INSIDE INTO THE 3D-TRABECULAR ARCHITECTURE OF THE HUMAN PATELLA

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Introduction

The subchondral bone plate (SBP) is a dynamic component that shows functional adaptation to its long-term loading history. This can be seen in the density distribution of the subchondral bone plate and visualized with the help of CT-osteoabsorptiometry (CT-OAM) [Mueller-Gerbl, 1989; Hoechel, 2012]. Since the impact force experienced by a joint is transmitted through the cartilage and SBP into the trabecular system, we expect that the subarticular trabecular bone also exhibits structure-dependent topographical differences. This anisotropic deformation property of the trabecular bone of the patella is known to exist, but not in sufficient detail reported since recent tests were only conducted by analysis of 2D X-ray images [Raux, 1975; Toumi, 2012].

Methods

All human patellae (4 so far, 20 planned, Outerbridge 0, formalin-fixed, acquired from body donors to the Anatomical Institute, University of Basel, Switzerland) where scanned using a conventional CT-scanner (Siemens Somatom, 0.6 mm slice thickness) for CT-OAM and a phoenix nanotom® m (0.02 mm voxel size) for trabecular analysis. CT-OAM was used for visualization of density distribution and acquisition of density values of the SBP (HU). VGStudio® Max 2.2 (Heidelberg, Germany) and CT-analyser (Bruker-Microct, Belgium) for structural analysis of the trabecular bone. Each patella was virtually divided into 24 measuring cubes and analysed in 1 mm slices up to a depth of 5 mm perpendicular to the SBP (Fig. 1).

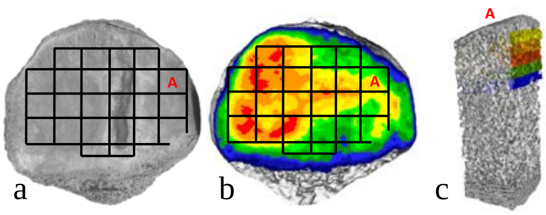

Figure 1: a) Patella, dorsal view - 24 measuring cubes b) Patella, dorsal view - density distribution by CT-OAM c) Cube 'A'-5x1 mm measuring slice.

Obtained Measurements for analysis (visual display and Pearson correlation: density values of the SBP (HU) and: total bone volume (BV); trabecular number (TN); trabecular thickness (TT); trabecular separation (TS); and structure model index (SMI) as structural and numerical parameters for trabecular bone.

Results

The structural and numerical parameters varied throughout the articular surface of each specimen as well as between them. BV, TN, and TT decreased with depth, TS and SMI increased (Fig. 2). The correlation of displayed density and BV (r^2=0.81); TN (r^2=0.88); TT (r^2=0.79); TS (r^2=-0.76); and SMI (r^2=-0.75) was significant (p<0.01).

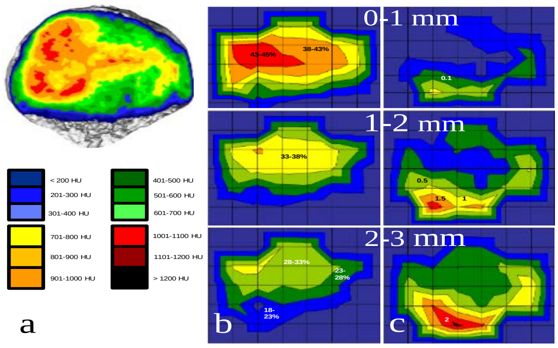

Figure 2: a) Density b) BV c) SMI.

Discussion

The trabecular network, in its function to support the SBP, adapts to its needs and is therefore not homogenous in distribution. According to the intake of long term load, the trabecular structure remodels in a way to optimize the support. The density distribution of the SBP correlates significantly with the structural and numerical parameters of the trabecular bone as both can be seen as functional unit.

References

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