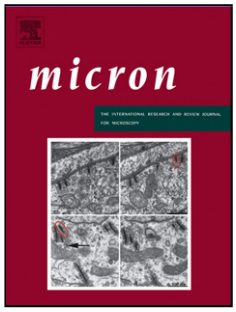

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A three-dimensional geometric quantification of human cortical canals using an innovative method with micro-computed tomographic data

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Abstract

The complex architecture of bone has been investigated for several decades. Some pioneer works proved an existing link between microstructure and external mechanical loading applied on bone. Due to sinuous network of canals and limitations of experimental acquisition technique, there has been little quantitative analysis of three-dimensional description of cortical network. The aim of this study is to provide an algorithmic process, using Python 3.5, in order to identify 3D geometrical characteristics of voids considered as canals. This script is based on micro-computed tomographic slices of two bone samples harvested from the humerus and femur of male cadaveric subject. Slice images are obtained from 2.94 μm isotropic resolution. This study provides a generic method of image processing which considers beam hardening artefact so as to avoid heuristic choice of global threshold value. The novelty of this work is the quantification of numerous three-dimensional canals features, such as orientation or canal length, but also connectivity features, such as opening angle, and the accurate definition of canals as voids which ranges from connectivity to possibly another intersection. The script was applied to one humeral and one femoral samples in order to analyse the difference in architecture between bearing and non-bearing cortical bones. This preliminary study reveals that the femoral specimen is more porous than the humeral one whereas the canal network is denser and more connected.

Keywords: Cortical Porosity, Canal orientation, Canal geometry, Canal connectivity

1. Introduction

Cortical bone is the part of skeleton which provides mechanical properties and ensures resistance of bone to fracture. The macroscopic strength is strongly influenced by the micro-scale matrix which reveals a heterogeneous medium (Mirzaali et al., 2016; Bala et al., 2016). A 2D transverse slice of bone shows that tissue is composed of pores, called Haversian canals, enclosed by a lacuno-canalicular network called active osteonal bone (Buenzli and Sims, 2015; Ashique et al., 2017). This phase can be considered (in

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