A finite element of an electric scooter model for simulating traffic accidents

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BACKGROUND

Electric scooters are a relatively new form of transportation that have become popular and widely available leading to an increase in injuries related to their use [1]. The most common injuries resulting from scooter accidents are fractures/dislocations and contusions [2]. Injuries are typically mild to moderate in severity and occur most frequently to the head and limb regions of the body [3]. The injuries are most commonly result from the rider falling off the scooter [2]. For this reason, the accident configuration simulated was a fall caused by an impact with a curb.

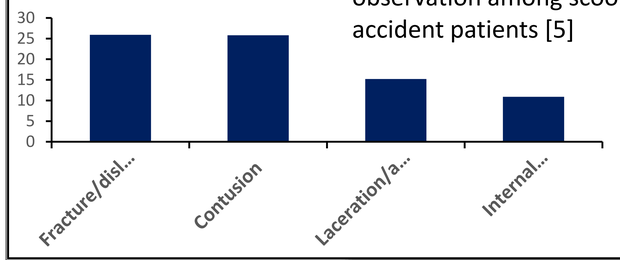

Figure 1: Frequency of injury observation among scooter accident patients [5]

OBJECTIVE

To investigate the trauma associated with electric scooter accidents by creating a model of an scooter rider falling of an electric scooter.

METHODS

A model of a 50th percentile male Hybrid III dummy was used to simulate a scooter rider. The dummy was calibrated using the methods and specifications provided in the LSTC_NCAC Hybrid III Dummy manual [4]. Then, the dummy was positioned to mimic a person operating an electric scooter.

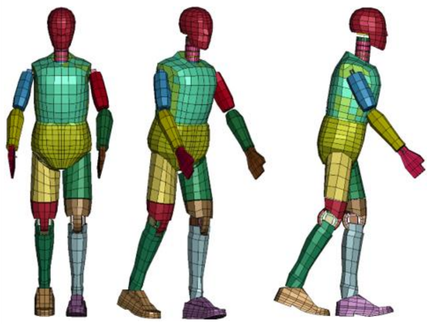

Figure 2: 50-P FE model showing different orientations of dummy position

METHODS

The scooter geometry was acquired using a FARO scanner, and then reconstructed in Rhino 3D. The reconstructed geometry was then meshed, and the material properties of each part was assigned based on literature data. The electric scooter rode on a flat ground with a 52-mm high bump in front of the scooter's path. The scooter and dummy were set to impact the bump with a speed of 4.47 m/s (~10 mph). The constraints between the dummy and scooter were set so the dummy would fall off the scooter after the impact. The Rider Injury Measure (RIM) was calculated using the same equation as the Occupant Injury Measure. After running the model with a scooter velocity of 4.47 m/s, the velocity was increased to 6.70 m/s (~15 mph) to observe the impact of velocity on rider injury risk.

RESULTS

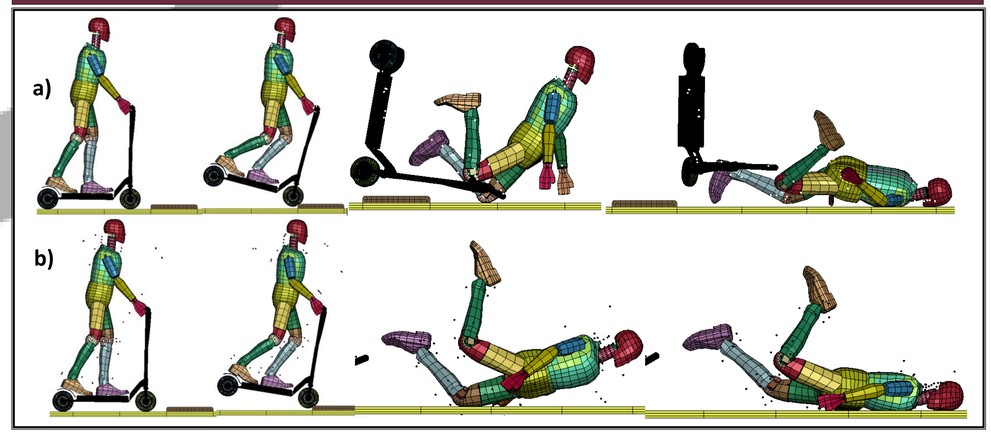

Figure 3: Series of images depicting the modeled scooter accident: a) initial speed of 4.47 m/s and b) initial speed of 6.70 m/s

The calculated RIM for an initial speed of 4.47 m/s was 0.96747. The biggest contributors to the RIM were the probability of serious neck injury and the probability of serious brain injury. The peak HIC value observed at this speed was 395

$$RIM_{AIS3+} = 1 - [1 - p(HIC)] * [1 - p(BrIC)] * [1 - p(N_{ij})] * [1 - p(Chest)] * [1 - p(Fem)]$$

Equation 1: Used to calculate the overall probability of serious injury to the rider based on the probabilities of body-region injuries

The calculated RIM for an initial speed of 6.70 m/s was 1. Once again the probabilities of serious neck injury and serious brain injury were the highest. The probability of serious neck injury specifically was nearly 1. The peak HIC value observed at this speed was 568.

RESULTS

Table 1: Probability of serious Injury of each region consider in the RIM

	Speed of Test	
Probability of Serious injury	**4.47 m/s**	**6.70 m/s**
$p(HIC)$	0.0775	0.1161
$p(BriC)$	0.8693	0.9903
$p(N_{ij})$	0.7244	0.999999998
$p(Chest)$	0.0128	0.2466
$p(Fem_{left})$	0.1187	0.0099
$p(Fem_{right})$	0.0095	0.0056
RIM_{AIS+}	0.9675	1

CONCLUSIONS

Overall, a higher scooter speed at the time of fall increased the risk of serious injury to the rider. Of the body regions accounted for in the RIM, the risk of serious injury was greatest for the brain and neck. This was expected as the head is one of the most common regions injured as a result of electric scooter accidents [3]. Moving forward a variety of speeds and impact angles will be tested to see the impact o both on the probability of serious injury to the rider. In addition, the material properties of ground will be varied.

REFERENCES

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