EFFECTS OF ACL INTERFERENCE SCREWS ON ARTICULAR CARTILAGE THICKNESS MEASUREMENTS WITH 1.5T AND 3T MRI

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INTRODUCTION

ACL injury places patients at risk for early osteoarthritis (OA). Quantitative MRI (qMRI) can be used to track changes in tibiofemoral (TF) articular cartilage volume and thickness, and could provide insight into OA progression after surgical ACL reconstruction. Titanium interference screws are frequently used to fix ACL grafts. However, metallic implants can produce magnetic susceptibility artifacts with MRI, artifacts that may increase with magnetic field strength (Guermazi et al, 2003). The purpose of this study was to assess the effects of interference screws and magnetic field strength (3T vs. 1.5T) on measurements of articular cartilage thickness.

METHODS

MR Imaging: 5 fresh-frozen intact right human knees (3 female, 2 male; mean age = 56, range 51-59) were imaged on 1.5T and 3T scanners (Siemens Symphony and Trio, respectively, Erlangen, Germany) using surface knee coils. The T1-weighted WE-3D FLASH sequence (1.5mm slices) was used on the 3T scanner (Eckstein et al, 2004), and a similar sequence was adapted for use on the 1.5T magnet (2mm slices).

Test Protocol: After thawing, each knee was imaged on the two scanners with and without two 9x20mm titanium interference screws implanted (Arthrex, Inc; Naples, FL). To minimize bias, the test order was block randomized, first by screw condition (with screws vs. without), and then by magnetic field strength (1.5T vs. 3T).

Segmentation Technique: The femoral and tibial articular cartilage structures of each specimen were manually segmented in the sagittal plane and reconstructed using commercial software (Mimics 9.11; Materialise, Ann Arbor, MI). 3-D voxel models were generated and wrapped with a triangular mesh to create a virtual solid model of each cartilage structure.

Regions of Interest (ROI): We focused our thickness measurements to the regions of greatest load bearing. A cylinder was fit to the bone-cartilage interface of the femoral cartilage model of the TF joint. The notch marking the junction between the TF and patellofemoral joints on the lateral condyle was identified on sagittal MR views (Fig. 1). A line was drawn from the notch (0^o) to the center of the cylinder. Each condyle of the TF joint was then divided at 40^o, 70^o, 100^o, and 130^o from the notch point toward the posterior aspect of the condyles to create 6 patches of cartilage (3 medial, 3 lateral); the width of each patch was 20% of the overall width (M-L) of the femoral cartilage and centered about the midline of each condyle. Two patches on the tibial cartilage (1 medial, 1 lateral) were also defined by calculating the centroid of each compartment and the inertial axes of the medial compartment using MATLAB (The Mathworks, Inc., Natick, MA). The inertial axes served as a coordinate system, and the patch in each compartment was defined as the area ±20% of the overall depth (A-P) and ±15% of the overall width (M-L) from the centroid. The average thickness of each patch was calculated by the closest point algorithm using MATLAB.

Statistical Analysis: Two-way repeated measures analyses of variance were performed to compare the cartilage thickness of each ROI in response to screw condition (screws vs. no screws) and magnetic field strength (1.5T vs. 3T). Pair-wise comparisons were made with the Holm-Sidak test.

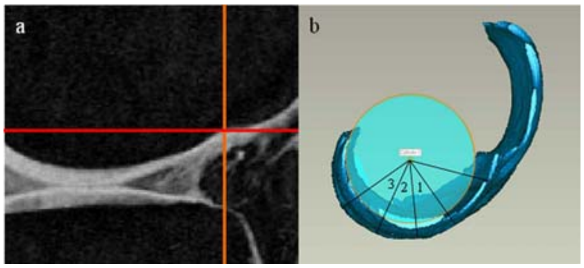

Figure 1: (a) The "notch" is marked by crosshairs on the lateral side of the TF joint, seen in the sagittal plane. (b) A cylinder was fit to the femoral condyles, with a line drawn from the notch to the cylinder axis. The location of the 3 ROIs are shown.

RESULTS

There were no significant differences in the average femoral articular cartilage thickness values due to field strength or screw condition for any ROI examined (Table 1). There were no significant differences in tibial articular cartilage thickness values at different field strengths (Table 1). There was no significant difference in the medial tibial articular cartilage thickness with different screw conditions (Table 1). However, there was a significant difference (mean 0.28mm) in the lateral tibial cartilage thickness at different field strengths (3T>1.5T, $p=0.04$). The difference was independent of screw condition; however, there was a trend for interaction between field strength and screw condition ($p=0.06$).

Table 1: Mean (standard error) thickness (mm) of each region of interest (ROI) at each field strength and screw condition. "M" denotes medial; "L" denotes lateral. "Tib" and "Fem" denote tibial and femoral, respectively. "Fem1" represents the ROI between 40-70^o, "Fem2" 70-100^o, and "Fem3" 100-130^o (see Fig. 1).

Magnet	**3T**		**1.5T**	
Screw	**Yes**	**No**	**Yes**	**No**
MTib	2.3(.07)	2.6(.07)	2.2(.07)	2.5(.07)
LTib	3.9(.05)	4.0(.05)	3.7(.05)	3.6(.05)
MFem1	1.9(.06)	2.0(.06)	1.8(.06)	1.8(.06)
MFem2	2.0(.05)	1.9(.05)	2.0(.05)	2.0(.05)
MFem3	2.0(.06)	1.9(.06)	2.0(.06)	1.9(.06)
LFem1	2.5(.05)	2.5(.05)	2.5(.05)	2.4(.05)
LFem2	2.8(.05)	2.8(.05)	2.7(.05)	2.7(.05)
LFem3	2.3(.06)	2.4(.06)	2.3(.06)	2.4(.05)

DISCUSSION

Our data demonstrate that measurements of TF articular cartilage thickness are not affected by the presence of titanium interference screws for the ACL-reconstructed patient when using the T1-WE-3D FLASH sequence at 1.5T. The lack of screw effect, however, was not independent of magnetic field strength. While the difference in thickness in the lateral compartment of the tibia between screw conditions was not statistically significant (<0.1mm; Table 1), there was a trend for interaction between these parameters at 3T. Thus, caution should be used when interpreting the mean thickness values in the lateral tibial cartilage at 3T with interference screws present. As a result, 3T and 1.5T qMRI should not be used interchangeably to assess structural changes in lateral tibial articular cartilage during longitudinal studies.

REFERENCES

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