UTE MR Morphology and Histopathology of the Osteochondral Junction of the Knee

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INTRODUCTION: Articular cartilage has a zonal architecture consisting of uncalcified cartilage tissue anchored to the underlying bone via calcified cartilage.[1] The osteochondral junction has been implicated in the pathogenesis of osteoarthritis, as injury to this region can occur during joint loading.[2] Recently it was shown that, using ultrashort time-to-echo (UTE) sequences, the deepest layer of uncalcified cartilage as well as calcified cartilage were detectable.[3] The images showed the calcified and deep radial layers as continuous, linear, and high signal intensity. Focal abnormalities in UTE MR morphology were also noted, but have not been correlated with histopathologic features of the osteochondral junction, including tidemark duplication[4] and blood vessels penetrating the tidemark.[5] ***The goal of this study was to compare histopathology of osteochondral junction of samples with normal or abnormal UTE MR morphology.***

METHODS: ***Samples.*** Cadaveric knees (n=5, 2 females, 76±11 yrs) were sectioned (5 mm thick) sagittally through central weight bearing regions of the lateral and medial condyles. ***MR Imaging.*** Using a UTE MR technique (3-T, 3" coil, TR=500 ms, TE=0.008 and 8 ms, slice=1 mm, FOV=8 cm, matrix=512x512), subtraction images of the samples (**Fig.1A**) were obtained. UTE MR morphology of the osteochondral junction was evaluated by a musculoskeletal radiologist with 15 yrs of experience. Normal morphology consisted of a continuous linear high signal intensity (**Fig.1A**, **arrows**), while abnormal morphology (**Fig.1A, triangles**) included deviations such as marked thinning or absence of the signal intensity, diffuse thickening, or irregularity. Regions exhibiting normal or abnormal morphology, within the same knee slice, were selected and resected (**Fig.1A, dashed lines**) for histologic processing. ***Histopathology.*** Samples were fixed, decalcified, paraffin-embedded, sectioned (5 μm), stained with Safranin-O/fast green, and micrographed (**Fig.1BC**). The osteochondral junction was evaluated for the presence of duplicated tidemarks, as well as vessels penetrating the tidemark. ***Statistics.*** Associations between UTE morphology and histopathologic features were determined using the chi-square test.

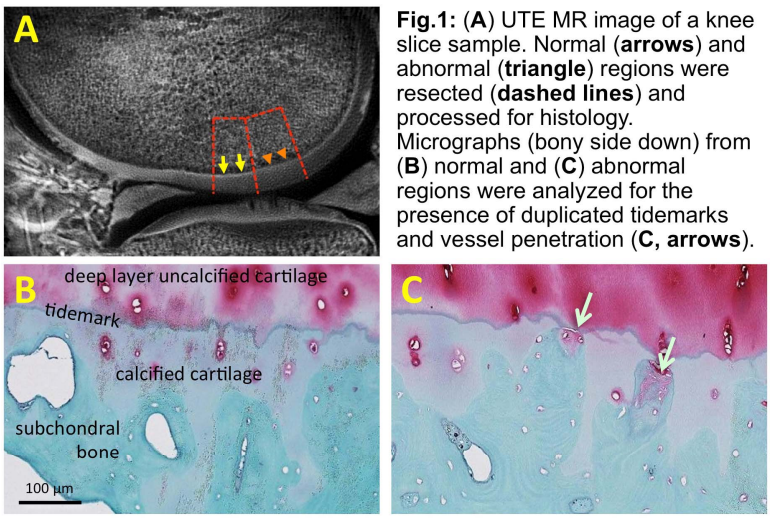

Fig.1: (**A**) UTE MR image of a knee slice sample. Normal (**arrows**) and abnormal (**triangle**) regions were resected (**dashed lines**) and processed for histology. Micrographs (bony side down) from (**B**) normal and (**C**) abnormal regions were analyzed for the presence of duplicated tidemarks and vessel penetration (**C, arrows**).

Histology	UTE Morphology		chi-square p-value
	Normal	Abnormal	
Duplicated Tidemark, Yes	7	8	0.70
Duplicated Tidemark, No	6	5	
Vessel Penetration, Yes	4	11	0.005
Vessel Penetration, No	9	2	

Table 1: Distribution of duplicated tidemarks and vessel penetration in osteochondral junctions of the knee.

RESULTS: A total of 12 regions from femoral condyle and 14 regions from tibial plateau were analyzed. Duplicated tidemarks were found in more than half of UTE normal and abnormal samples (Table 1), and no significant difference was found between the sample groups. In contrast, samples exhibiting vessel penetration (Fig.1C, arrows) were found in a significantly greater proportion (p=0.005) in UTE abnormal samples (11 of 13, or 85%) compared to normal samples (4 of 13, or 31%).

DISCUSSION: UTE sequences allow direct evaluation of the osteochondral junction of the knee. In this preliminary study, UTE abnormalities were associated with increased vascular invasion, which is often observed in osteoarthritic knee.[6, 7] The lack of association between UTE morphology and duplicated tidemarks may be due to the generally high age of the samples, and may indicate that tidemark duplication does not result in change in bulk tissue properties, sufficient to be reflected in UTE MRI. Future studies will assess quantitative measurements such as calcified cartilage thickness and roughness, to further investigate whether other osteochondral changes are related to UTE MR morphology.

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