In Vitro Demonstration of the Vasculature of Human and Bovine Meniscus of the Knee with MRI at 11.7T

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Target Audience: Scientists and radiologists interested in the meniscus of the knee.
Purpose: To demonstrate the vasculature of the meniscus and its relation to cartilaginous and fibrous regions using high field MRI.
Introduction: There has been considerable interest in demonstrating the vascular (red) zone of the meniscus with MRI and distinguishing it from the avascular (white) zone. This is because tears involving the red zone generally heal well after surgery, while those solely in the white zone frequently heal badly. In vitro efforts to visualize either the red zone or the vasculature of the meniscus at 1.5T have not been successful[1]. The use of intravenous gadolinium chelates has allowed the red zone to be demonstrated in vivo, but the blood vessels in this region have not been shown[2]. The objective of this study was to image fresh samples of bovine and human meniscus at 11.7T to see if it was possible to observe the vasculature in the meniscus and, if so, to determine how this related to other structures within the meniscus.
Materials and Methods: Six fresh bovine menisci (aged 18-30 months) and four adult human cadavers' menisci were harvested in accordance with institutionally approved protocols, and frozen and thawed prior to scanning. An 11.7T Bruker Biospec (117/16) (Billerica, MA) system with 750 mT/m gradients was used together with a 72 mm transmit/receive (T/R) resonator, a four element receive only rat brain array, and a 12 mm diameter T/R solenoid. Techniques used were a fat saturated 2D multislice multiecho (MSME) TR=3000 ms TE=8-32 ms, voxel size 50-70 x 50-70 x 500 μm, NEX=10-12 sequence as well as a fat saturated 3D multiecho gradient echo (MGE) (TR=80 ms, TE=2-18 ms) 100-150 μm isotropic NEX=8-26 sequence. Samples of intact menisci were orientated with the plane of the meniscus perpendicular or parallel to Bo. In the former orientation circumferential and radial fibers are generally perpendicular to Bo while in the latter orientation different circumferential and radial fiber orientations were available. The orientations chosen were generally parallel or perpendicular to Bo.
Results: A vascular pattern was observed in the peripheral regions of the meniscus and in the adjacent perimeniscal tissue branching was readily observed (Fig. 1). Some blood vessels proceeded centrally beyond the outer third of the meniscus. The vessels were generally seen with greater contrast on longer TE sequences consistent with a T2 longer than that of the fibrous components. Vessels were not seen in the more cartilaginous regions. The vessels could frequently be located between circumferential and radial fibers. Conspicuity varied depending on the signal level of the adjacent fibers and this varied with fiber orientation to Bo.

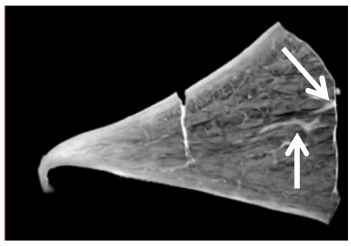

Fig 1. Human meniscus, radial section. MSME sequence. High signal structures consistent with blood vessels are seen (arrows). (A surgically induced tear is seen centrally.)

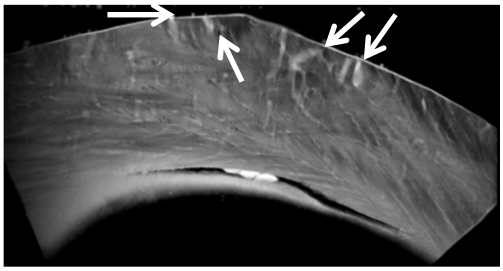

Fig 2. Bovine meniscus, axial section. MGE sequence, maximum intensity projection image. Evidence of blood vessels is seen in the more peripheral regions (arrows).

Discussion: The vasculature of the meniscus was demonstrated and was generally similar to that shown using angiography in the dog meniscus[3]. The residual blood in the vessels was probably in the form of clot and free fluid. This could account for its relatively long T2. The more central presence of vessels in some of the bovine speciments could reflect the relative immaturity of the animals. The blood vessels could be distinguished from radial fibers by their continuity into the perimensical region, their relatively long T2 and their lack of obvious magic angle effects. They were also narrower, of more uniform diameter and were generally not present in the central region of the meniscus. The study is supported by optical projection tomography studies which have also shown blood vessels and their relation to fibers[4]. The work provides a basis for understanding the issues involved in imaging the meniscus vasculature including distinguishing radial fibers or ties from blood vessels and may be of importance in clinical imaging at higher field strengths.

References

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