Ultra structure of articular cartilage

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Introduction

Articular cartilage has a hierarchical structure which includes superficial, transitional, radial and calcified layers. These layers have distinct structures. Fibers are perpendicular to the bone cartilage interface in the radial layer, parallel to the surface in the superficial layer, and curved in the transitional layer. This structure largely explains the magic angle (MA)[1] effect seen in cartilage in which prolonged where T2 values are observed when fibers are oriented at ~54º relative to the B0 field. However, collagen fiber structure may be more complicated further than that described above .By the presence of sheets which result in vertical striations which have different degrees of magic angle effect. In this study we aimed to investigate the fiber structure in different layers including the striated region using high resolution magnetic resonance imaging (MRI), polarized light microscopy (PLM) [2-3] and histology.

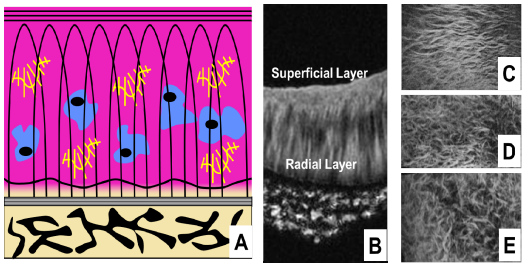

Fig 1. Diagram of cartilage fiber structure (A), MRI microscopy of a tibial plateau in the longitudinal (B) and three representative slices in the cross-sectional plane (C-D-E)imaged at 3T.

Methods and Materials

Cartilage samples (n = 6) from the tibia plateau were harvested from cadaveric human knee joints. High resolution 3D gradient echo images were acquired using a clinical 3T scanner and a 11.7 T Bruker system: FOV = 2 cm, matrix = 512×512, slice thickness = 0.2 mm, TR = 80 ms, NEX = 8, acquired voxel size = 39×39×200 μm^3, total scan time ~ 5 hours. A custom made solenoid coil was used for signal excitation and reception at 3T and at 11.7 T. Cartilage samples were immersed in Fomblin in a 3 ml syringe during MRI to minimize tissue-air susceptibility effects .After examination with MRI, the cartilage samples were sent for PLM and Safranin O staining. Slides were cut parallel to the superficial surface of the cartilage in order to study the transverse collagen fiber structure.

Results and Discussion

Figure 1 shows a diagram of the cartilage fiber structure and high resolution images of a cartilage sample. The cross-sectional slices show a meshwork pattern rather than a linear pattern typically reported in the literature.

Figure 2 shows Safranin O-fast green staining and PLM of the medial and lateral part of the tibial plateau sample imaged in Figure 1. Again a meshwork pattern [4-6] was observed, consistent with the findings on high resolution MRI (Figure 1C-E).

The meshwork fiber structure exists in all the layers of articular cartilage, including the radial layers where collagen fibers [8] were typically thought to be perpendicular to the bone-cartilage interface. The cross-sectional collagen fibers may have different MA effects than the linear collagen fibers, contributing to differences in degree of MA effects between layers or leaves or sheets within cartilage.

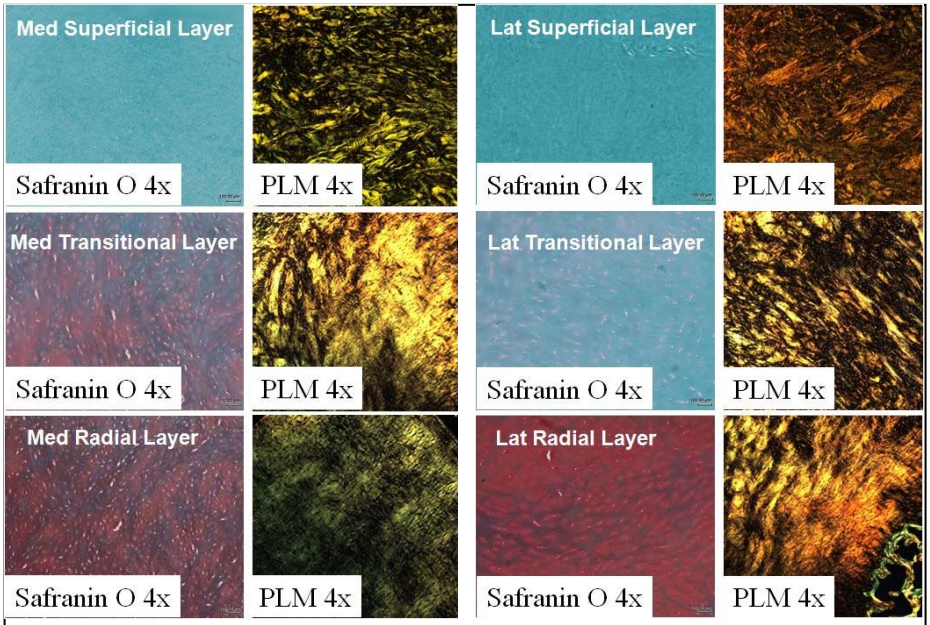

Fig 2. Safranine O-Fast Green staining and PLM of medial and lateral tibial plateau imaged in Figure 1B.Proteoglycan increased from superficial layer to the radial layer ,as indicated by the Safranin O staining .PLM clearly confirms the cross-sectional meshwork pattern of the collagen fibers in all superficial , transitional and radial layers. Thicker collagen fiber bundles are observed in covered region (medial and lateral covered with menisci)[7] probably due to mechanical response to increase loading in the region.

References

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