UTE imaging of the patella with bi-component analysis: correlation with histopathology and polarized light microscopy
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INTRODUCTION
The majority of the water in cartilage exists in the form of free water, with a smaller fraction bound to either PG or collagen fibrils. Bound water has a much shorter T2 than free water. Ultrashort echo time (UTE) sequences have been developed to image short T2 tissues or tissue components in vitro and in vivo and have been implemented on clinical MR scanners. In this study we aimed to evaluate cadaveric human patellae using UTE imaging with bi-component analysis to quantify the short and long T2* water components and correlate the results with conventional histology and polarized light microscopy (PLM). Clinical T2 measurements were also performed for comparison.

MATERIALS AND METHODS
Twenty fresh human patellae from 11 donors (7 males, 4 females; age range = 48-92, mean 67.2 ±17.9 years) were obtained from tissue banks and processed within 24-72 hours of death. After harvesting, a transverse slab of 5-8 mm thickness was prepared for MR imaging. A single slice at the center of each patella sample was imaged with the apex normal to the B1 field. A 2D UTE imaging sequence was used for data acquisition with the following parameters: TR = 200 ms, FOV = 6 cm, matrix = 512×512, slice thickness = 1.7 mm, 13 TEs ranging from 8 ms to 80 ms, 2 minutes per image. CPMG acquisitions with 8 echoes were acquired with the same spatial resolution and a 12 minute scan time. After MRI the patellae slabs were prepared for histology. 5 μm sections were cut at the defined location to match the MRI scans. Several sections from each patella were stained with Safranin O-Fast Green for histopathology and Picrosirius Red for polarized light microscopy (PLM).

Four to six regions of interest (ROI) were chosen per patella for correlation of histopathology, PLM and MRI. The number of regions was determined by one author depending on the grade of OA severity. Each ROI was given a Mankin score ranging from 0 to 14. Each score was converted to a grade as follows: G1 = 0-1, G2 = 2-5, G3 = 6-9, G4 = 10-14. Each ROI was also qualitatively assessed using the grading scale (grade 0-4) published by Vaudey to describe the birefringence characteristics of the articular cartilage matrix.

Single-component fitting was performed on data from the CPMG images for T2 measurement. Bi-component fitting was performed on data from the UTE images for bound and free water T2* and fraction measurements. Short and long T2* values and their fractions, as well as T2, were correlated with the Mankin and Vaudey scores.

RESULTS AND DISCUSSION
OA is a complex disease which displays considerable heterogeneity. Figure 1 shows an example with histology, PLM and UTE images as well as bi-component analysis of three ROIs with mild, moderate and severe degeneration, respectively. UTE bi-component analysis shows a significant increase in short T2* water fraction from 21.9% for mild OA, to 28.5% for moderate OA and 36.0% for severe OA. The residual signal (G-I) is less than 5%, suggesting that the bi-component model is well suited for UTE T2* analysis of cartilage.

CONCLUSIONS
In conclusion, we have shown that UTE bi-component analysis can be performed with a clinical imager to evaluate short T2* (bound water) and long T2* (free water) components in articular cartilage. Short T2* water fraction probably reflects collagen matrix degradation and is significantly correlated with cartilage degeneration. CPMG T2 values are poorly correlated with histology and PLM.

REFERENCES