Demonstration of Striations in Articular Cartilage at High Field

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Introduction: Magic angle effects in articular cartilage have been studied extensively (1). The lamellar appearance of articular cartilage with signal decreasing from superficial to deep is seen at the lower end of the femur and in the tibial plateau when patients are examined in a conventional solenoidal cryomaget with B_0 parallel to the long axis of the body. Magic angle effects involving the radial, transitional and tangential fibers produce this distinctive appearance.

However, equally striking in articular cartilage is the appearance of vertical striations (2,3), which are orthogonal to the layers described above. They are seen in cartilage at the lower end of the femur and in the tibial plateau and have a periodicity of about 0.56 mm (3). The appearances have also been attributed to magic angle effects in studies performed at 3T (4).

In contrast to studies performed at 1.5 and 3T, striations have not been observed or commented on in the very detailed studies performed at high field (7T) over a decade or more in which magic angle effects were identified as the source of the lamellar structure seen in cartilage (1,5). In order to determine whether or not vertical striations can be seen at high field, studies of articular cartilage were performed at 3T and 11.7T.

Methods and Materials: Eight human cartilage samples from the lower end of the femur and tibial plateau were examined using 3D isotropic spoiled gradient images (70-120 micron isotropic resolution, TE=10ms, TR= 25-80ms). Studies were performed on a clinical 3T HDX scanner (GE Healthcare) and an 11.7T 117/16 USR (Bruker Biospin) small bore animal system using 13mm internal diameter transmit/receive solenoid coils. The cartilage surface was orthogonal to the static field.

Results: Striations were demonstrated at both fields in each case (eg Fig 1, 11.7T). They were more obvious on the tibial plateau then in the lower end of the femur. In addition both linear and network patterns were observed as described previously (5).

Discussion: The vertical striations are attributable to differences in degree of magic angle effects between layers or leaves or sheets within cartilage. There may be differences in number, order and orientations of fibers between different leaves. The parallel distributions seen correspond to sheets as demonstrated by freeze-fracture technique but the network pattern corresponds to a more random orientation of fibers. The features are particularly well seen in the uncovered areas of the tibial plateau (i.e. in cartilage not covered with menisci) (6,7).

The failure to observe striations at high field in previous studies may be due to a species difference (e.g. bovine vs. human tissue) (7) or sampling issues, since striations are obvious in some locations such as the uncovered area of the tibial plateau but are less obvious elsewhere in the body.

The similarity of patterns at 3T and 11.7T argues in favor of a magic angle effect as the origin of appearances since susceptibility effects would be expected to be markedly increased at 11.7T.

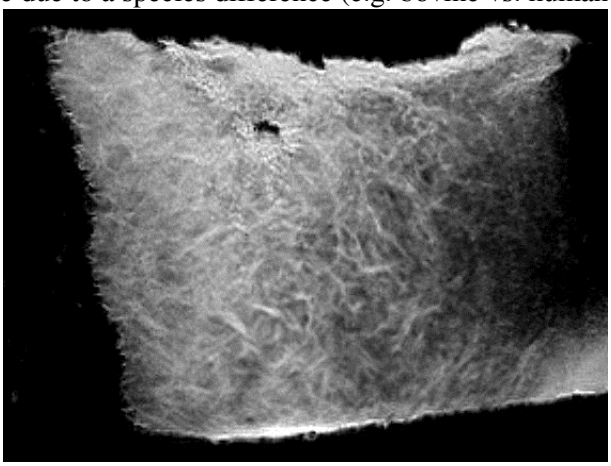

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Figure 1: Axial (upper right) and sagittal (lower right) 70 micron isotropic resolution FLASH MR images of the Tibial plateau at 11.7T. The network pattern is seen in the axial view, while the vertical striations are evident in the sagittal view.