

# Comparison of Different Quantitative Approaches in $T_{1\rho}$ Relaxation Time Assessment of the Knee

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## Introduction

Magnetic resonance (MR) imaging provides useful information for the assessment of articular cartilages (1). In addition to morphologic assessment, MR imaging can evaluate the biochemical properties of articular cartilages using various parameters (1-4). It has been reported that  $T_{1\rho}$  relaxation time can be used to assess the glycosaminoglycan content of articular cartilages (1-4). In previous literature, four or five different  $T_{1\rho}$  prepared images acquired with different times of spin-lock pulse (TSLs) have been used for the calculation. However, a prolonged time for MR examination is disadvantageous for the patient. In this study, we assessed a simplified method of calculating  $T_{1\rho}$  relaxation times, which can be obtained using only two different  $T_{1\rho}$  prepared images. This method allows the examination time to be shortened. Additionally, we investigated the quality and efficacy of this method for diagnosis of the knee.

## Materials and Methods

Ten volunteers (age = 25 – 37, average = 30.2 years) were scanned on a 3 Tesla MR system (Achieva 3.0T, Quasar Dual, Philips Electronics) using an 8-channel T/R knee coil. Three of these 10 volunteers had a history of cartilage or meniscus injuries. Sagittal  $T_{1\rho}$  maps were calculated with an in-house developed software using IDL 6.3 (ITT Inc. Boulder, CO, USA) from  $T_{1\rho}$  prepared 3D-balanced gradient echo (GRE) images (TR/TE = 4.7/2.4 ms, FOV = 140 x 140 mm, matrix = 256 x 256, slice thickness = 3 mm, TSL = 1/20/40/60/80 ms, spin-lock pulse frequency = 500 Hz, number of slices = 26). Three types of simplified  $T_{1\rho}$  map ( $sT_{1\rho}$  map\_1\_40,  $sT_{1\rho}$  map\_1\_80 and  $sT_{1\rho}$  map\_40\_80) were calculated from signal intensities of  $T_{1\rho}$  prepared images using two different TSLs (1 and 40 ms, 1 and 80 ms, and 40 and 80 ms). We compared them with the conventional  $T_{1\rho}$  ( $cT_{1\rho}$ ) map, which was calculated from the signal intensities of  $T_{1\rho}$  prepared images using five TSLs (1, 20, 40, 60 and 80 ms). Sagittal 3D water selective excitation-cartilage (WATSc) balanced GRE images (TR/TE = 8.1/4.2 ms, FOV = 140 x 140 mm, matrix = 304 x 304, slice thickness = 2 mm) were also performed for the morphologic reference.  $T_{1\rho}$  values were statistically analyzed by paired t-test and  $p < 0.05$  was considered significant.

## Results

The entire imaging time required for  $sT_{1\rho}$  maps (6min 30s) was three-fifths shorter than that of the  $cT_{1\rho}$  map (16min 15s). The image quality of the  $sT_{1\rho}$  map\_1\_40 and of the  $sT_{1\rho}$  map\_1\_80 was the similar to that of the  $cT_{1\rho}$  map (Fig. 1). However, the  $sT_{1\rho}$  map\_40\_80 showed a poor image quality (Fig. 1). There was no significant difference in the  $T_{1\rho}$  relaxation times between the  $sT_{1\rho}$  map\_1\_80 and  $cT_{1\rho}$  map ( $p > 0.05$ ) (Fig. 2). The  $T_{1\rho}$  relaxation times of the  $sT_{1\rho}$  map\_1\_40 were lower and those of  $sT_{1\rho}$  map\_40\_80 were higher than those of the  $cT_{1\rho}$  map (Fig. 2). However, these differences were significant ( $p < 0.05$ ).

## Discussion

The simplified  $T_{1\rho}$  calculation method has the same potential as the conventional method to diagnose articular cartilage. We speculated that it would be appropriate to select two  $T_{1\rho}$  prepared images using the shortest and longest TSLs. However, the image quality would be poor if images using long TSLs only were selected because long TSL may decrease the signal-to-noise ratio of  $T_{1\rho}$  prepared image.

## References

[1] Choi YS et al. RadioGraphics 2008; 28:1043-1059, [2] Duvvuri U et al. Radiology 2001; 200:822-826, [3] Li X et al. Osteoarthritis and Cartilage 2007; 15:789-797, [4] Whitschey WRT et al. JMIR 2008; 28:744-754

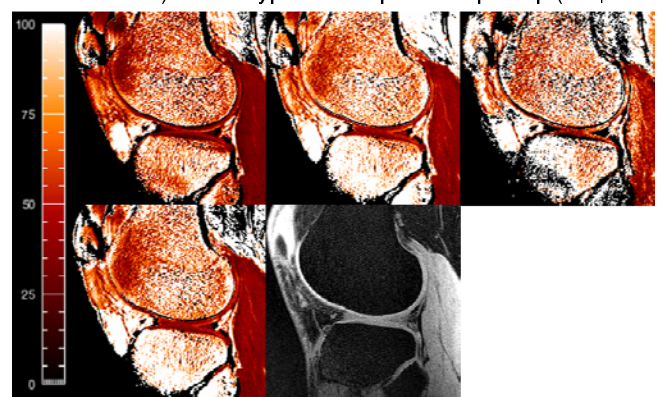


Figure 1.  $sT_{1\rho}$  map\_1\_40 (upper left),  $sT_{1\rho}$  map\_1\_80 (upper middle),  $sT_{1\rho}$  map\_40\_80 (upper right),  $cT_{1\rho}$  map (lower left), and 3D-WATSc image (lower middle) of the knee of a healthy volunteer.

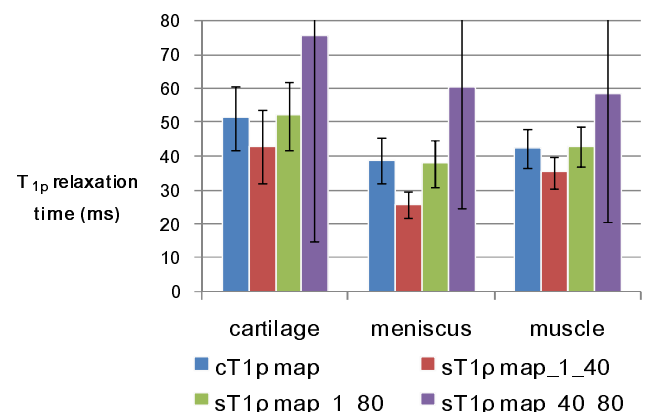


Figure 2.  $T_{1\rho}$  relaxation times of the cartilage, meniscus and muscle of a healthy volunteer calculated using four different methods