

Longitudinal T1ρ MRI of adults with chondromalacia following arthroscopy

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Background

While it has been shown that the T1ρ relaxation rate correlates with focal cartilage lesions from arthroscopically confirmed chondromalacia⁽¹⁾, it is unclear the effects arthroscopic of debriding and chondroplasty has on surrounding cartilage tissue. While these arthroscopic procedures are routine surgical methods to mitigate pain and improve patient mobility, it has been shown that 10% of patients with arthroscopic procedures have found to be unnecessary⁽²⁾. This study aims to track the longitudinal effects of arthroscopic procedures on patellar cartilage. Cartilage integrity and biochemical composition are quantified using T1ρ MRI 3 and 9 months post arthroscopic surgery.

Materials and Methods

Three symptomatic subjects (2 female; 76 years and 51years and 1 male -50 years old) had arthroscopy performed. Subjects had confirmed chondromalacia and were scored using a modified Outerbridge classification scale. Individual operative reports described surgical procedures performed, such as debridement and chondroplasty, with their relevant anatomical locations. MR Images were gathered at 3 and 9 months post-arthroscopy. Initial T1ρ measurements were deferred 3 months after surgery to ensure swelling and immediate inflammation due to the arthroscopy was mitigated. T1-weighted isotropic MPRAGE images were acquired for segmentation of cartilage and T1ρ-weighted TrueFISP images were acquired to calculate spatial T1ρ relaxation maps. Image acquisition parameters have been described previously⁽¹⁾. Isotropic sagittal MPRAGE images were re-sliced along coronal and axial views and interpolated to match the resolution of T1ρ-weighted images. Patient motion during image acquisition was found to be problematic for T1ρ quantification, especially in axial views where non rigid body rotation of the leg was observed. An initial manual alignment of the axial T1ρ-weighted images to the re-sliced axial T1-weighted image was performed by in-plane rotation and translation after which a region of interest containing cartilage and bone was selected. Masked, axial T1ρ-weighted images were exported to 3DVUEWPIX (MIPG, University of Pennsylvania, Philadelphia, Pennsylvania) where T1ρ-weighted images were co-registered to T1-weighted images. The T1-weighted images of the cartilage were segmented using the SliceOMatic (Tomovision, Quebec, CA) software package. Masked, co-registered T1ρ-weighted images were fit pixel-wise to the linearized, mono-exponential signal decay equation $\ln(S) = -TSL/T1\rho + \ln(S_0)$. Analysis of the mean T1ρ changes from the two time points, 3 month and 9 month, was performed using a two-tailed paired t-test. Patellar cartilage was divided into six regions (medial/lateral deep/middle/superficial zones). Only the lateral compartment was surgically altered in one subject while in the other two subjects, both medial and lateral compartments were altered.

Results and Discussion

Mean T1ρ values were computed for each of the six zones of the patellar cartilage at 3 and 9 months post arthroscopy. Mean whole-patellar T1ρ values in regions where arthroscopic procedure had taken place 3 months prior was significantly lower than regions six months later (41.1 ms v. 48.4 ms, p value <0.001). A compartmental analysis of mean T1ρ values was performed (3 month deep vs. 9 month deep, 3 month middle vs. 9 month middle, 3 month superficial vs. 9 month superficial). A significant increase in T1ρ values was found in all compartments (deep – 24%, p<0.05, medial – 18%, p<0.05, superficial – 11%, p<0.05). Visual inspection of same slice images is indicative of global T1ρ increase in all patients. In subject 1 (Figure 1A, 1B), medial and lateral debridement increased T1ρ values in ROI selected from 44.41 ms to 51.65 ms. In subject 2 (Figure 1C, 1D), medial and lateral chondroplasty occurred which increased the volumetric T1ρ value from 44.56 ms to 49.94 ms. In subject 3 (Figure 1E, 1F), only a lateral debridement occurred which resulted in an increase of mean T1ρ value (44.80 ms to 51.47 ms) in the superficial zone

Conclusion

While arthroscopy is a commonly performed surgical procedure for general cartilage and meniscus repair, longitudinal effects of surgical alterations of the cartilage tissue is unknown. It has been shown that the surgical intervention of the cartilage, even though to be beneficial in the short term, potentially increases the rate of biochemical breakdown in healthy cartilage as seen by T1ρ MRI.

References

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- 2) Nickinson, R., Int. Orthop. 2009, Online – 01 April 2009.

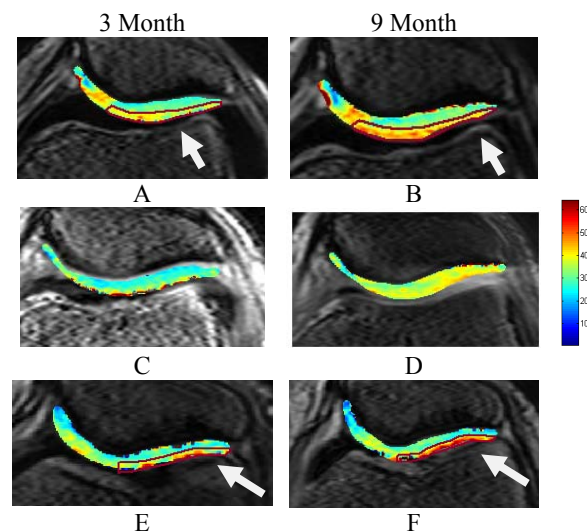


Figure 1: Same slice T1ρ Maps for subjects 1 (A-B), 2 (C-D), and 3(E-F). Colorbar in ms.