Towards a more Realistic Human Model Crash Simulation with Real Sternal Cortical Thickness based on Micro-CT Scans

R. Segura - Biomechanics Group, Institute of Legal Medicine, University of Munich (LMU) and Vehicle Safety Development and Simulations AUDI AG. F. Fuerst – Vehicle Safety Development and Simulations AUDI AG. A. Wagner – Biomechanics Group, Institute of Legal Medicine (LMU). S. Peldschus – Biomechanics Group, Institute of Legal Medicine (LMU) and Hochschule Furtwangen University.

I. INTRODUCTION

The thorax is the second leading most frequently injured body region of car occupants in traffic accidents [1]. Despite advanced restraint systems and injury mitigation mechanisms, rib and sternal fractures still occur in vehicle crashes. Therefore a more accurate geometrical description of these structures is needed for integration into finite elements (FE) human body models (HBM) in order to improve their injury prediction capabilities with restraint system induced-loading. Current human HBMs define bone cortical thickness with a constant value whereas real cortical thickness is not uniform. Micro-CT scans on real Sterna were performed in order to obtain the thickness distribution. The need for modeling improvements at this level of detail is driven by the advances of restraint systems performance and thus by the change of focus to less severe injuries.

II. METHODS

Three sterna were harvested from the Post Mortem Human Subjects (PMHS) following the University of Munich Institute of Legal Medicine approval. The specimens underwent a 0.625 mm slice micro-CT scan with a resolution of 0.9mm. The micro-CT data thickness was averaged in different regions according to the original shell-element locations of the human model sternum, then the data was assigned on the FE sternum model.

A 3-point bending test based on Kerrigan et al. [2] were simulated using a Sternum model extracted from the THUMSv3 (Total Human Model for Safety) in Pam-Crash. Potted ends were simulated as nodal rigid bodies at both ends. The impactor was simulated as a rigid body and moved with a prescribed velocity of -1115 mm/ms in Z direction. The cortical thickness of the original sternum of the THUMSv3 has a constant value of 0.7mm.

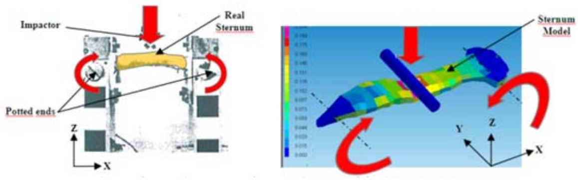

Fig 1. Left: Experiment set up from Kerrigan et al. [2]. Right: Simulation

III. INITIAL FINDINGS

The initial simulations with the original THUMS sternum model show a remarkable difference (+61% peak force) in comparison with the experimental data. The vertical peak force of the original sternum model is not within a confidence range given by the real experiments. Validation tests based on [2] were simulated in order to compare the bending behavior of sterna with constant cortical thickness vs. sterna with varied cortical thickness distribution and indicated a remarkable sensitivity to thickness distribution (additionally to the thickness value itself).

IV. DISCUSSION

The simulation shows that a FE Sternum model with constant cortical bone thickness does not represent the real behavior of the sternum under bending loading (which is the typical injury mechanism for this bone in vehicle crashes [2]) even if the constitutive material definition correlates with the real data (Young modulus, density, strain rate factors etc). FE Sterna models with real cortical bone thickness distribution are needed in order to correct the gap between experimental data and simulation results.

V. REFERENCES

[1] Cavanaugh JM, *In* Accidental Injury Biomechanics and Prevention, 1993.
[2] Kerrigan JR et al , Biomed Science Instrumentation, 2010.