Investigation of osteons properties in human cortical bone using X-ray phase micro-CT

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Cortical bone, which plays a major role in the biomechanical properties of bone, has a complex multi-scale structure. Due to the bone remodeling process, cortical bone is made of osteons and interstitial tissue having different material properties. There are however, still few 3D quantitative data regarding bone osteonal systems. This lack of data can be explained by the difficulty to distinguish osteons from interstitial tissue using standard 3D imaging techniques [1]. Since phase contrast techniques permit to increase image sensitivity, they are good candidates to analyze osteons [2].

In this work, we used phase micro-CT at the sub-micrometer scale for the quantitative analysis of osteons in human cortical bone and their relationships to the distribution of osteocyte lacunae.

Rectangular cortical bone samples prepared from eight female donors radii (50 to 91 y.o.). were imaged on beamline ID19 at the European Synchrotron Radiation Facility (ESRF, France). Phase contrast was obtained by propagation with a sample-to-detector distance set to 40 mm and an effective pixel size on the detector of 0.7 µm. We used a "pink beam" with an energy of 31 keV. Phase retrieval was performed using Paganin's method. The Haversian canals, osteocyte lacunae and micro-cracks were segmented automatically using a home-made method [3] and the osteons were segmented manually using Avizo software.

Figure 1 illustrates one phase micro-CT slice in cortical bone and a 3D display of the segmented image. Our quantitative results showed differences of lacunar density between osteonal and interstitial tissue and a higher volume fraction of micro-cracks in the interstitial tissue.

X-ray phase micro-CT can be used to obtain new information about the properties of osteons and their role in the biomechanical resistance of bone tissue.

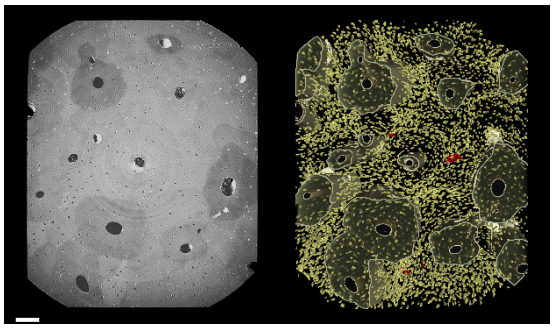

Figure 1: Phase micro-CT image of radius cortical bone. left: original slice (osteons appear darker) ; right: 3D display of the segmented volume (osteon border: green, lacunae: yellow, micro-crack: red). Scale bar 100 µm.

References

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