Development of a Dummy Thorax for the Response and Localized Deformation under Multi-directional Impact

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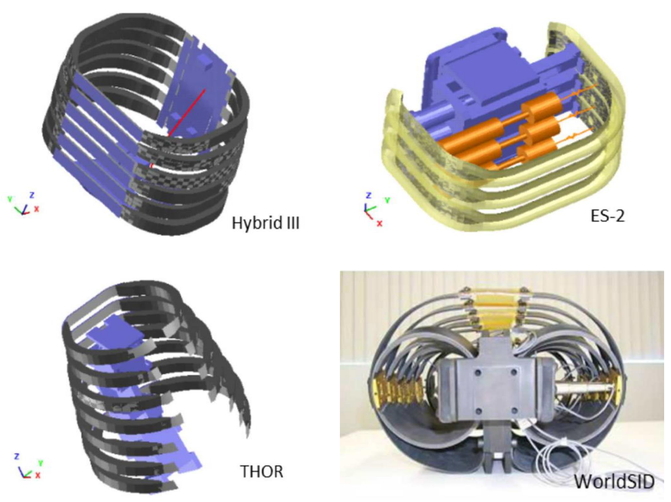
Background

Thoracic injury is the second leading cause of fatalities and severe injuries in motor vehicle crashes (MVCs). To assess occupant protection in various types of collisions, Anthropomorphic Test Devices (ATDs), such as Hybrid III and ES-2, are widely used. However, the response targets for the existing dummies were only derived from responses of cadavers and volunteers subjected to specific impact directions. The response and localized deformation under multi-directional impact were not considered. For the current automotive environment in vehicles equipped with advanced restraint systems, previous studies showed that the current dummies are unable to evaluate the occupant protection accurately.



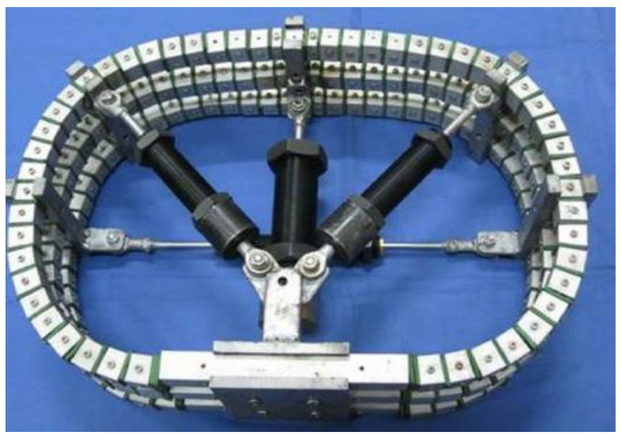
Objective

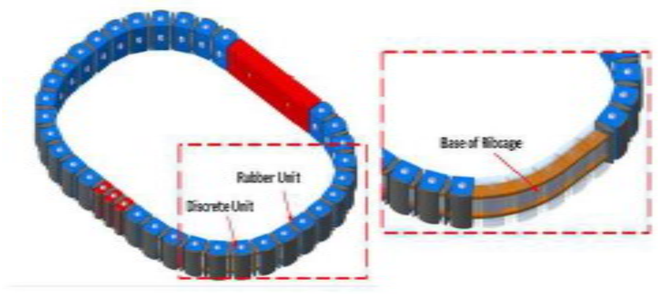
The objective of this study is to design a new dummy thorax, with a focus on the responses and localized deformation under multi-directional impact.

Methods

➢ Design of Dummy Thorax

A new concept of dummy thorax has been developed. The dummy was assembled with six ribs and six dampers. For each rib, a set of plastic or aluminum discrete units were connected by the Base of Rib, which was made of Fiber Reinforced Plastics in this prototype.

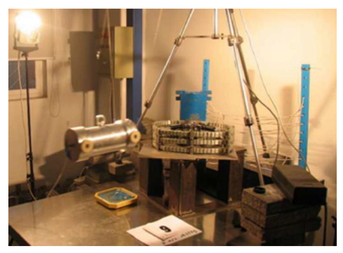




Methods

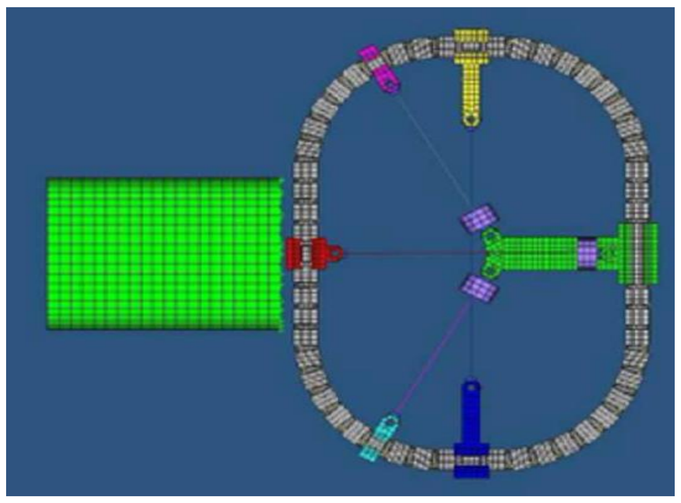
➢ Pendulum Tests on the Prototype

Three types of pendulum impacts, frontal, lateral and oblique lateral impacts, were conducted to assess that whether this design can achieve the targets. The impactor had a rigid surface with a mass of 14.67 kg and was at 2 m/s for each test.



➢ Development and Validation of FE-model

The FE model of dummy was developed using hexahedron elements. A series of simulations in the same conditions with tests were conducted for validation.



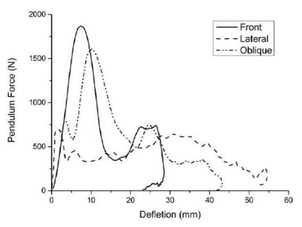
➢ Optimization of Dummy Thorax

The validated FE model was installed on a FE-Hybrid III dummy model. Within this model, a matrix of simulations will be done to optimize the key parameters and make sure that the biomechanical requirements can be met .

Results

➢ Responses of Dummy Thorax

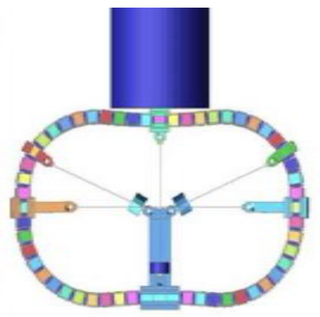
The figures below show that localized deformation of ribs occurred when the dummy was impacted by the pendulum. In addition, the dummy is able to withstand the impacts from different directions , but the responses of the thorax should be optimized.

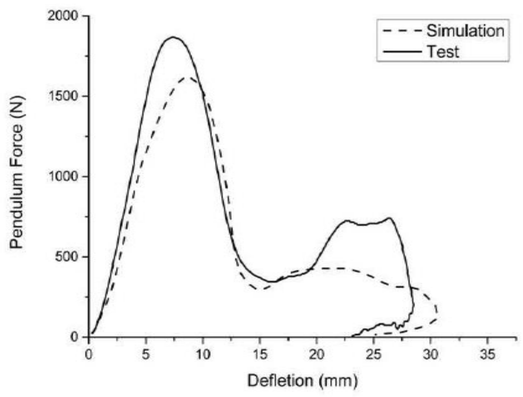


Results

➢ Validation of FE model

The figures below show that the deformation patterns, as well as responses, of prototype and FE model are matched. The results indicate that the FE model can be used for optimization.





Discussion

➢ Key Parameters of Dummy Thorax

Based on the tests and simulations, two key parameters having significant effects on deformation patterns and mechanical responses of the dummy thorax were found. The elastic coefficient (K) and the damping coefficient (C) should be optimized at the same time.

➢ Measurement of Localized Deformation

With respect to localized deformation, it is of great importance to find new methods for measuring it along the ribs during the impact.

Conclusions

This study developed a new thorax dummy for the responses and localized deformation under multi-directional impact. The prototype was tested and the FE-model was validated. A series of tests and simulations showed that the localized deformation of ribs could be realized. Meanwhile, the mechanical response of the dummy under different impact directions may be able to be optimized to meet biomechanical requirements in the future. The FE Hybrid III dummy model with this validated model of dummy thorax will be used for further studies.

Acknowledgement

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