Active Dummy-active muscle modelling with finite elements

Autors	Daniela Wertenauer, Nadia Jäckle, Tobias Stöckerl, Eduardo Key
Betreuer	Oleksandr Martynenko
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Introduction – initial question

Simulation techniques are widely used within all fields of engineering, over the last past years. The most commonly used simulation method is the so called finite element method. With this method different questions can be solved: The stability of materials, the behavior of electric fields or cinematic calculations of fluids. This method of simulation also can be used within the human modeling and calculations of muscle forces, reactive joint forces or loads on the lumbar discs. In the following study, the method is used to simulate the acting forces on the human body during a car crash. The initial question was to add muscles to the neck of the existing model and show how they influence the motion of the head during the crash.

Materials

The software used for the simulation was LS-DYNA. For pre- and postprocessing LSPrePost was used. For calculation, the model was uploaded to the university server. The basis model used for the study was offered by the University of Stuttgart. The model consisted of a passive dummy, where no muscles were implemented. In addition, the model was diagonally belted. The regarded timespan of the crash was 20ms.

Simulations & Results

First of all, the muscles had to be implemented in the model. It has been decided, that 4 anatomic aligned muscles in the neck should be implemented. These muscles need material properties, which were entered within the model, given values were used here. In order to place the muscles, every muscle needs two nodes within the model which define the endpoints of the muscle. In LSDYNA, a muscle is represented as a 3D beam. For all these muscles there are two different parameters, which can be varied to change the result of the simulation. The first one is the muscle activation curve, which defines how the muscle is activated over the time. The second one is the cross sectional area of the muscles, which defines the cross section of the muscles, and with this, its strength. To compare the influence of the different parameters three different version of the model were created. The used parameters can be seen within the following table:

Version 1:	Basic passive model without changes (Reference)
Version 2:	Active dummy with 2 muscles implemented
	- Full activation (time independent)

	- Cross sectional area: 0,075
Version 3.1/3.2/3.3:	Active dummy with 4 muscles implemented
	- Full activation (time independent)
	- Cross sectional area: 0,075 / 2 / 200
Version 4:	Active dummy with 4 muscles, edited activation curve
	- Step up in activation after 0,02ms from 0 to 1
	- Cross sectional area: 0,075
Version 5:	Active dummy with 4 muscles, change in muscle nodes
	- Nodes attached differently (for 2 dorsal muscles)

Podcast

Active Dummy Project podcast

Conclusion

As the results show, the added muscles do not have a significant influence on the crash-caused movement of the head during a crash. This may be a viable result, as the muscles of the neck are not supposed to compensate such huge forces occurring during a crash.

References