MR-Assessment of Load-Influenced Collagen Fiber Orientation of Articular Cartilage

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INTRODUCTION

MR-appearance of the articular cartilage is determined by its anisotropic three-dimensional collagen network. In earlier works has been shown, that the MR-intensity of the cartilage is influenced by the orientation relative to the static magnetic field B_0 and by mechanical load (1). Elastic properties of the cartilage can reflect the early degradation of the tissue while development of osteoarthritis. Under load, the radial collagen fibers are bent (2) and thus their orientation to B_0 is changing (Fig. 3). The aim of this study was to investigate quantitatively the alteration of cartilaginous collagen ultrastructure by means of MR-microscopy.

METHOD

Cartilage-bone plugs (Ø 15 mm) of adult sheep femoral condyles and tibial plateaus (from the main load region) were statically loaded (stepwise up to 1.0 MPa). The equal pressure over the whole cartilage surface was applied, realized by means of quick-hardened acryl resin (1). The measurements were performed on a 7T Bruker DRX300 spectrometer with an imaging unit. T_2-wighted MR-images were acquired using a SE-sequence with TR = 500 ms, TE=10…80 ms (8 echoes), slice thickness 1.5 mm, in-plane resolution 44 µm. Afterwards the T_2-maps were pixel-by-pixel calculated.

RESULTS AND DISCUSSION

In the T_2-wighted pressure influenced MR-images we observed a general rising of the MR-intensity as well as a shift of a hyperintense region from the side to the middle of sample (Fig.1). This effect was also visible on the T_2-maps. We suppose that this is caused by bending of collagen fibers under load which leads to the changing of fiber orientation relative to B_0 (Fig.3). Assuming homogeneous radial fiber distribution within the cartilage and proceeding from the magic angle conditions in the hyperintense regions the pressure-conditioned bending of collagen fiber can be estimated (Fig.2).

CONCLUSIONS

With this method, an in principle non-invasive determination of pressure influence on the mean fiber orientation and the load distribution in adult articular cartilage from MR-intensity evaluation is possible. The deformation of cartilage network under pressure could yield necessary information to detect early arthritic changes in the tissue.

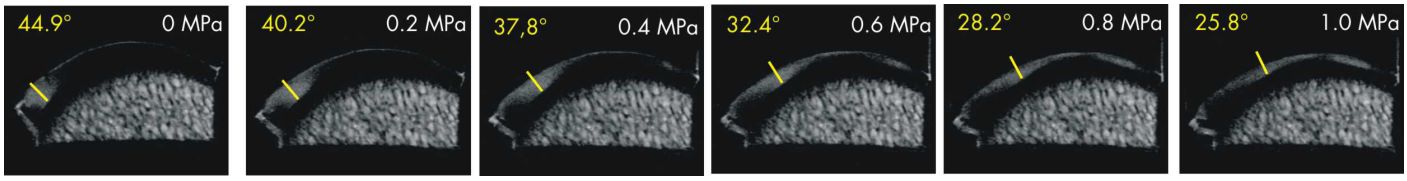

Fig.1: T_2-wighted MR-images of pressure influenced cartilage samples (adult ovine femoral condyle).

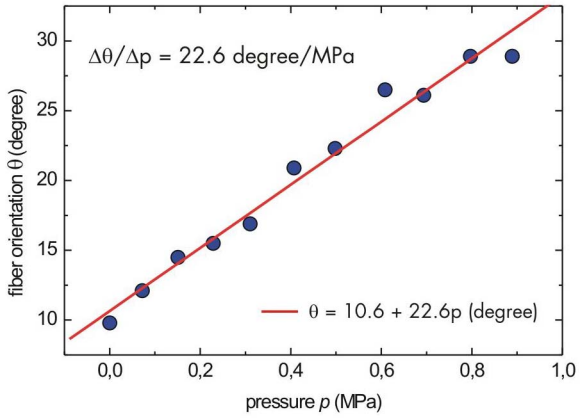

Fig.2: Pressure influenced bending of collagen fibers (from the experiment shown in Fig.1).

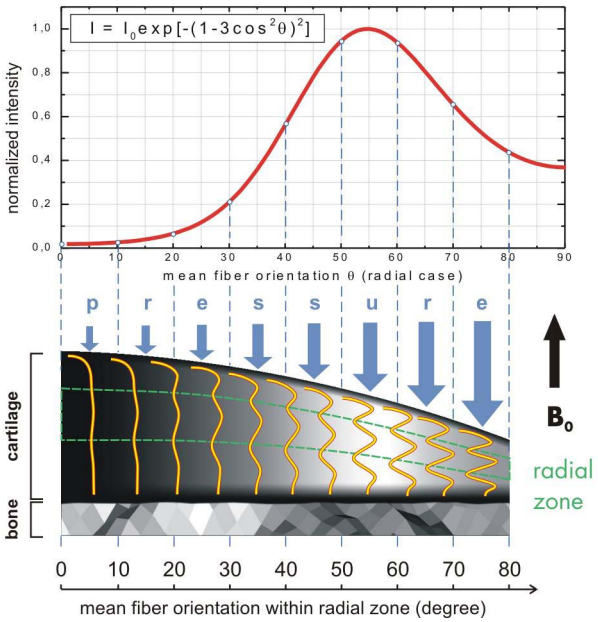

Fig.3: Influence of collagen fiber orientation on the MR-intensity.

REFERENCES

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