A method to extrapolate the geometrical properties of human ribs using micro-CT and clinical-CT images.

Rafal Perz, Jacek Toczyski, Jeff Crandall, Damien Subit

University of Virginia

Abstract

Finite element (FE) models of the ribcage are commonly created from medical images obtained by computed tomography (CT). While clinical-CT can be used to image the entire human body, its resolution (0.2 to 1 mm/voxel) is not sufficient to capture the detail geometry of the ribs. On the contrary, micro-CT offers a better resolution (0.02 mm/voxel), but at the expense of a limited field of view.

Therefore, the aim of this work was to quantify the variability in the measurements of the rib geometry obtained from micro-CT and clinical-CT images, to ultimately derive correction factors that can be used to infer the detail rib geometry solely from clinical-CT images.
Thirty-four rib slices that were about 5 mm long were harvested from one cadaver. These slices were imaged using the micro- and clinical-CT modalities. The cross-sectional area, the cortical area and the principal moments of inertia were estimated for each slice from the two sets of images. The clinical-CT based measurements overestimated the overall cross-sectional area by 7.6%, the cortical area by 40.2% and the moments of inertia by about 50% compared to the micro-CT based measurements.

This data provides insight about the bias in the geometrical reconstruction of body segments depending on the image modality. This bias could lead to an incorrect prediction of the rib cage stiffness when only clinical-CT images as the tensile and bending stiffness of the individual ribs would be overestimated.

The next step in this research is to perform a parametric analysis on the human rib geometry by developing a 3D beam model of the rib. Such a model is fully scalable as cross-sectional and moments of inertia can be varied independently, and will be used to assess how the predicted rib stiffness varies based upon the variability in the value of the geometrical parameters.