The Relationship between Microstructure and Material Properties of Pediatric Ribs

Amanda M Agnew MA[1,2], Kevin Moorhouse PhD[3], Bruce Donnelly PhD[3], John H Bolte IV PhD[1]

[1]Injury Biomechanics Research Laboratory, The Ohio State University;
[2]Department of Anthropology, The Ohio State University;
[3]National Highway Traffic Safety Administration (NHTSA)/Vehicle Research & Test Center (VRTC)

ABSTRACT

Biofidelic pediatric crash test dummies are necessary to assist in designing vehicles and child restraint systems that ultimately reduce the risk of rib and thorax injury to children involved in vehicular impacts. Because of the complex bone modeling that takes place during growth of the thorax, pediatric ribs have been shown to behave different mechanically and have different material properties than adult ribs. This information should be used to design more biofidelic pediatric dummies using biological data from a precise developmental stage instead of scaled down adult data as used currently. The purpose of this research is to quantify patterns of development in bone microstructure and how they relate to material properties of the pediatric rib. Excised pediatric rib sections from post-mortem human subjects were subjected to quasi-static 3-point bend tests and strength properties such as peak force, force at yield, Young's modulus, and stiffness were calculated. Ribs were then thin-sectioned to ~80µ and cross-sectional geometric variables (e.g. cortical area, height at impact) and histomorphometric variables (e.g. cortical porosity, bone types) were analyzed to correlate with strength parameters and skeletal developmental data. The use of skeletal histomorphometric data in injury biomechanics research is a new approach to understanding why pediatric bone has such a varied response. Chronological age is not as strong of a predictor as was anticipated and does not explain the behavior of bone upon impact. Results suggest that cross-sectional geometry is a better predictor of rib strength than histomorphometry, and that the amount of different bone types present is a better predictor of rib strength than the amount of porosity present. These variables have the potential to explain and predict the unique behavior of the pediatric rib during impact.