

# MRI relaxometry to assess the tension state of the anterior cruciate ligament in vivo

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**TARGET AUDIENCE:** Orthopaedists will benefit from the evaluation of the tension within the anterior cruciate ligament (ACL) after a reconstructive surgery. Physicians will appreciate the MRI protocols used to measure in vivo the relaxometric parameters T1rho, T2 and T2\* of the ligament and the descriptive statistics used to quantify the MR parameter distribution within the ACL.

**PURPOSE:** While the diagnosis and treatment of a ruptured ACL have been under heavy study for the last three decades, the postoperative evaluation is still performed using qualitative methods assessing the success of the ACL reconstructive surgery. The aim of this study is to propose MRI relaxometry to assess the tension state of the ACL to bring a quantitative element to the postoperative evaluation process.

**METHODS:** Eight healthy volunteers, all male aged between 22 and 37, who gave their informed consent, were included in this protocol approved by the ethic committee of our institution. They had their left knee imaged using multi-parametric MRI in two positions: in full extension with the ACL under heavy tension, and at 20 degrees of flexion with the ACL nearly at rest<sup>1</sup>. All MRI acquisitions were performed on a 3T whole-body Philips Achieva X-Series scanner using a standard knee coil. Slices were oriented in the axis of the ligament in an oblique-sagittal plane. The sequences used to map the three relaxometric parameters T1rho, T2 and T2\* were adapted from Martirosian et al.<sup>2</sup> for a total measurement time of 25 minutes per position of the knee. The relaxometric parameters were extracted from the signal intensity by non-linear regressions to their respective signal expressions<sup>3,4</sup>. Using a semi-automated active contour model segmentation algorithm, the ligament was isolated in the relaxometric parameter maps (Figure 1). The distribution of the relaxation times within the ACL was analyzed using the descriptive statistics (average, standard deviation, minimum, maximum, coefficient of variation, third central moment, skewness, kurtosis, interquartile range, 5th percentile value and 95th percentile value) of the histogram (Figure 2). A two-way ANOVA was used to assess significant differences between knee positions and subjects. The repeatability study consisted in imaging the same patient on three separated occasions.

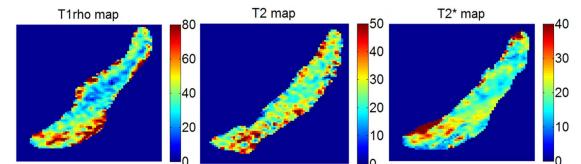


Figure 1 : Relaxation time maps.

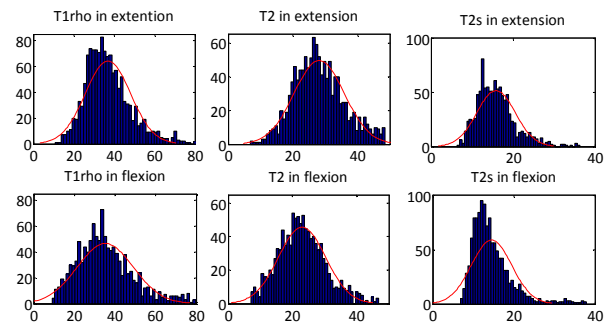


Figure 2 : Histograms

**RESULTS:** There were significant differences between knee positions for T1rho and T2\*, and between subjects for T1rho only (Table 1). The histogram analysis did not show any significant trend between knee positions or subjects. No significant differences were found between the 3 acquisitions performed on the same subject.

**DISCUSSION:** To our knowledge, this study represents the first attempt to assess directly *in vivo* the tension state of the ACL using multi-parametric MRI. T1rho seems to be a good indicator of the tension state within the ACL. T2\* could also be a good indicator, but since the repeatability study showed no difference for the knee position factor, more data should be acquired before concluding. Other relaxometric parameters could be tested to assess the tension state of the ACL such as T1, the apparent diffusion coefficient (ADC), or the magnetization transfer (MT). This study also shows the importance of detailing the position of the subject when comparing data since some relaxometric parameters (T2\*) are affected.

**CONCLUSION:** This study shows that T1rho is a good indicator to assess the tension state in the ACL non-invasively. Further developments could lead to quantitative measurement of the tension of the ACL thus helping in postoperative evaluation as well as in diagnosis.

## REFERENCES

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Table 1 : Two-way ANOVA results for the three relaxometric parameters at a  $\alpha=5\%$  significance level for all 8 subjects

	p-values		
	T1rho	T2	T2*
Subject	0.017*	0.15	0.207
Position	0.003*	0.055	0.012*