Measuring Rib Cortical Bone Thickness and Cross Section from CT.

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This study assesses the ability to measure local cortical bone thickness, and to obtain mechanically relevant properties of rib cross-sections from clinical-resolution computed tomography (CT) scans of human ribs. The study utilized thirty-four sections of ribs published by Perz et al. (2015) in three modalities: standard clinical CT (clinCT), high-resolution clinical CT (HRclinCT), and microCT. Clinical-resolution images were processed using a Cortical Bone Mapping (CBM) algorithm applied to cross-cortex signals resampled perpendicularly to an initial smooth periosteal border. Geometric constraints were applied to remove outlier signals from consideration, and final predicted periosteal and endosteal borders from HRclinCT and clinCT were developed. Target values for local cortical thickness and for overall cross-sectional area and inertial properties were obtained from segmentation of the periosteal and endosteal borders on each corresponding CT image. Errors in prediction (mean ± SD) of local cortical bone thickness for HRclinCT and clinCT resolutions were -0.03±0.17 mm and -0.05±0.22 mm, respectively, with R2 coefficients of determination from linear regression of 0.82 and 0.71 ($p < 0.0001$ for both). Predicted cortical shell measures derived from the periosteal and endosteal borders included total cross-sectional area (prediction errors of 6 ± 3% and -1±5% respectively for HRclinCT and clinCT with R2 correlations of 0.99 and 0.96), cortical shell area (errors of -3±8% and -8±11% with R2 correlations of 0.91 and 0.87), and principal area moment of inertia (errors of 2 ± 8% and -3±11% with R2 correlations of 0.98 and 0.95). Results here show substantial reductions in rib cross-sectional measurement error compared to past histogram-based thresholding methods and provide first validation of the CBM method when applied to rib bones. With the ubiquity of clinical CT scans covering the thorax and ribs, this study opens the door for individualized and population-wide quantification of rib structural properties and their corresponding effects on rib injury.