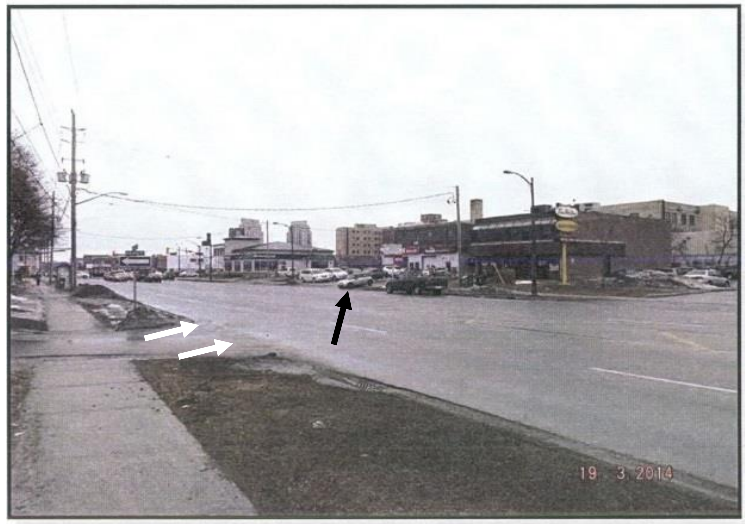
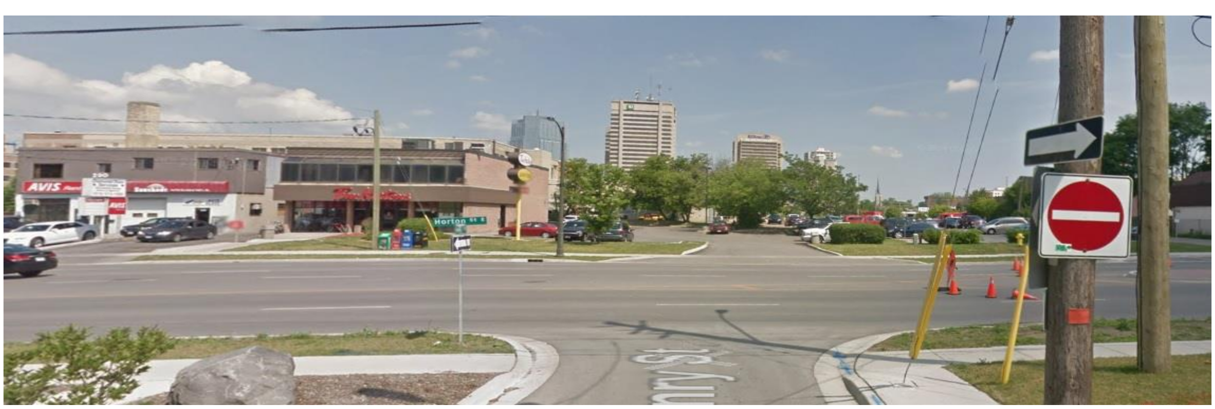


Figure 2: Street view of the Horton Street facing westbound looking from the south side. The Tim Horton's is seen on the north side of Horton. The exit from the drive thru-lane is shown with the black arrow. Henry Street's entry on the left side is shown with the white arrows.

Figure 1: The intersection of Horton Street and Henry Street (Google Earth). North is upward. The exit from the drive-thru (single white arrow) and the exit from the parking lot (pair of white arrows) are shown.

Figure 3 (below): Street view of the intersection of Henry Street and Horton Street facing north along Henry. Note the exit to the main portion of the Tim Horton's parking lot is almost straight ahead. Also note the signage on the east side of Henry Street clearly indicating that this is the wrong way for traffic.



DAMAGE TO THE DEFENDANT VEHICLE

No repairs were done on the defendant's Chevrolet Silverado as a result of the collision. From the photographs provided of this vehicle after the collision, no damage could be seen on the front bumper, grill or hood of the vehicle where the impact occurred (Figure 4).

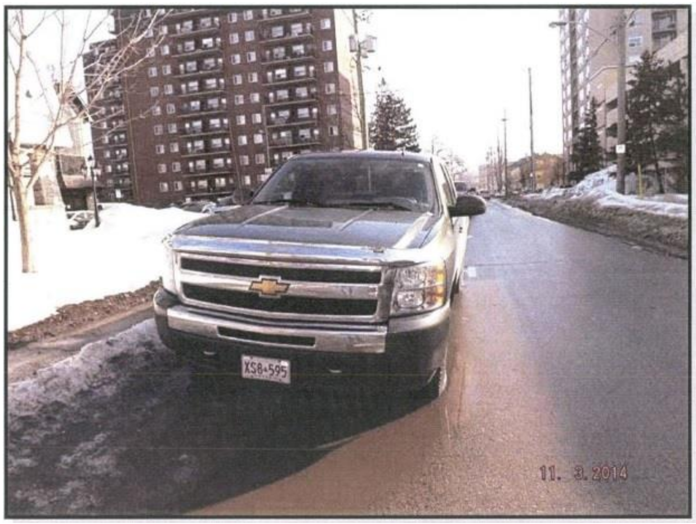


Figure 4: A front view of the defendant 2011 Chevrolet Silverado pickup truck shows no damage to the front bumper, grill or hood.

INJURIES TO THE PLAINTIFF

The plaintiff was attended on the scene by an ambulance crew. He was unresponsive initially, becoming conscious soon afterward. He was transported by ambulance to hospital with a suspected fractured shoulder. EMS reported that the plaintiff was non-cooperative and combative and had no memory of the collision or of leaving his apartment prior to the collision. At the hospital the plaintiff was diagnosed with subdural and subarachnoid hematomas (brain bleeds) on the left side accompanied by a fracture to the temporal bone of the skull.

HEAD INJURY THRESHOLD AND INFLUENCE OF BICYCLE HELMETS

A current standard for quantifying the magnitude or severity of linear accelerations of the head is the Head Injury Criterion (HIC; Versac, 1971), which is an integral measure that quantifies the area under the acceleration-time curve during an impact (Hodgson and Thomas, 1972; Prasad and Mertz, 1985; Mertz and Irwin, 1994). The chance of injury to the brain increases with an increasing value of the HIC. The probability of different severity of head injuries as categorized by the Abbreviated Injury Scale (AIS) as a function of HIC have been estimated by Gennarelli and Wodzin (2005) and will be used in this case to establish threshold of head injury.

Another measure has been more recently introduced correlates accelerations of the head with change in intracranial pressure (IP) that causes brain injury (Zhang et al., 2004). The minimum intracranial pressure for which the Zhang et al. (2004) study observed a mild traumatic brain injury was 53 kPa in the coup region and 48 kPa in the contre-coup region. This will also be used to establish threshold of brain injury.

Wearing a bicycle helmet protects the rider from both skull fracture and brain injury during an impact by lengthening the duration of impact and avoiding direct contact with the scalp. All bicycle helmets sold in North America meet the requirements for either Canadian Standards Association (CSA) or American American Society for Testing and Materials (ASTM) certification. These certification standards are mostly intended to avoid skull fracture rather than concussion. However, helmets are effective in reducing the occurrence of concussion and other traumatic brain injuries, such as contusions and brain bleeds, as well.

Helmets are most effective up to changes in speed of up to 20 km/hr and partially effective above than speed. This impact speed is the maximum speed at which most impacts occur for a cyclist either striking a vehicle, being thrown from a vehicle after impact or falling over their handle bars (a fall from about 2 meters onto the roadway; Syed et al, 2013; Cripton et al, 2014). So, the protective range of certified bicycle helmets is well chosen. The peer-reviewed biomechanics literature consistently shows that a properly fitted and worn certified bicycle helmet protects from skull and facial fracture, facial injury and most brain injuries (Amoros et al, 2012; Attewell et al, 2001; Bambach et al, 2013).

HVE SIMULATION OF THE COLLISION

The simulations were conducted using HVE (version 2016, SP 4) with the EDSMAC4 solver and GATB. The pickup truck model was selected from the EDVDB-3D vehicle database as a Chevrolet Silveradoo 1999-2007. The curb weight of this vehicle is 5329 lbs (2417 kg as per http://www.nadaguides.com/Cars/2011/Chevrolet/Silverado-1500-V8/Crew-Cab-LT-4WD/Specs
Several simulations were performed to determine the severity of the collision on the plaintiff's head. The head injury criterion (HIC; Versac, 1971), intracranial pressure (IP), change in velocity (delta-v) and peak acceleration were all estimated. Intracranial pressure was calculated using the method of Zhang et al (2004).

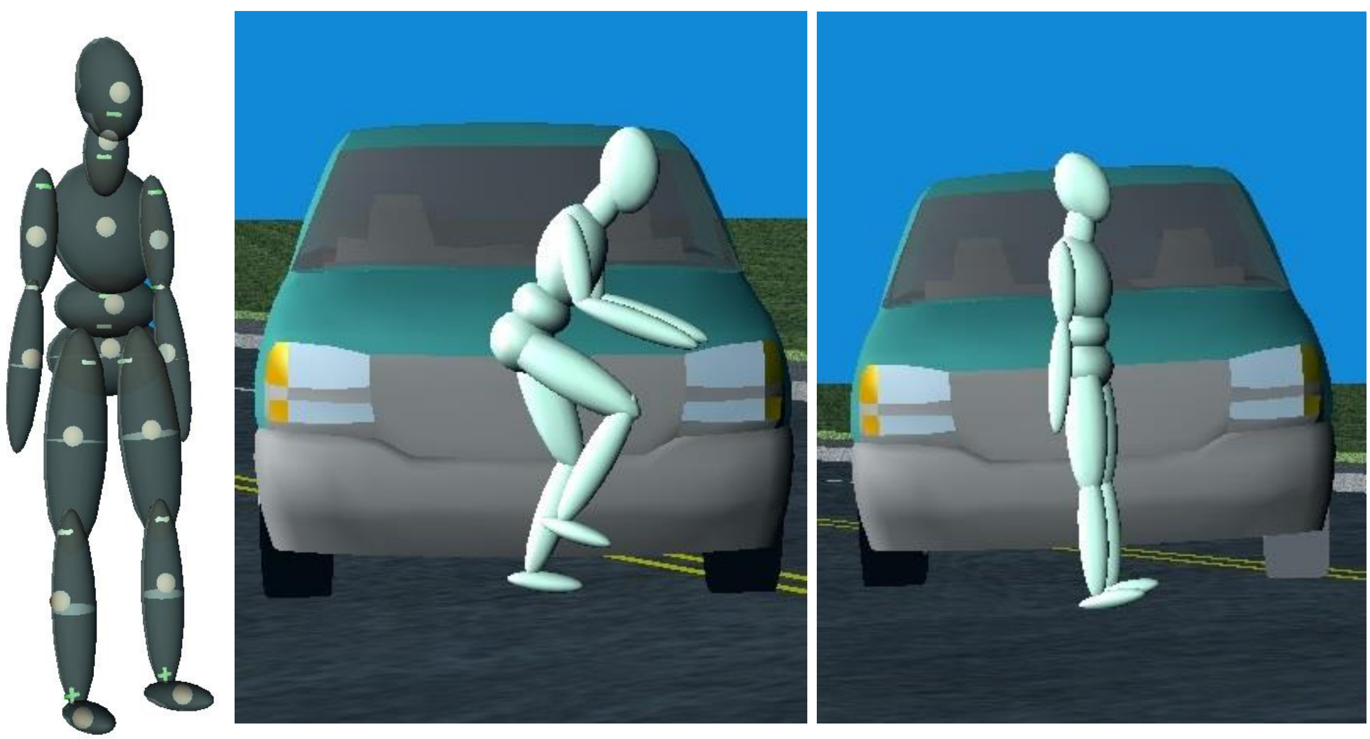


Figure 5: The 15-segment body model scaled to the height and weight of the plaintiff. The image in the center shows the positioning at the moment of impact for the cyclist simulation. The right image shows the body model positioning at the moment of image for the standing pedestrian simulation.

Within the HVE simulation an environment was created that represented the roadway of Horton Street. This was simply modeled as a flat level asphalt roadway surface since the geometry of the site was not a significant factor in the collision.

The plaintiff's body was modeled using an adult male that was 170 cm (5'-7") tall and 65 kg (143 lbs) in mass and placed in front of the pickup truck (Figure 5). Two body positions were simulated. The first had the plaintiff riding his bicycle across the front of the pickup from the driver's right to left. The second had the plaintiff standing in front of the pickup truck. In both cases, the plaintiff impacted the vehicle dead center.

Contact surfaces on the front of the pickup truck were placed on the front bumper, the grill and the hood. Any contact between any segment of the body model and a contact surface results in force being applied to the body model. This way repeated contact between the plaintiff's body and the exterior of vehicle is simulated during the collision.

Two simulations were performed. The first simulation assumes the plaintiff was riding his bicycle at the moment of impact. The pickup truck is modeled as performing a left hand turn out of the north side of Horton Street. At the moment of impact, the vehicle is travelling at 18 km/hr and strikes the body model as shown in Figure 5 (middle image). The motion of the body model during the collision is shown in Figure 6 in five images at 0.1s increments. Note that at 0.2s (Figure 6C) the plaintiff strikes his head on the hood of the pickup truck. After that the plaintiff is thrown from the vehicle onto the roadway.

The second simulation assumes the plaintiff was walking his bicycle as a pedestrian at the moment of impact. The pickup truck is still modeled as performing a left hand turn out of the north side of Horton Street. At the moment of impact, the vehicle is travelling at 18 km/hr and strikes the body model as shown in Figure 5 (right image). The motion of the body model during the collision is shown in Figure 7 in five images at 0.1s increments. Note that, similar to the cyclist simulation, at 0.2s (Figure 7C) the plaintiff strikes his head on the hood of the pickup truck. After that he is thrown from the vehicle onto the roadway. The motion of the body model in both simulations is similar.

SIMULATION RESULTS

The GATB simulation of the plaintiff as a cyclist showed that the peak acceleration acting on his head during the collision was 32.3 g's, the change in velocity (delta-v) was 28.4 km/hr, the peak HIC was 92.5 and the intracranial pressure (IP) 47.7 kPa. All four output measures of collision severity show that the plaintiff was above the threshold of injury for the skull fracture and the brain injuries with which he was diagnosed.

The GATB simulation of the plaintiff as a pedestrian, walking his bicycle rather than riding it, showed that the peak acceleration acting on his head was 41.7 g's, the delta-v was 18.7 km/hr, the peak HIC was 78.4 and the IP was 52.8 kPa. Similar to the first simulation, all four output measures showed that the plaintiff was above the threshold of injury for the skull fracture and the brain injuries diagnosed. Therefore, both scenarios, either as a pedestrian walking his bicycle or as a cyclist on his bicycle, the plaintiff was very likely to have suffered the same diagnosed injuries to his head and brain.

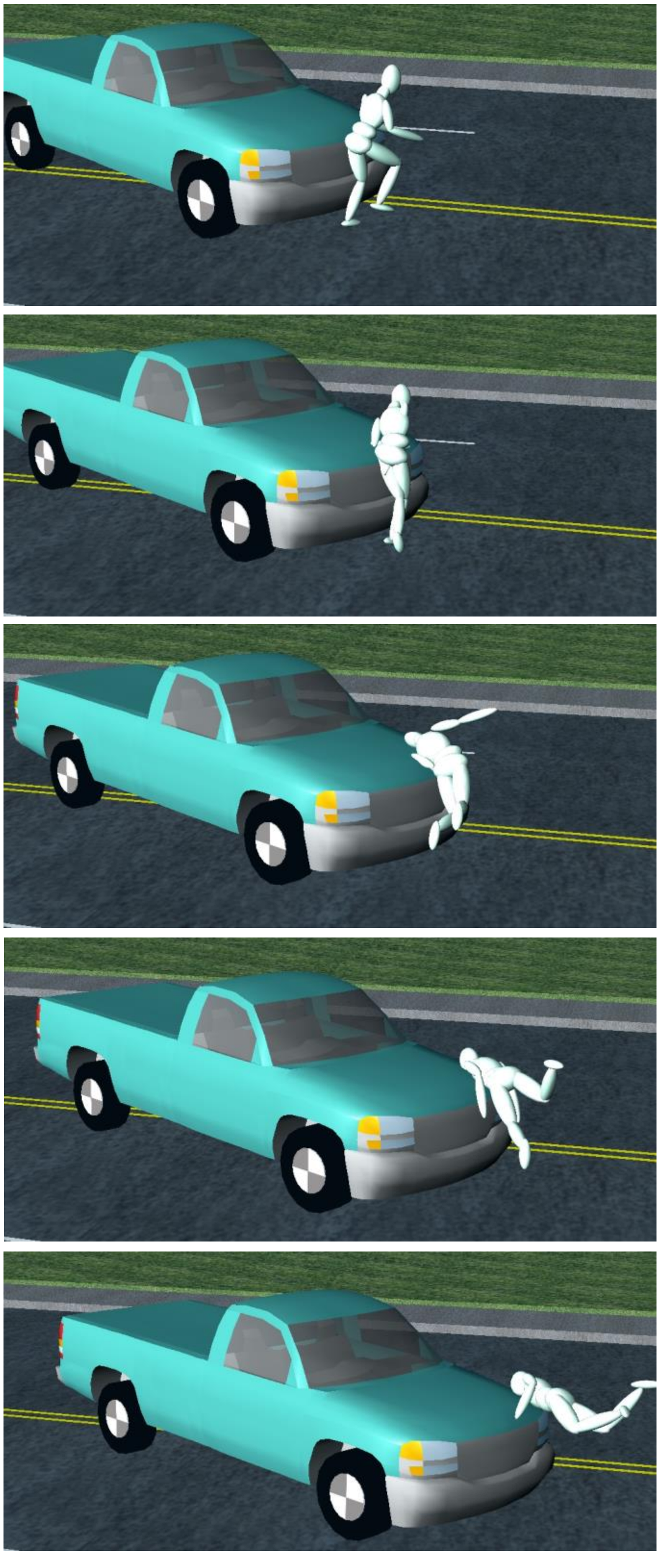


Figure 6: The simulation of the plaintiff as a cyclist. This series of images shows (A) the initial positioning, (B) at 0.1s into the simulation, (C) at 0.2s, (D) at 0.3s and (E) at 0.4 s into the simulation.

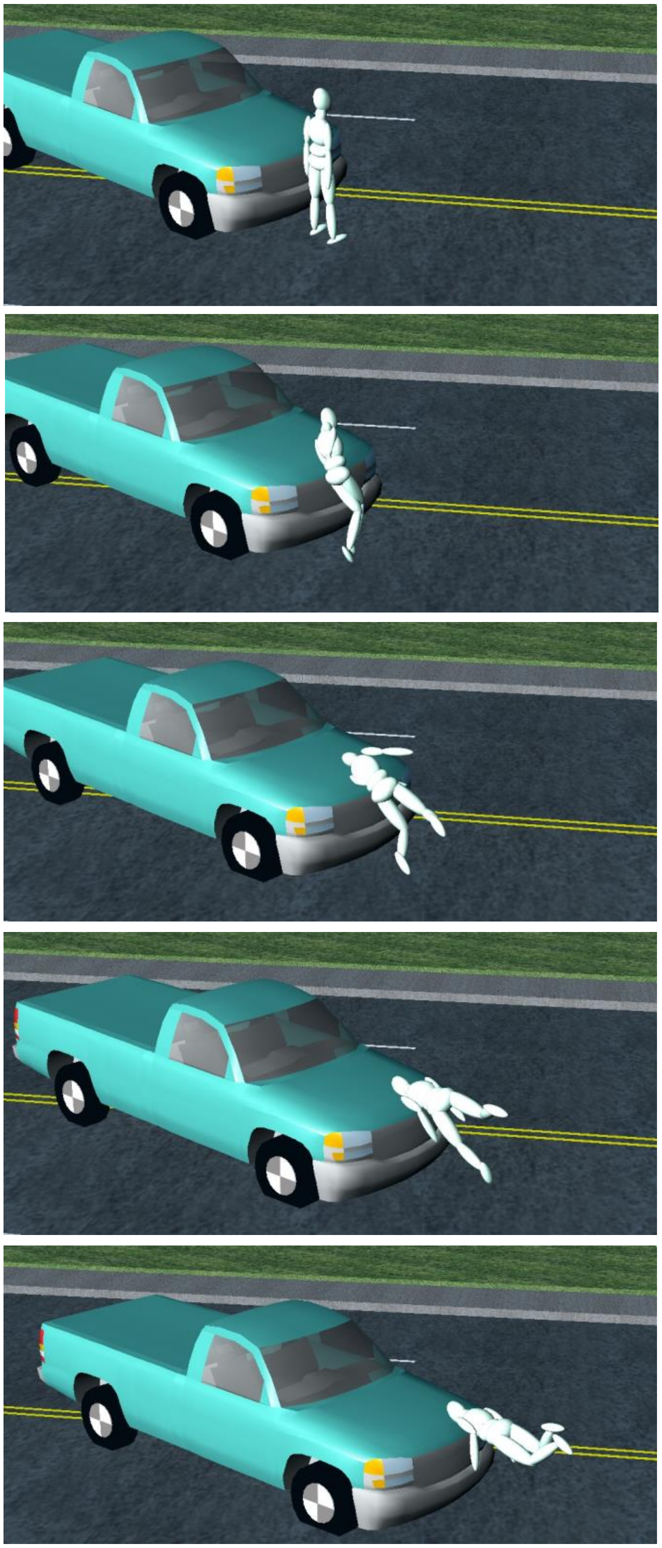


Figure 7: The simulation of the plaintiff as a pedestrian. This series of images shows (A) the initial positioning, (B) at 0.1s into the simulation, (C) at 0.2s, (D) at 0.3s and (E) at 0.4 s into the simulation.

But in both scenarios, the change in velocity of the head and the peak accelerations acting on the head were within the range for which a properly fitted bicycle helmet would have provided protection. In the case of the pedestrian collision, the delta-v of the plaintiff's head was 18.7 km/hr. This is less than the design specification for a certified helmet (delta-v of 20 km/hr) for which a helmet provides protection. So, in the pedestrian scenario, it is very likely that the plaintiff would not have suffered any injury to his head or brain whatsoever had he been wearing a bicycle helmet. In the case of the cyclist scenario, the delta-v of the plaintiff's head was 28.4 km/hr. This slightly exceeds the design specifications for a bicycle helmet. Therefore, in the cyclist case, the plaintiff may still have sustained an injury to his head or brain. It is most likely that the injury in the cyclist scenario, had he been wearing a bicycle helmet, would have been a concussion.

CONCLUSIONS

It was the author's opinion that the plaintiff sustained his skull fracture and brain injuries when he collided with the hood of the pickup truck driven by the defendant. It was also the author's opinion that the plaintiff would have suffered similar injuries to the skull and brain had he been a cyclist riding his bicycle or a pedestrian walking his bicycle at the time of impact.

Further, it was the opinion of the author that had the plaintiff been wearing a properly fitted, certified bicycle helmet during the collision, then the injuries to his skull and brain would have been significantly less severe. Had he been wearing a helmet in the pedestrian scenario, then it is very likely that he would have suffered no injuries whatsoever to his skull or brain. Had the plaintiff been wearing a helmet during the cyclist scenario, then it is very likely that his head injury would have been limited to a concussion, or he could have avoided head injury altogether. The biomechanics literature is clear that wearing a certified bicycle helmet in a proper manner significantly reduces the risk of head injury, skull fracture and facial injury.

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Thomas Jenkyn is the Senior Engineer at TLS Forensic Biomechanics and Engineering Ltd in London, Ontario, Canada. His undergraduate and master's degrees are in Engineering Science from the University of Toronto. His doctoral degree is in Biomedical Engineering with a specialty in Biomechanics from the University of Strathclyde in Glasgow, Scotland. His Post-doctoral Research Fellowship was in Orthopaedic Biomechanics in the Department of Orthopaedic Surgery and the Department of Diagnostic Radiology at the Mayo Clinic, Rochester, MN. Thomas Jenkyn has been a licensed professional engineer in Canada since 2004 where he sets and marks the technical examination to attain expertise in the field of 'biomechanics' for the Association of Professional Engineers in Ontario.

In addition to his consulting work, Thomas Jenkyn is a Professor of Biomechanics at the University of Western Ontario (UWO) in London, Ontario, Canada. He holds a joint appointment in the Department of Mechanical and Materials Engineering and the School of Kinesiology. Since 2002 he has been the Co-Director of the Wolf Orthopaedic Biomechanics Laboratory (an advanced x-ray imaging facility) at the Fowler Kennedy Sport Medicine Clinic and the Director of the Craniofacial Injury and Concussion Laboratory at UWO campus.