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Analysis of the spinal 3D motion of post-mortem human surrogates in nearside oblique impacts

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Abstract-

Objective: The objective of this study is to analyse the 6 degrees of freedom (DOF) motion of the spine using the finite helical axis (FHA) in three post-mortem human surrogates (PMHS) sled tests.
Methods: The sled test configurations corresponded to a 30º nearside oblique impact at 35 km/h. Two different restraint system versions (RSv) were used. RSv1 was used for PMHS A and B while RSv2 was used for PMHS C. The 6 DOF motion of the head and three selected vertebrae have been analysed using the FHA which describes the 3D motion of a rigid body between two instants of time as a rotation about and a translation along a unit vector. A minimal amount of rotation is necessary to the FHA calculation, thus the FHA components have been calculated based on a pre-defined interval of 8º of rotation.
Results: The analysis of the FHA components demonstrated right lateral bending until around 100ms, when the rebound phase was reached and the head and the lower spine undergoes left lateral bending. The three PMHS exhibited, in general, flexion movement of the whole body and torsion to the right side of the occupant. This general motion can be associated to the effect of the seatbelt acting as a fulcrum of the rotational movement of the bony landmarks. The interaction of the PMHS with the retention system can be noted by analysing the time in which the head and the upper spine initiated the rotation and the sudden changes of rotational direction of the three PMHS’s head.
Conclusions: The rotational analyses have shown to be more sensitive to experimental events than the trajectory analyses for the studied physical tests. Additionally, the results presented in the present study contributes to the analysis of the body kinematics during an oblique impact and adds new experimental data for Human Body Models (HBM) and Anthropometric Test Devices (ATD) benchmarking.
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Index Terms- Finite Helical Axis (FHA), kinematics, nearside oblique impact, Post Mortem Human Surrogates (PMHS), spine.

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