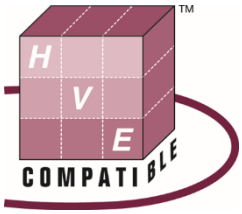

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Three Vehicle Chain Reaction Collision Injures an NHL Hockey Player

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Three vehicle chain reaction collision injures an NHL hockey prospect

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ABSTRACT

Two roadways meet at a traffic light-controlled intersection. In all directions the roadways have two lanes in each direction separated by grass medians. There are left turn lanes in all directions. Stopped at a red light in the westbound left turn lane is a small sedan (V1) driven by a minor league hockey player who is being actively scouted by NHL teams. Waiting to turn left in the southbound left turn lane is a small sedan (V2). Approaching the intersection heading northbound is a midsize sedan (V3) that has the intention of continuing straight through the intersection.

As V3 approaches, V2 starts to turn left. But V2 strikes the front left corner of V3 and causes V3 to veer off toward the northeast and into V1. V3 strikes the left front corner of the stopped V1. This second impact moves V1 backward and to the right by about 8 feet and rotates the car to the right by 45 degrees. Airbags deploy in all vehicles. The hockey player in V1 suffers a neck injury and a concussion. Unfortunately, his post-concussion symptoms force him to retire from hockey and he never makes the NHL.

A series of simulations were done using HVE and EDSMAC4 to determine the range of speeds V3 could have been approaching the intersection and the range of circumstances that V2 could have made her left turn in safety. The simulations showed that V2 initiated her left turn with a very narrow window of safety and should not have proceeded.

THE LITIGANTS

The author was retained by the lawyers for the driver of V1 (the plaintiff) in this case to investigate this collision from a biomechanical perspective. In particular, the author was asked to determine the magnitude of accelerations acting on the plaintiff's head and neck during the collision and to determine whether the biomechanical loading was sufficient to cause injury. The author was also asked to determine whether driver of V2 (the defendant) initiated her left turn in safety, or whether her actions were reckless and the foreseeable cause of the plaintiff's injuries.

THE INCIDENT

The accident occurred at 10:30 PM on September 11 at the intersection of Kortright Road and Highway 6 in the Guelph, Ontario, Canada. An aerial view is shown in Figure 1.

Figure 1: An aerial view of the intersection of Kortright Road West and Highway 6 as shown on Google Maps. Kortright Road West is the vertical roadway and Highway 6 is the horizontal roadway. North is to the right.

There were three vehicles involved, a 1996 blue Mazda Protégé car (V2) travelling southbound on Highway 6, a 2000 green Nissan Altima car (V3) travelling northbound on Highway 6 and 2002 silver Volkswagen Jetta car (V1) stopped in the left turn lane of westbound Kortright Road. The view westbound along Kortright Road is shown in Figure 2. The posted speed limit on northbound Highway 6 was 80 km/hr.

There were two distinct collisions, the first between V2 and V3, the second between V3 and V1. For the first collision, V2 attempted to make a left turn from southbound Highway 6 onto eastbound Kortright Road. V2 collided with V3, which was travelling northbound on Highway 6. This collision resulted in V3 veering off to the north and east and colliding with V1 in the second collision.

All roadways were asphalt and on the level. The weather had rain and the roadways were wet. The light condition was dark, since the sun had set and the light was artificial. The intersection was controlled by multi-phase traffic lights. At the time of the first collision, both directions on Highway 6 had green lights.

Figure 2: The intersection of Kortright Road and Highway 6 as shown on Google Maps dated the same month as the accident. The view is westbound along Kortright Road. The left turn lane in which V1 was stopped is shown with a white arrow.

The accident was investigated by the Ontario Provincial Police who found that the driver of V2 made an improper turn due to inattention. The drivers of V1 and V3 were driving properly. The officer considered the driver of V2 to have been inattentive.

DAMAGE TO THE VEHICLES IN THE SECOND COLLISION, V1 AND V3

Both V2 and V3 are severely damaged as a result of the accident, V1 was moderately damaged. Impact on V3 was first on left front center and then front center. Impact on V2 was the same, first on left front center and then front center. Impact on V1 was on the front center.

Photographic evidence of the damage to the plaintiff vehicle (V1) was provided. The primary impact occurred on the front left bumper and the front left quarter panel (Figure 3). The bumper cover was badly scratched and scored. The overall bumper cover was grossly moved out of alignment. The trim on the front left headlight and the orange indicator light were both damaged and moved out of their proper positions (Figure 3). The alignment of the left and right front quarter panels is deformed with respect to the hood and the hood will no longer line up at its left and right sides. With the front bumper cover removed, the front impact bar can be seen to be grossly intact. However, it is not possible to determine whether the left and right brackets that hold the impact bar to the chassis are intact or are deformed and compressed (Figure 4).

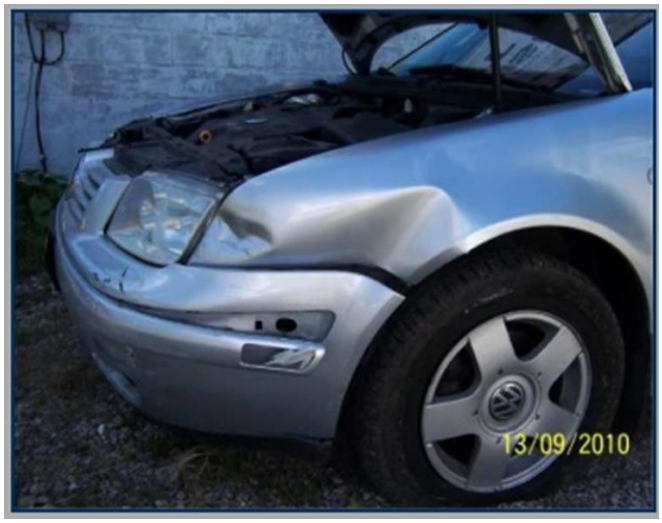

Figure 3: A left front view of the 2002 Volkswagen Jetta (V1).

Figure 4: A view of the left front of the Volkswagen Jetta (V1) with the front bumper cover removed.

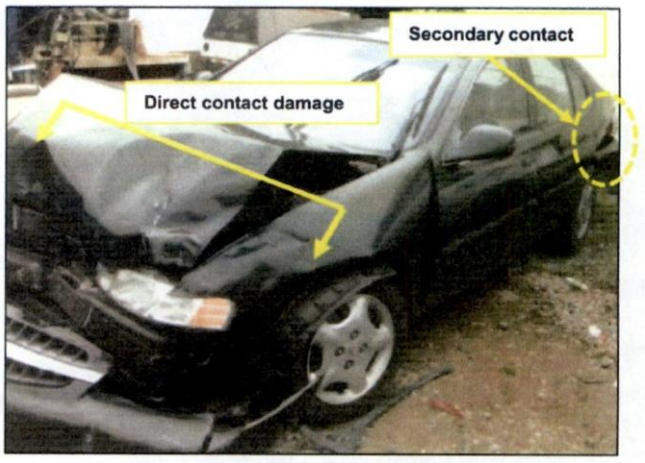

Figure 5: A view of the left front of the Nissan Altima (V3) showing primary and secondary contact damage.

INJURIES TO THE PLAINTIFF

The plaintiff in this incident was a healthy young man who played for a minor league hockey team and was being actively scouted by NHL teams. Soon after the accident, an ambulance was called to the scene of the accident. The plaintiff was assessed by paramedics but refused to be taken by ambulance to a hospital. The next day the plaintiff complained of headache with sensitivity to light and dizziness which he reported to his physician on September 15. On September 15 he received an x-ray of the neck that showed his cervical spine was straightened due to neck muscle spasm. On September 23, 12 days after the collision, the plaintiff had a CT of his head that was normal.

The plaintiff continued to complain of post-concussion symptoms. At a follow-up examination with his on December 30 the plaintiff had his concussion symptoms assessed and he was diagnosed with poor concentration and post-concussion syndrome. Unfortunately, due to his post-concussion symptoms, the plaintiff is forced to retire from professional hockey and he never makes the NHL.

HVE SIMULATION OF THE TWO COLLISIONS

The simulations were conducted using HVE (version 2016, SP 4) with the EDSMAC4 solver. Vehicles were selected from the EDVDB-3D vehicle database. V1 was modeled as a Volkswagen Jetta 1999-2005, V2 as a Mazda Proteger LX 1995-1998 and V3 as Nissan Altima GXE 1993-1997. Several simulations were performed to determine the likelihood that the collision between V1 and V3 was of sufficient severity to cause the injures diagnosed in the plaintiff. From the output of the simulations, the delta-v and peak acceleration were estimated from the simulation. The Neck Injury Criterion (NIC) was also calculated using the method of Funk et al (2011). It was decided to not include a human model within the plaintiff vehicle (V1) using GATB. Rather the threshold for injury was identified using the delta-v and acceleration experienced by a virtual accelerometer located at the driver's neck location.

Within the HVE simulation an environment was created that represented the location of the collision at Highway 6 and Kortright Road. This is shown in Figure 6. The relative positions of the lanes with V1, V2 and V3 are correct. Details that were not relevant to the accident were simplified, such as the exact shapes of the medians. The

pavement was wet so the friction multiplier was set to 0.645 for all asphalt surfaces. The roadways were all level and straight.

At the start of each simulation, V2 (blue car) approached the intersection heading southbound with the intention of turning left to then travel eastbound. There were two left turn lanes available and it was unclear from the evidence within which V2 was travelling. Both scenarios were simulated. V3 (green car) approached the intersection heading northbound. It was unclear from the evidence whether V3 was in the curbside or center lane. Both scenarios were modeled. In all scenarios simulated, V1 (plaintiff's white car) was at rest in the single left turn lane on westbound Kortright Road, facing westbound.

The initial speeds of V2 and V3 were also varied in each scenario to determine the range of speeds that would result in the first collision between V2 and V3 as well as the second collision between V3 and V1.

The plaintiff vehicle (V1) was a silver 2002 Volkswagen Jetta car with a curb weight of 2892 lbs (1312 kg as per http://www.edmunds.com/volkswagen/jetta/2002/features-specs/). A virtual accelerometer was placed in the driver's seat of V1 at the approximate height of the plaintiff's neck. V3 was a green 2000 Nissan Altima car with a curb weight of 2434 lbs (1104 kg as per http://www.edmunds.com/mazda/protege/2000/features-specs/). V2 was a blue 1996 Mazda Protégé car with a curb weight of 2573 lbs (1167 kg as per http://www.edmunds.com/mazda/protege/1996/features-specs/).

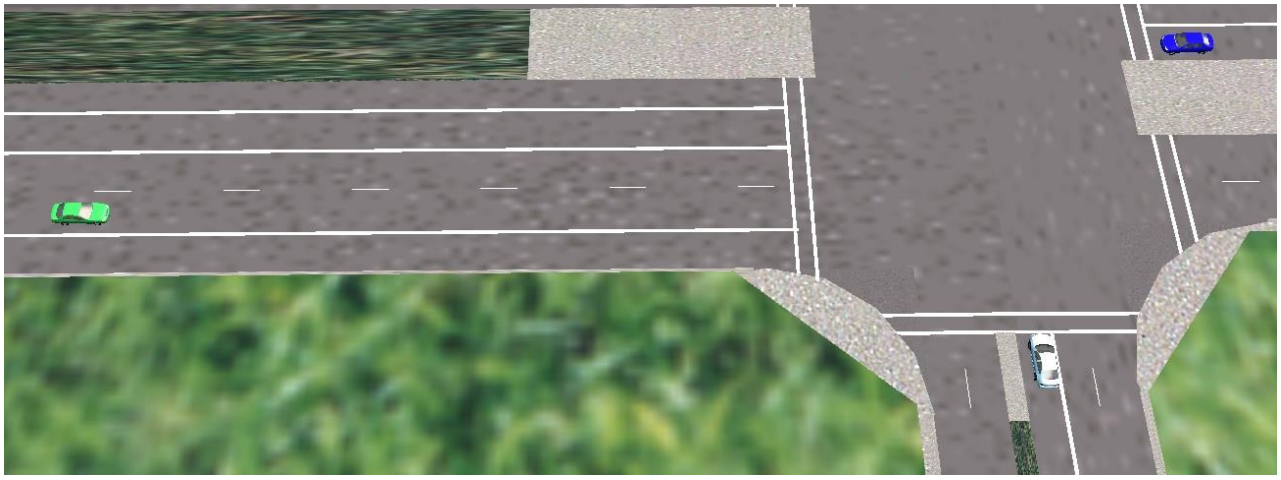

Figure 6: Representation of Highway 6 and Kortright Road in HVE environment. North is to the right as in Figure 1. The relative positions of the lanes for V1, V2 and V3 are correct if some details have been simplified.

An example scenario went as follows:

- At the beginning of the simulation (time=0.0), V1 was stopped in the left turn lane facing westbound on Kortright Road West with the intention of turning southbound onto Highway 6. His brakes were applied with 10% available friction (Figure 6).

- V3 was travelling northbound on Highway 6 in the curbside (right) through lane (this was altered for different scenarios). To her right was a right turn lane that started in the vicinity of the intersection. She was travelling at a constant speed (this was also altered for different scenarios) toward the intersection with the intention of travelling straight through without slowing. In this example, V3 was travelling at 60 km/hr (Figure 6).

- V2 was in the leftmost left turn lane (this was altered for different scenarios) on the southbound side of Highway 6 with the intention of turning eastbound onto Kortright Road West. In this example, V2 was travelling at 30 km/hr (Figure 6).

- At time 4.14s V3 and V2 collide. The front right corner of V2 hits the front left side of V3 (Figure 7). The two vehicles separate at 4.59s, but V3 is now headed toward the stationary V1.

- V3 strikes V1 at 4.91s into the simulation. The front right of V3 strikes the front left of V1 (Figure 8). The vehicles separate at 5.03s.

- V1 is sent backward by the force of the second collision and rotates in a clockwise direction, coming to rest on the median of Kortright Road West (Figure 9).

SIMULATION RESULTS

In the example simulation, the collision deformation classification for the plaintiff's Volkswagen Jetta (V1) was `11FYEN1` which corresponds to an impact from the front left side with a small amount of penetration into the structure of the vehicle. The amount of penetrating crush of the bumper was simulated to be 5.7 cm. This was consistent with the physical evidence shown in the photographs in Figures 3 and 4. So, this damage profile should conservatively estimate the force applied to the V1 during the collision with V3, the Nissan Altima. The direction of the force and the location of the impact were consistent with the collision.

The simulated collision deformation classification for V3 was `01RFEW3' which corresponds to an impact from the right front in a wide area over the front quarter with a significant amount of penetration into the structure of the vehicle. The amount of penetrating crush was simulated to be 18.9 cm. This is consistent with the physical damage in the photograph in Figure 5 showing approximately this amount of penetration into the structure of the Nissan. The direction of the force and the location of the impact are consistent with the collision.

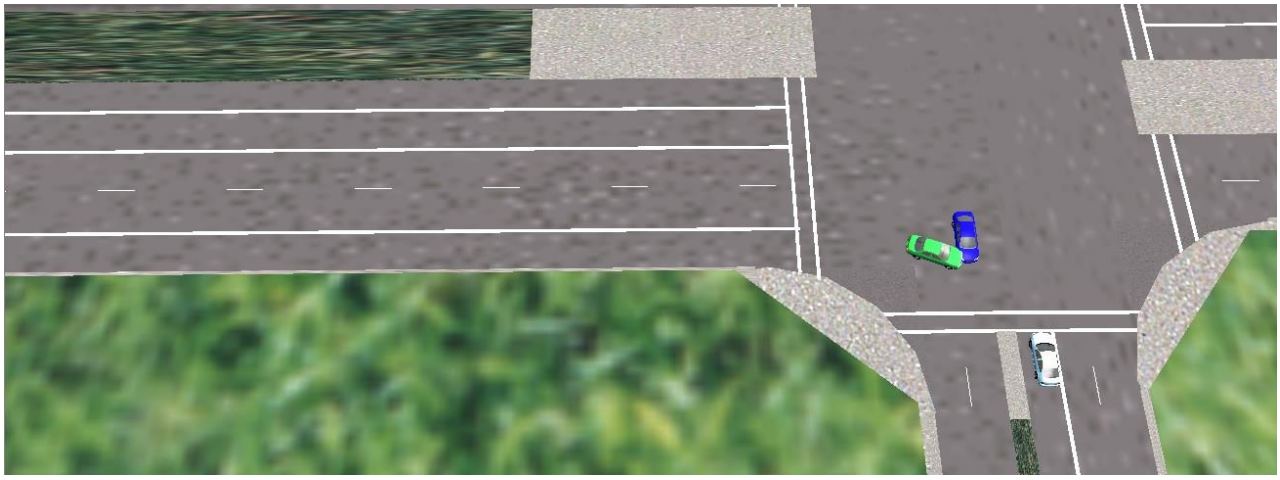

Figure 7: Initial collision between V2 (blue car) and V3 (green car) occurs at t=4.14s. The vehicles separate at t=4.59s but now V3 is headed toward V1 (plaintiff's white car).

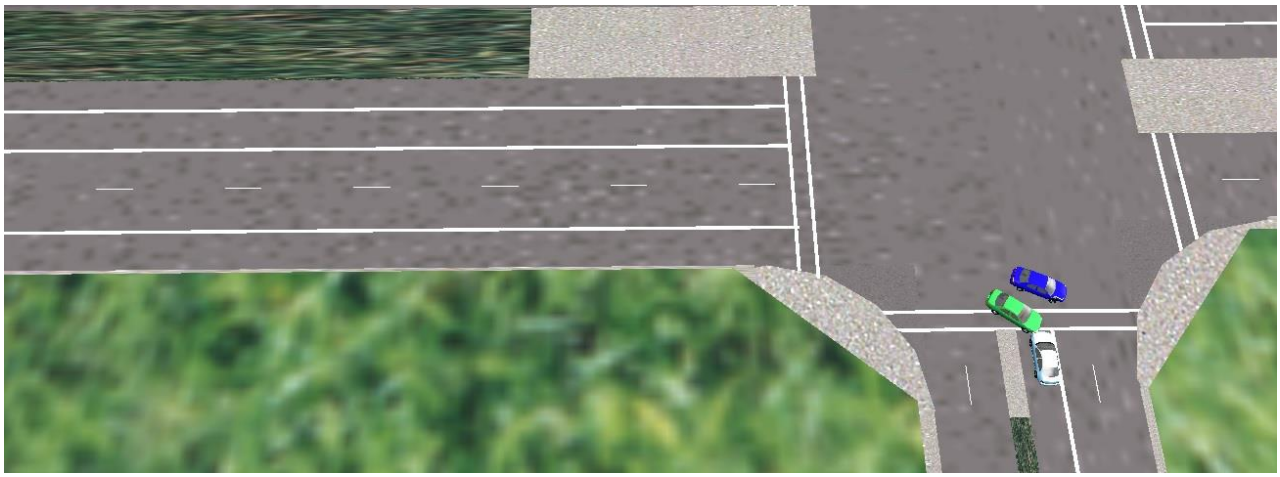

Figure 8: The second collision occurs between V3 (green car) and V1 (white car) at t=4.91s and separation at t=5.03s.

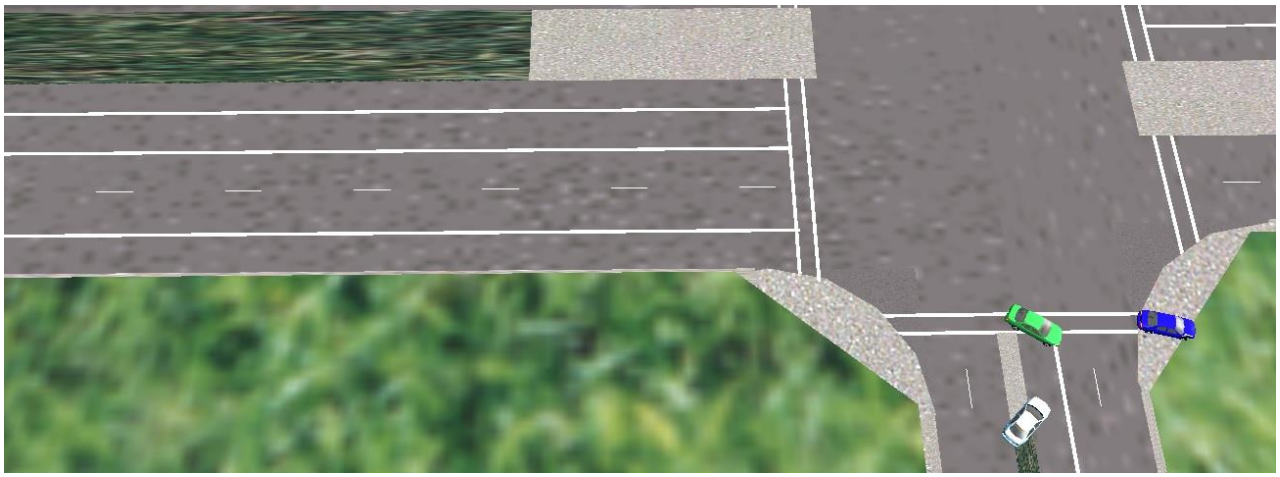

Figure 9: All vehicles come to rest by t=8.16s. V1 (white car) is pushed backwards and onto the median on Kortright Road, which is consistent with the physical evidence in the police report.

At the accelerometer, the maximum acceleration experienced during the second collision by the driver of V1 was 8.43 g's (Figure 10). This is above the threshold for injury at the neck of 8 g's (Ivancic et al, 2005). The NIC was calculated using the method of Funk et al (2011) to be 43.3 m^2/s^2. This is also significantly greater than the threshold for injury at the neck reported in the literature, 17.9 m^2/s^2 (Ivancic et al, 2005). It might be informative to note that the NIC and peak acceleration associated with sitting down rapidly onto a rigid wooden chair are NIC=5.5 m^2/s^2 and a=3.7g respectively (Funk et al, 2011). The delta-v experienced by the occupant of the Jetta was simulated as 15.9 km/hr, or 4.4 m/s. This is greater than the minimum delta-v required to cause a concussion in the Viano study (Viano et al, 2007). Therefore, the simulated collision between V3 and the plaintiff's V1 was of sufficient severity to cause a whiplash injury (WAD2) injury to the neck with symptoms lasting longer than 6 months, and to cause a concussion.

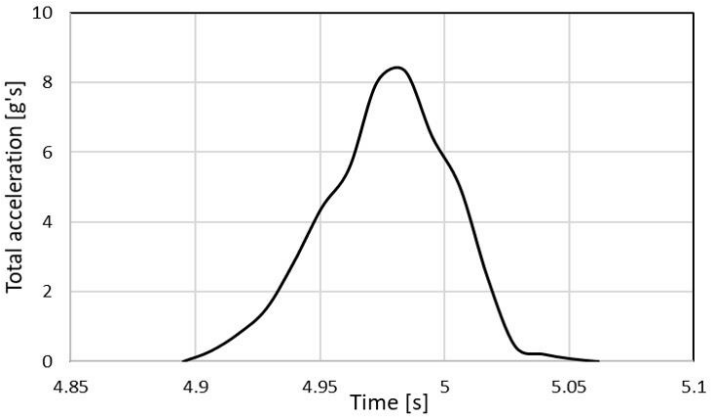

Figure 10: Collision pulse experienced at the position of the virtual accelerometer.

The HVE simulation was run with V2 turning from both the left and the right left turn lanes on southbound Highway 6. The left turn speed of V2 was varied between 25 and 45 km/hr. The simulation was also run with V3 in either the center lane or the curbside lane heading northbound on Highway 6. The approach speed of V3 was varied between 50 km/hr and 80 km/hr.

Out of the 20 scenarios tested, for only 5 simulations was there no collision between V2 and V3. In the 15 scenarios where the first collision occurred, in 7 scenarios V3 went on to strike V1 in a second collision. The two scenarios that fit the physical evidence of damage to V1 and V3 the best two scenarios were as follows: V2 was in the left side left turn lane, turning at 30 km/hr and V3 was in the center lane approaching at 65 km/hr; and V2 was in the right side left turn lane, turning at 40 km/hr and V3 was in the curbside lane approaching at 70 km/hr. Given how few scenarios resulted in no collision, it was concluded that the window for a safe left turn by V2 was very narrow and V2 was in error to have initiated her left turn under these conditions.

CONCLUSIONS

It was the author's opinion in this case that the change in speed (delta-v) experienced by the plaintiff in V1 during the collision with V3 was of sufficient severity to biomechanically cause a whiplash injury (WAD2) and a concussion. Further, the severity was sufficient for the symptoms of the neck injury to persist for longer than 6 months. The series of simulations done using HVE and

EDSMAC4 showed that V2 initiated her left turn with a very narrow window of safety and she should not have proceeded.

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ABOUT THE AUTHOR

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.