A PARAMETRIC MADYMO ANALYSIS FOR DETERMINING SEAT BELT USAGE IN A FRONTAL COLLISION

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INTRODUCTION

Forensic biomechanics is often called upon for the purposes of determining whether a seat belt was utilized in automotive collisions. A parametric analysis utilizing MADYMO was performed to elucidate seat belt usage in a high speed frontal collision based upon the known injury outcome.

METHODS

Vehicle accident reconstruction was performed utilizing PC-Crash to determine the impact severity. Since PC-Crash does not have the ability to generate a crash pulse, two pulses were assumed: AAMA generic MVSS 208 sled pulse and a NCAP pulse from the NHTSA vehicle crash test database. The AAMA pulse was felt to represent the lower bound of the impact severity and the NCAP the upper bound of the impact severity based upon the vehicle reconstruction analysis.

Medical records were reviewed that revealed a C2 fracture, intimal rupture of the aortic arch and right tibial plateau fracture. Geometric measurements of the vehicle determined from NHTSA's vehicle database were used to generate a MADYMO model of the right front passenger compartment [1]. A generic passenger side airbag model was utilized. The Hybrid III 5th percentile female ellipsoid model was chosen as best representing the subject. Additional unknowns were included leading to an overall matrix of two collision pulses, three fore/aft passenger seat positions, and four deployment times of the passenger side airbag for both belted and unbelted conditions. For the belted condition, a generic MADYMO belt was utilized. Injury assessment values were monitored for the neck, chest and lower extremities. Injury indices (Nij, Chest G, Tibial Index) were calculated and related to MVSS 208 injury criteria.

RESULTS AND DISCUSSION

The subjects C2 fracture was consistent with biomechanical literature on compression-extension injury mechanisms to the upper cervical spine [2]. Figure 1 demonstrates representative kinematics of both belted and unbelted conditions. Nce (compression-extension) values were significantly higher for both AAMA and NCAP pulses for unbelted than belted conditions but only exceeded the injury criteria of 1.0 for the unbelted NCAP conditions as seen in Figure 2. Ncf (compression-flexion) values were also found to exceed the injury criteria in the NCAP unbelted condition with airbag deployments of 40-50 milliseconds (ms) for all three seating positions. Upper tibial indexes were also significantly higher for unbelted conditions for both AAMA and NCAP pulses and exceeded the injury criteria in all unbelted conditions but met for belted conditions. Chest acceleration (3 ms clip) was not significantly different between belted and unbelted AAMA pulse conditions. Chest accelerations did exceed the 60 G criteria in the NCAP, unbelted conditions for all three seat positions for the 40-50 ms airbag deployment times as a result of bottoming out the bag and striking the dummy's chest to the dashboard.

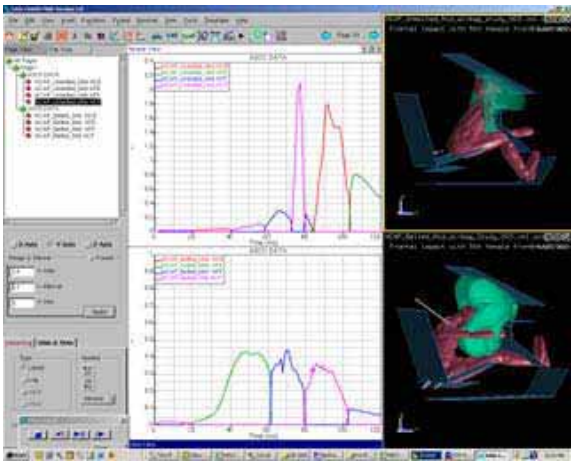

Figure 1

Tibial indexes and Nce increased as seat fore/aft position increased. Chest accelerations had an increasing trend when in closer proximity to the deploying airbag.

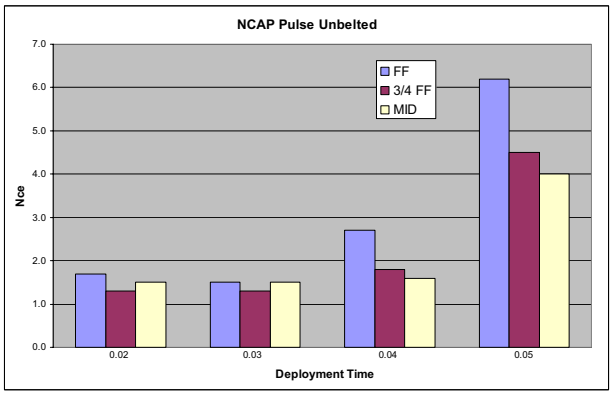

Figure 2

SUMMARY

A parametric MADYMO study was performed to determine seat belt usage in a frontal collision based upon known injury outcome. Analysis of accepted injury indices and criteria demonstrated a significantly higher probability of injury in the unbelted scenario with the occupant located at the approximate mid fore/aft position at the time of impact.

REFERENCES

1. MADYMO Users Manual
2. Myers BS, Winkelstein BA. *Critical Rev in Biomedical Engineering*, 23(5&6): 307-409, 1995.