

INFRASTRUCTURE OF MENISCI WITH MR IMAGING

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BACKGROUND/PURPOSE

The importance of the menisci in the biomechanics of the knee joint, particularly with respect to load distribution, is well established. Its non-invasive evaluation has been emphasized more recently in an attempt to consider the joint as a whole with respect to the pathogenesis of osteoarthritis (OA). To fulfill the function of load distribution and shock absorption in the knee, the meniscus has a complex infrastructure that affords it hoop strength. This structure includes a collagen fibrillar pattern comprised of 5 different fiber orientations (circumferential, radial, tie, vertical and lamella fibers). Four functional and anatomical zones are also distinguished within meniscal substance: 1) a central fibrocartilaginous portion, 2) a peripheral fibrous portion, 3) a central vascular white zone, and 4) a peripheral vascularized red zone. Knowledge of this structure is intrinsic to the diagnosis and characterization of meniscal pathology, the understanding of injury patterns, as well as their management. The non-invasive MR imaging analysis of meniscal infrastructure has not yet been described due to the intrinsic MR properties of this tissue, its relatively short T2 properties, resulting in lack of signal and contrast with conventional MR techniques. We aimed at using a tailored MR sequence to demonstrate the infrastructure of cadaveric menisci, including the fibrillar pattern, the fibrous and the fibrocartilaginous as well as the red and the white zones on a 3T clinical scanner.

MATERIAL AND METHODS

Five normal and degenerative cadaveric human menisci were imaged using a 3-inch coil in a 3T clinical scanner, in the axial and sagittal planes. To determine the optimal TE for the visualization of the meniscal infrastructure, morphological sequences (T2 SE, SPGR, UltrashortTE with fat)saturation were performed, allowing the acquisition of images covering a wide range of TEs, from 12microsecs to 45 ms. In order to analyse the effect of dipolar interaction on the contrast, menisci were placed in the magnetic field with different angles relative to B₀. Images were visualized in the axial and sagittal planes of the menisci. Two musculoskeletal radiologists reviewed the images in both planes and evaluated the visibility of the following structures: each of the 5 different collagen fiber orientations, the central fibrocartilaginous zone, the peripheral fibrous zone, the white and the red zones. Loss of fiber organization in case of degeneration was also analyzed.

RESULTS/DISCUSSION

At visual inspection, the optimal TE for the visualization of the menisci infrastructure ranged from 3 to 6 ms, which is consistent with the intrinsic T2 relaxation time of this tissue (according to our previous works). With these parameters, the fibrillar pattern, as well as the fibrocartilaginous/fibrous and red and white zones were all visualized. The disruption of the fibrillar pattern in case of meniscal degeneration was also visible.

CONCLUSION

The visualization of the infrastructure of menisci is optimized with TEs in the range 3 to 6ms. We show that with the appropriate coil and parameters, MR imaging can show the infrastructure of the menisci on a clinical 3T scanner.

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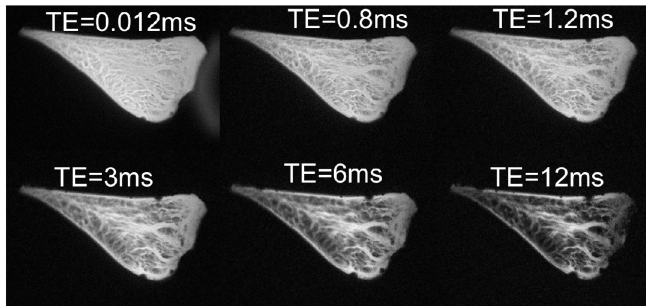


Fig. 1: Sagittal UTE FS images of cadaveric menisci with varying TEs (ranging from 0.012 to 12 ms). The best visualization of the infrastructure of menisci is achieved with a TE of 3 or 6ms.

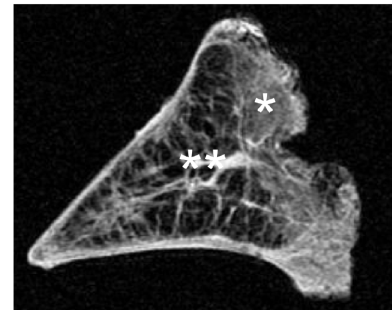


Fig. 2: Sagittal SPGR image of the meniscus showing the red (*) and white zones (**).

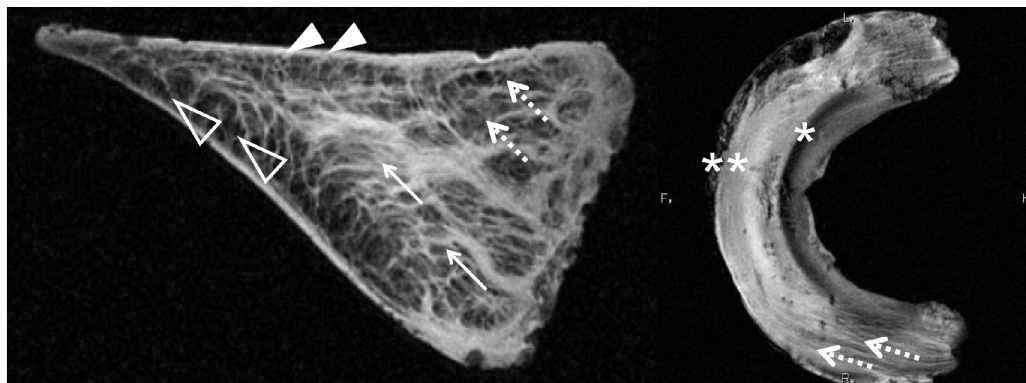


Fig. 3: Sagittal and axial images obtained with an SPGR sequence (TE of 4.7ms). The fibrillar pattern is well depicted with the visualization of tie (solid arrows), circumferential (dotted arrows), vertical (open arrowheads), lamellar (arrowheads), as well as the central fibrocartilaginous (*) and peripheral fibrous (**) zones.