DEVELOPMENT AND VALIDATION OF THE FINITE ELEMENT HUMAN BODY MODEL FOR LESS – LETHAL BALLISTIC IMPACTS

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INTRODUCTION

The need to test less lethal kinetic energy rounds before their deployment in the field is becoming increasingly necessary with the increase in their usage and potential associated injuries. A cost effective and efficient way to test these rounds is by observing their effects on previously validated finite element human body models. This paper deals with development and validation of the Wayne State Human body model and comparison of the model response with the physical tests performed on cadavers for the assessment of blunt ballistic impacts [1].

METHODS

The Wayne State Human Body Model includes a detailed representation of the lung, heart, liver, spleen, spine, ribcage, sternum and major blood vessels [2,3]. Material properties for various tissues of the model were derived from those reported in the literature and the material tests performed at Wayne State University. The model was developed using Hypermesh (Altair Engineering) as the pre/post processor and LS-DYNA (Livermore Software Technology Corporation) as the solver.

The model was tested for three impact conditions listed in Table 1. Displacement of the projectile was calculated using the nodal displacements and the force was calculated based on the contact interaction forces. Displacement-time, force-time and force-displacement graphs were plotted so as to compare the results with the corridors developed from the experimental test results [1].

RESULTS AND DISCUSSION

Results obtained from the FE analysis show good correlations between numerical simulations and experiments. It was observed that the properties and thickness of the skin covering the thorax plays a major role in the response characteristics. Based on the stresses observed in the FE model, sternum and rib fractures can be predicted. Figure 1 shows the force-displacement plot for Condition B. Similar co-relation was observed for the remaining two conditions. The displacements and the forces were computed until 4 ms after which the impactor is not in contact with the body in all the three conditions.

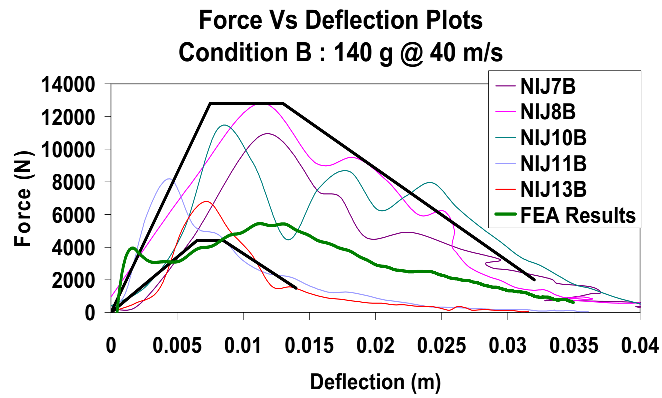

Figure 1: Force-Deflection Plot for Condition B

The energy balance was maintained by reducing the hourglass energies and the skin was given a fully integrated element formulation. In the force-time curves an initial steady rise in force is observed due to the energy absorbed by the skin.

CONCLUSIONS

Results from this study demonstrate that finite element thorax model is powerful tool for assessment of the injury mechanisms to the human thorax against blunt ballistic impacts.

REFERENCES

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Table 1: Impact conditions from experimental testing.

Impact Conditions	Diameter *(mm)*	Length *(mm)*	Mass *(grams)*	Velocity *(m/s)*
Condition A	37	100	140	20
Condition B	37	100	140	40
Condition C	37	28.5	30	60