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Experimental determination of Young modulus and Poisson ratio in cortical bone tissue using high resolution scanning acoustic microscopy and nanoindentation

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Nanoindentation allows measurements of local mechanical properties of bone tissue. Scanning Acoustic Microscopy (SAM) provides images related to bone density and elasticity. In both techniques, the estimation of Young modulus (E) relies on the accuracy of Poisson's ratio value (σ). In cortical bone ,σ varies between 0.15 and 0.45 but, is classically set to 0.3, resulting in an approximate value of E. This study describes a new method combining SAM and nanoindentation techniques to locally evaluate σ in human femoral cortex. A 200 MHz SAM-based acoustic impedance (8μm lateral resolution) was combined with synchrotron microtomography (to provide local bone mineral density) to map the distribution of near surface elastic modulus. Whereas, nanoindentation modulus was calculated on several osseous regions. Assuming the equalization rule, the intersection of both modulus curves versus σ permits to accurately derive σ. The method was tested on aluminium, PMMA and polycarbonate samples of known σ and provided experimental σ values with a precision better than 3%. In bone, σ was 0.42+/-0.01 corresponding to E = 20 +/-1 GPa. Our preliminary results indicate that combination of high-resolution SAM and nanoindentation may be relevant to accurately determine both Poisson ratio and Young modulus of bone tissue.