ELASTIC MODULI AND HARDNESS OF CORTICAL BONE: NANOINDENTATION OF FEMUR SAMPLE

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Cortical bone has a complex hierarchical structure and anisotropic physical and mechanical properties; these properties are revealed both along the length of the entire bone and in the anatomical quadrants of the cross section of the bone [1, 2]. The aim of this study is to determine the elasticity modulus of a human cortical bone tissue for various quadrants of a femur specimen from an upper part of the middle third of the bone (from its proximal department) using nanoindentation, and to compare the obtained values for the elasticity modules with the known elastic constants for a cortical human bone tissue determined with various experimental methods.

A sample for an experiment was cut out from the upper third part of a dry human femur (sample provided by the Republican Scientific and Practical Centre for Traumatology and Orthopedics, Minsk, Belarus). For experiment in this study a NanoTest 600 testing machine (Loughborough University, UK) was used. For indentation, a spherical diamond tip with a radius of 25 μm and an indenting head for a small load of 0.1 – 500.0 mN was used. The results of the experiment were processed using the Oliver-Pharr theory [3].

Variability of the elastic moduli and hardnesses for different quadrants of the human femur demonstrates anisotropy of mechanical properties of a femur depends on anatomic position. Mechanical properties of cortical bone tissue are more non-uniform in a circumference direction, than in a longitudinal one. The average value of the longitudinal elasticity modulus for the studied femur specimen is 27.80 GPa, and it exceeds many of the respective values measured in other studies. Still it is rather close to the data of [4].

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