

Material Properties of Calcifying Costal Cartilage

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ABSTRACT

Studies have found that older drivers are more prone to chest injuries in automotive crashes. With the increasing number of older drivers, understanding the mechanical properties of the aging thorax is important for developing restraint systems for these occupants. Although not a direct metric of age, the prevalence of calcification in the costal cartilage has been found to increase with age. The calcification in the costal chondral region could affect the overall thoracic response. This study investigates the material properties and geometry of the calcifying costal cartilage through indentation testing and micro computed tomography (micro-CT).

Costal cartilage and rib segments were taken from the rib cages of four human cadavers, ages 23, 44, 61, and 63. High resolution (30 μ m isotropic) micro-CT scans were performed on select specimens from all four cadavers. Material properties of the local calcification regions as well as cartilage and rib bone were found from displacement controlled indentation tests.

Preliminary findings from the micro-CT analysis show various types of calcification patterns including random nodes and solid rods of calcification, as well as “rib bone” like structures infiltrating the costal cartilage regions. These “rib bone” like structures exhibit a cortical-like shell and a trabecular inner structure similar to rib bone, but occur inside the costal cartilage midsubstance. In addition, the scans show that the calcification rods have a higher density than that of the actual rib bone.

Using the material properties obtained by indentation testing, and the geometries from the micro-CT scans, current finite element models of the rib cage can be improved to account for the changes in the material properties in this costal chondral junction region.