Trabecular micro-architecture in the knee joint

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Introduction

Osteoarthrosis (OA) is a prevalent disorder affecting a significant large population. It has been postulated that in addition to articular cartilage changes, changes in subchondral bone and trabecular bone occurs in OA (1,2). Magnetic Resonance Imaging (MRI) is ideally suited for visualizing all components of the joint simultaneously. MRI is capable of monitoring the cartilage morphology and can provide a non-invasive assessment of the trabecular bone micro-architecture when coupled with image processing and quantitative analysis. It is important to understand the relationship of trabecular bone structure and cartilage in order to understand the patophysiology of OA. In this study we develop MR techniques to depict and quantify trabecular bone in the knee joint. The purpose was to determine the variations of the stereological bone parameters along the distal femur in order to quantify the spatial variation of bone structure.

Methods

In-vivo MR images of the femoral condyle on 5 young normal volunteers were investigated. The images were acquired on a GE SIGNA 1.5 Tesla echo-speed system equipped with self-shielded gradients (2.2 G/cm magnitude; 184 µs rise time). High-resolution MR images were obtained with a 3D fast gradient-echo sequence (TE = 4.5 ms; TR = 30 ms; 30° flip angle). The spatial resolution was 195 x 195 x 700 µm³. A four-element phase array coil covering the knee joint (half circle) was used to increase the sensitivity of the MR images. In order to correct the image signal intensity variations induced by the inhomogeneous reception profile of the coil, a low-pass filter based correction algorithm was used (3). Two regions of interest (in the lateral and medial part) were selected over 45 slices and covering ~ 3 cm along the distal femur. The apparent trabecular bone parameters such as trabecular bone fraction (App BV/TV), trabecular number (App Tb.N), trabecular spacing (App Tb.Sp) and trabecular thickness (App Tb.Th) were measured.

Results and Discussion

As shown in Figure 1, coil correction improves the signal homogeneity in the plane of the images. Also, due to coil sensitivity drop-off on the SI direction, coil positioning was a critical part of the exam.

![Figure 1](image1.png)

**Figure 1.** Axial images of the trabecular micro-architecture in the distal femur located at 15 mm from the joint line without (a) and with (b) coil correction. The images are shown in reverse gray scale.

![Figure 2](image2.png)

**Figure 2.** Measured structural parameters (App Tb.N and App Tb.Sp) on two different volunteers (first and second column). The measurement start at the joint line and move into the femoral shaft.

There are considerable variations in the bone structure as progressing from the epiphysis to the metaphysis and diaphysis. Representative graphs from two subjects are shown in Fig. 2. The epiphysis shows a clear decrease of the Tb.N and an increase of the Tb.Sp and Tb.Th. At the growth plate there is a distinct change in trabecular bone. This transition between epiphysis and metaphysis is marked by a plateau. Although the global behavior is similar, there is a considerable range of variations between the subjects. However, no significant difference was found between the morphological MR parameters in the medial and the lateral part of the distal femur.

References


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