

The Effects of Aging on the Material Properties of Human Costal Cartilage

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Automotive safety for the older population is becoming a greater concern, especially with an aging population of “baby boomers.” Understanding the mechanical properties of the aging thorax is important in the development of restraint systems to protect these occupants. This study investigated how the material properties of costal cartilage change with age.

Indentation testing was used to study the material properties of human costal cartilage. Ribcages were obtained from 11 human subjects ranging in age from 23 to 77 years. Costal cartilage from the second, third, and fourth left ribs were excised and prepared into 6mm thick cross sections. The cross sections were tested using spherical indentation with a ramp-hold relaxation test. Using Hertzian contact theory, the localized material properties were calculated from the stress relaxation response.

The results showed only a slight trend of increasing costal cartilage stiffness with age. There was also increasing inhomogeneity of the cartilage with increasing age, as observed visually and in the larger overall standard deviation in the older specimen results. Inhomogeneity in the costal cartilage was observed as shells of calcification surrounding the softer cartilage, as well as calcified strata running transversely through the interior of the cartilage. These regions should affect the overall mechanical response from macro-scale loading, but are not as apparent in the results because the indentation area is localized near the center of the cartilage cross sections. Future work could target these calcified areas for localized testing. In addition, nano-indentation and micro CT analysis would be valuable tools for investigating these inhomogeneous morphological changes in future studies.