ARTICULAR CARTILAGE AND SUBCHONDRAL BONE COVERED BY MENISCI


Purpose: Cartilage that is uncovered by menisci usually bears the body weight in intact knee. However it has been suggested that structural change of the knee due to meniscectomy leads to alternation of contact regions. The mechanical properties of cartilage and subchondral bone may vary according to the regions covered and uncovered by menisci and the covered regions by menisci may be more susceptible to extreme mechanical stress after meniscectomy. However few studies have focused on the difference of mechanical property of cartilage and subchondral bone architecture between the regions covered and uncovered by menisci. The purpose of this study is to investigate the mechanical and histological properties of cartilage and subchondral bone architecture that may differ between covered and uncovered regions.

Methods: Articular cartilage was obtained from the 5 porcine knees. After the knee joints were opened, osteochondral plugs (full-depth thickness 2mm) were obtained from tibial cartilage which were covered and uncovered region by menisci. Only sites with a macroscopically normal articular cartilage were included in this study. From one plugs of each regions, cartilage thickness was determined as the average of four sides of plugs. After that, unconfined compression was applied using a mechanical testing instrument (Autograph AG-X, Shimazu, Japan). Each sample was compressed uniaxially in a testing chamber located 1mm beneath the osteochondral junction. All structural analyses were based on the 3D image data sets using software (Amira5.4, Visage, Germany). Bone volume ratio (BV/TV) and trabecular thickness (Tb.Th) were calculated based on the 3D data. After that the 6um thick sections were made and collagen amount was observed by integral calculus of Amide-I area using Fourier-transform infrared imaging (IRT-5000, FT/IR-4100, JASCO, Japan). Further, the sections were stained with SafraninO-Fast green staining to assess glycosaminoglycan (GAG) content, Hematoxylin-Eosin for morphological measurement and Picrosirius red for collagen orientation measurement by using polarizing microscope.

Results: The average cartilage thickness of each area was significantly larger in medial and lateral uncovered regions (P < 0.05). Both Young’s modulus and peak stress were significantly greater in medial and lateral covered regions (P < 0.05), while relaxation time for force to decrease to 37% was shorter in medial and lateral covered regions (P < 0.05). The subchondral trabecular showed BV/TV and Tb.Th were significantly larger in uncovered regions (P < 0.05). The integral calculus of Amide-I area was significantly higher in uncovered regions. Safranin O staining revealed that much proteoglycan was confirmed in medial and lateral uncovered regions. Picrosirius red staining revealed that superficial zone and middle zone showed brightly in uncovered regions, while deep zone showed brightly in covered regions.

Conclusions: Our results revealed a difference of the mechanical properties and structures of articular cartilage and subchondral bone between the regions covered and uncovered by menisci.

FULLY-AUTOMATED CARTILAGE SEGMENTATION FROM MAGNETIC RESONANCE IMAGES OF THE KNEE USING ATLAS AND GRAPH-CUT ALGORITHMS


Purpose: To develop fully automated method to segment cartilage from magnetic resonance (MR) images of the knee and evaluate the performance on public open dataset.

Materials and Methods: 100 cases of MR images from public open dataset (available at www.ski10.org) were used for this study. The MR images were acquired at multi-centers and multi-vendor machines. All images were acquired in the sagittal plane with a pixel spacing of 0.4*0.4mm and a slice distance of 1mm. MR Field strength was 1.5 T in about 90% of the cases, the rest was acquired 3T and 1T. The vast majority of images were scanned by gradient echo based T1-weighting MRI sequence with fat suppression. After acquisition, all images were segmented interactively by experts at Biomet, Inc. to label and delineate the bone and cartilage of the femur and tibia. Each case from the dataset was available with original MR images and the corresponding segmentation mask to form the ground truth segmentation result. We divided total 100 cases into training set (60 cases) and test set (40 cases).

The segmentation scheme was composed of two procedures, atlas building and local adjustment. In the atlas building procedure, all training cases were registered to the given test case by non-rigid registration scheme. The final metric values from each registration were recorded for sorting. Nine best matched results were selected and merged to generate the atlas based segmentation mask. In the local adjustment procedure, the statistical information of bone, cartilage and surrounding regions was computed from the atlas based segmentation result. We incorporated a graph-cut based method for local adjustment. Firstly, the inside and outside seed points were selected from the statistical information and the bone regions were identified by the graph-cut based method. Secondly, distance and intensity based probability maps were generated and used as weighting factor in calculating capacity values. The inside and outside seed points for cartilage were