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Numerical analysis of injuries of e-scooter riders in frontal impacts against SUVs

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Abstract-

The rising popularity of e-scooters in urban areas highlights the importance of understanding potential collision dynamics and consequences to enhance rider safety, especially since 80% of fatalities for these vulnerable road users result from incidents involving motor vehicles. This study aims to identify potential injury mechanisms of e-scooter riders involved in frontal impacts against Sports Utility Vehicles (SUVs) using Finite Element Analysis (FEA) and a Human Body Model (HBM). Six impact scenarios at 25 km/h were simulated: on the passenger's side door (1-SD), on the trunk door (2-TD), on the bonnet (3-FB), on the bonnet from the side (4-SB), on the windshield from the side (5-SW), and finally, on the bonnet with an offset (6-FO). A wide range of Injury Risk Criteria (IRCs) was analyzed, including A3MS, HIC15, BrIC, DAMAGE, Cmax and PC Score, and head contact forces were output. Injury Risk Curves were then used to calculate the probability and severity of the sustained injuries predicted by the mentioned IRCs. Overall, the results corresponding to the most injurious scenarios suggested serious (30% to 40% overall probability) and critical (45% probability for the 4-SB scenario) brain, moderate head (30% probability for scenarios 1-SD and 2-TD), and serious thoracic (26% to 78% overall probability) injuries. Additionally, in two scenarios (1-SD and 2-TD), the e-scooter rider's mandible impacted against the vehicle's roof side rail and rear spoiler, involving potential anterior-posterior serious mandible fractures. The conclusions reached in this study help to understand potential injury sources and provide valuable information for the design of specific safety systems or the creation or improvement of e-scooter legislation.

Index Terms- E-scooterSafetyInjury risk criteriaHuman body modelSUVFinite element analysis

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