Demonstration of the Root Ligaments of the Meniscus of the Knee Using a 3D UTE Cones Subtraction Sequence With and Without Contrast Enhancement

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Introduction: The root ligaments of the meniscus have an essential role in maintaining the mechanical integrity of the knee (1). They anchor the meniscus to the tibia and prevent extrusion under load and thereby protect the adjacent cartilage. Demonstration of the root ligaments may be difficult with conventional fat saturated T2 weighted sequences because they are low signal structures adjacent to other low signal tissues including the ACL and PCL, saturated fat and the meniscus itself. It is possible to demonstrate tendons and ligaments as high signal structures using UTE subtraction images in which short T2 tissues are highlighted. In order to assess whether this was feasible and whether contrast administration would be detectable over time we studied a volunteer before and after injection of gadolinium – DTPA in serial studies.

Fig.1: 3DCones k-space trajectory. K-space trajectories originate at the center and move outwards.

Materials and Methods: Imaging was performed using a radial out 3D Cones acquisition on a healthy male volunteer (age 69). The 3D cones sequence employs a unique data sampling trajectory scheme that samples MRI data along twisting paths along evenly spaced cone surfaces in 3D (2). It samples data starting from the center of k-space and twists outwards from there with the data acquisition starting as soon as possible after the RF excitation (Fig.1). To minimize scan-time, anisotropic FOV encoding together with slab-selection was used to excite and encode a small axial region around the meniscus (see Fig.2). Two echoes were obtained at TE = 30µs and TE =12ms, to allow dual echo subtraction. Scans were repeated for four cycles, one before gadolinium injection (0.26mmol/kg) and four at different post injection time points.

Experimental Results: The root ligaments were well demonstrated as high signal structures on the subtraction images. The ACL and PCL were closer to the magic angle (3) giving those longer T2s and lower signal on the subtraction images. The 3D images allowed separate demonstration 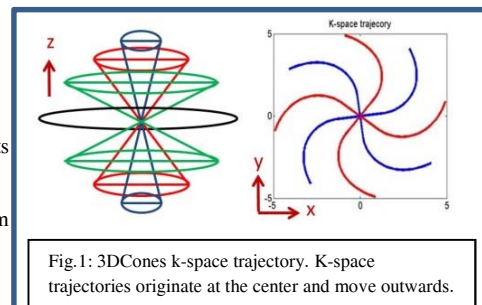of the root ligaments at different horizontal levels including in particular, demonstration of an extended posterior root ligament of the lateral meniscus. An example set of a dual echo images and the dual echo subtraction is shown in Fig.3. Enthesis fibrocartilage was also demonstrated. Calcification was seen as a high signal area on the first UTE and subtraction images. Obvious enhancement was apparent on the UTE and subtraction images.
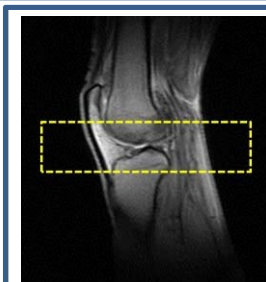

Fig.2: Sagittal localizer image showing the approximate slab selection of the axial images.

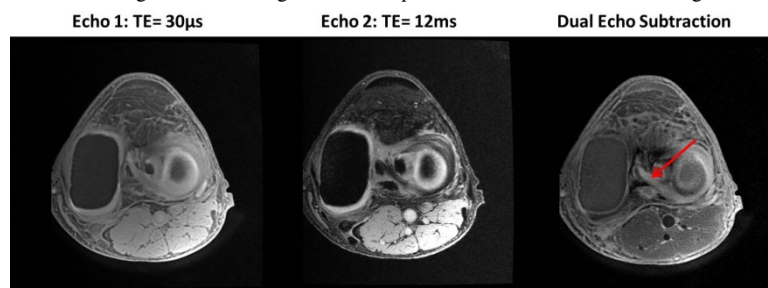Fig.3: Axial 3DCones images at TE = 30µs and TE =12ms. Their subtraction shown on the right shows positive contrast for short T2 tissues such as the root ligament (arrow).

Conclusion: The root ligaments can be readily demonstrated and can be identified by their cross sectional appearance, internal structure (vertical septa rather than radial fibers in the meniscus) and location. Differentiation from the ACL and PCL was straightforward. The ligaments showed enhancement that was less than the red zone but much more than the white zone of the meniscus. Magic angle effects were in minimal since the circumferential fibers were essentially at 90º to B0 apart from the posterior root ligament of the lateral meniscus which was tilted over the tibial plateau. However this did not result in significant reduced signal on the subtraction images or the enhanced images.

References: [1] Papalia et al, Br Med Bull (2013); [2] Gurney et al. MRM 55:575-582 (2006); [3] Peterfy CG, AJR 163: 149-54 (1994)
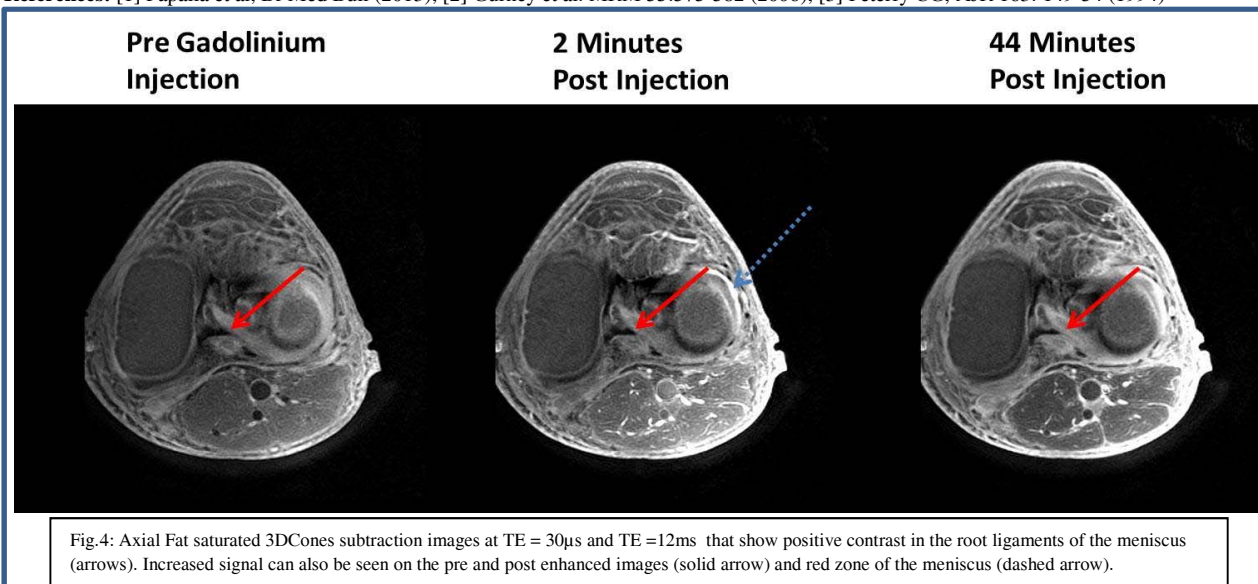

Fig.4: Axial Fat saturated 3DCones subtraction images at TE = 30µs and TE =12ms that show positive contrast in the root ligaments of the meniscus (arrows). Increased signal can also be seen on the pre and post enhanced images (solid arrow) and red zone of the meniscus (dashed arrow).