

Quantitative Evaluation Of Human Cadaveric Posterior Cruciate Ligament: Effect of Trypsin Digestion on T1rho values.

P. Omoumi¹, E. S. Diaz¹, J. Du¹, S. S. Statum¹, W. C. Bae¹, G. Bydder¹, and C. B. Chung¹
¹University of California, San Diego, San Diego, California, United States

BACKGROUND/ PURPOSE

The role of the cruciate ligaments of the knee in joint stability is well established. MR imaging is the technique of choice to evaluate cruciate ligaments of the knee¹. The PCL is usually injured as the result of tensile forces with some degree of posterior tibial translation². While the MR imaging diagnosis of cruciate ligament rupture in the acute setting is not challenging, structural alteration of tissues that may alter biomechanical properties of the joint have not been widely addressed in the imaging literature. In the orthopedic literature, the concept of tissue structural failure leading to microinstability has been introduced, emphasizing the importance of intact infrastructure to maintain normal biomechanics, thereby lessening the likelihood of mechanical causes for degeneration. Quantitative methods have been developed to probe early degenerative changes for the cartilage, and more recently applied to menisci. T2 values are thought to mainly be influenced by the organization and concentration of collagen fibers, whereas T1rho values are correlated with the concentration of glycosaminoglycans (GAG), the influence of collagen on T1rho values remaining controversial. As in cartilage and menisci, ligaments are mainly composed of collagen GAGs^{3,4}. We sought to evaluate the feasibility of conventional and novel UTE quantitative techniques for T1rho measurements of the PCL, and study the effect of the selective removal of GAG molecules by an enzymatic digestion^{5,6}.

MATERIAL AND METHODS

Five cadaveric PCL specimens were imaged before and after 2 days of enzymatic digestion of the GAG content (trypsin). Imaging was performed on a 3T clinical scanner using a custom-built quadrature birdcage coil with an inside diameter of 2cm and a length of 10cm was used. The imaging protocol included a novel UTE T1rho technique, associated with variable preparation times (0.04,3,8,16,32,50 msec) and a constant TE (8 microsecs), as well as a spiral T1rho (TSL: 0, 10, 20, 40 60, 80) measurement. In an attempt to minimize dipolar interactions, the ligaments were stretched and their long axis was placed parallel to B₀ (Fig. 1). To reproducibly image the same area at each imaging session, the PCLs were imaged in an axial plane equidistant from its ends.

As a control, one PCL specimen was placed in saline for two days, and quantitative imaging sequences were performed in the same fashion as for digested specimens.

RESULTS/ DISCUSSION

No change was noted in the T1rho values of the control specimen.

T1rho values increased significantly after digestion, both with conventional and UTE techniques (19.5 vs. 26.3 and 6.9 vs.12.1 respectively), as was expected (Fig 2).

The values obtained with UTE technique were significantly lower than those with the conventional technique (9.01 vs 21.96), which is expected as UTE techniques take into account shorter T2 components (Fig 2).

CONCLUSION

Both conventional and UTE techniques allow quantitative T1 rho assessment of the PCL. The UTE technique measurements appear to reflect GAG population in short T2 tissues. T1rho values increased with UTE and standard techniques after the enzymatic digestion of GAG molecules indicating the loss of GAG achieved through enzymatic digestion.

REFERENCES

1. Grover JS, Bassett LW, Gross ML, Seeger LL, Finerman GA. Posterior cruciate ligament: MR imaging. *Radiology*. 1990;174(2):527-530.
2. Rodriguez W, Vinson EN, Helms CA, Toth AP. MRI Appearance of Posterior Cruciate Ligament Tears. *Am. J. Roentgenol*. 2008;191(4):W155-159.
3. Bosch U, Gässler N, Decker B. Alterations of glycosaminoglycans during patellar tendon autograft healing after posterior cruciate ligament replacement. A biochemical study in a sheep model. *Am J Sports Med*. 1998;26(1):103-108.
4. Lemoine JK, Lee JD, Trappe TA. Impact of sex and chronic resistance training on human patellar tendon dry mass, collagen content, and collagen cross-linking. *Am. J. Physiol. Regul. Integr. Comp. Physiol*. 2009;296(1):R119-124.
5. Real-time ultrasound analysis of articular cartilage degradation in vitro. Nieminen HJ, Töyräs J, Rieppo J, Nieminen MT, Hirvonen J, Korhonen R, Jurvelin JS. *Ultrasound Med Biol*. 2002 Apr;28(4):519-25.
6. Quantification of the optical surface reflection and surface roughness of articular cartilage optical coherence tomography. Simo Saarakkala et al. 2009 *Phys. Biol.* 54 6837-

using

Fig 1a
 cartilage optical coherence tomography
 Simo Saarakkala et al. 2009 *Phys. Biol.* 54 6837-6852

al Med. 6852

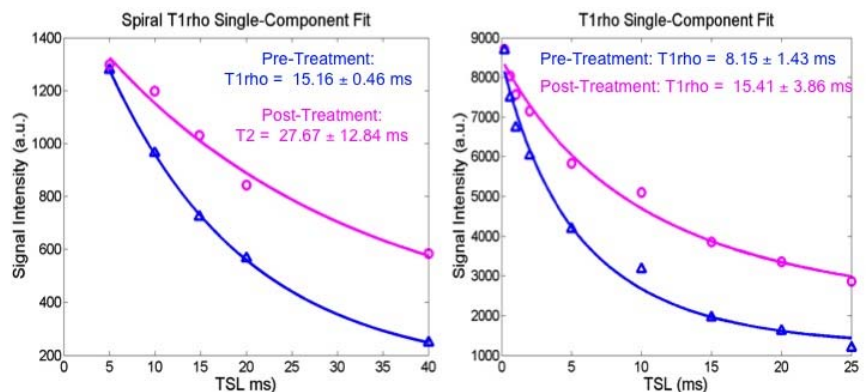
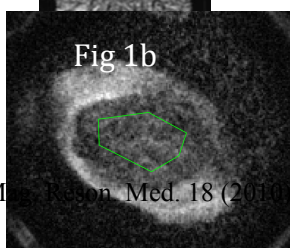
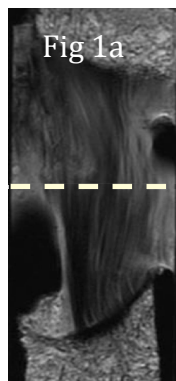


Fig. 1 : Sagittal T2 image of the PCL showing the positioning and the Imaging plane. (b) ROI placement.

Fig. 2 : fitting curve for one of the PCL, corresponding the the ROI shown in 1b.