Exploration of Magnetic Resonance Magic Angle T2-effect in collagen fibers.

Collagen fibers are important structural fibers in human and animal tissue, and it is known that in some tissue types the fibers are preferentially oriented and highly ordered. One important example is articular cartilage. In Magnetic Resonance Imaging, the signal from tissue of highly ordered collagen shows a directional dependence. This is due to dipolar interactions between protons in water, which are tightly bound to the collagen. The MR signal typically follows the expression $(3\cos^2\theta - 1)$, where θ is the orientation angle of the collagen fibers to the static magnetic field B_0. At $3\cos^2\theta - 1 = 0$, the dipolar interactions are minimized, maximizing the T2-relaxation time value. This happens at $\theta = 54{,}7$ degrees, which is called the magic angle.

By rotating a tissue sample in the magnetic field and measure the T2-relaxation time at each orientation angle, one can indirectly measure the degree of ordering of collagen fibers, see faximile below from Y. Xia (2000) Investigative Radiology 35 (10) p602.

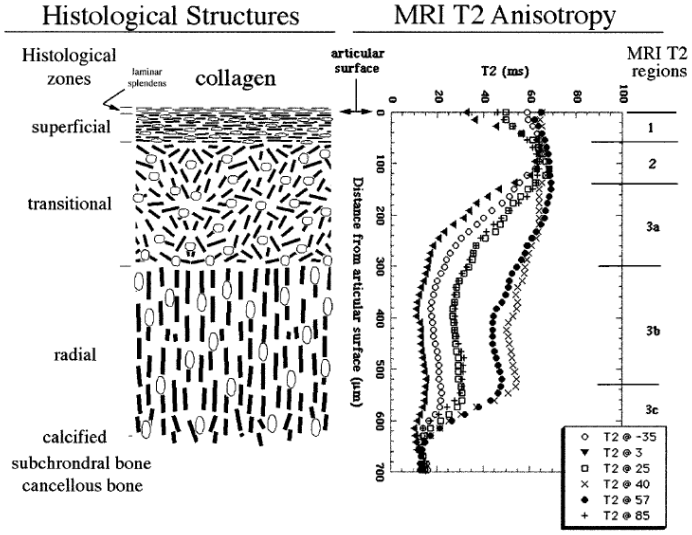

Figure 11. Comparison of the diagram of histological zones in cartilage with the T2 anisotropic profiles across the thickness of cartilage. (Reprinted from Xia Y. Relaxation anisotropy as a possible marker for macromolecular orientations in articular cartilage. In: Blümler P, Blümich B, Botto R, Fukushima E, eds. Spatially resolved magnetic resonance. Copyright © 1998, Wiley-VCH, Weinheim, Germany. Reprinted by permission of Wiley-Liss, a subsidiary of John Wiley & Sons, Inc.)

The project aim is to establish this method on the 7 Tesla small animal MRI scanner located at the Department of Circulation and Medical Imaging, NTNU. The work will include designing a suitable sample holder, optimizing MRI measurement protocols, and performing pilot experiments using cartilage samples. If successful, the method can be extended to be used for studying cancer tumor tissue samples, recently found to express varying collagen fiber anisotropy by researchers at IFY (Romijn et.al, submitted). The T2-measurements can be combined with diffusion tensor imaging, which also probes the collagen fiber anisotropy, but by mechanisms of restricted water diffusion.

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