IMAGING COMPOSITIONAL CARTILAGE RECOVERY AFTER EXERCISE USING T1RHO AND T2 RELAXATION MAPPING

DA Kessler[1], J Kaggie[1], JW MacKay[1], AR Morgan[2], R Janiczek[3], MJ Graves[1] and FJ Gilbert[1]

[1] Department of Radiology, University of Cambridge, [2] Independent Clinical Imaging Consultant, [3] Experimental Medicine Imaging, GlaxoSmithKline

INTRODUCTION

Quantitative MRI signal relaxation properties such as T1rho and T2 are particularly promising for assessing changes in cartilage composition. T1rho and T2 relaxation times are sensitive to alterations in the collagen/proteoglycan and water content of articular cartilage [1]. Exercise affects quantitative MRI through cartilage compression and nonuniform deformation [2,3]. Exercise prior to image acquisition has been described as a confound in compositional MRI, but its diagnostic utility has not been evaluated.

The aim of this proof-of-concept study was to 1) determine whether there were exercise related changes after exercise, 2) determine the extent of those changes in healthy volunteers, and 3) determine whether those changes had a substantial effect on T1rho or T2 measurements in femorotibial cartilage.

METHODS

Two volunteers were imaged on a 3.0 T MRI system (MR750 GE Healthcare, Waukesha, WI, USA) using an 8-channel transmit/receive knee coil. The participants were both male (26, 36 years) and had no knee pain and no known history of joint disorders.

The study design consisted of T1rho and T2 relaxation imaging before exercise, and at multiple time-points after exercise. The exercise part involved five minutes of stepping onto a step-stool (height~24cm) with one leg and stepping down onto the other side of the step-stool with the opposite leg (leg being imaged). This process was controlled so to always be the same leg when stepping down.

The MR protocol before exercise included a high-resolution 3D GRE anatomical scan, T1rho imaging using a 3D FSE pulse sequence with +90°:spin-lock:-90° preparation (TR=1565ms, TSL=1,10,20,35ms, scan time=5:23min) and T2 imaging using a 3D FSE pulse sequence with T2-preparation (TR=1580ms, TE=6.5,13.4,27.0,40.7ms, scan time=5:25min). The following parameters were identical for the T1rho and T2 pulse sequences: field-of-view=160x144mm^2, matrix size=320x256 interpolated to 512x512, slice thickness=3mm, number of slices per TSL/TE=72. The T1rho and T2 pulse sequences were unchanged for the acquisitions at multiple time-points after exercise.

Quantitative T1rho and T2 maps were calculated on a voxel-by-voxel basis by fitting the signal intensities of the acquired TSL and TE data to the mono-exponential decay function using a linearised least squares algorithm. Compartmental analysis was performed by drawing regions-of-interest (ROIs) over the lateral and medial central femoral condyle (cLF/cMF) and the lateral and medial tibial cartilage (LT/MT). Mean T1rho and T2 values for each subject were calculated from the compartmental ROIs drawn on four consecutive slices.

RESULTS

The medial compartmental changes in T1rho and T2 after exercise for one subject are shown in Figure 1.

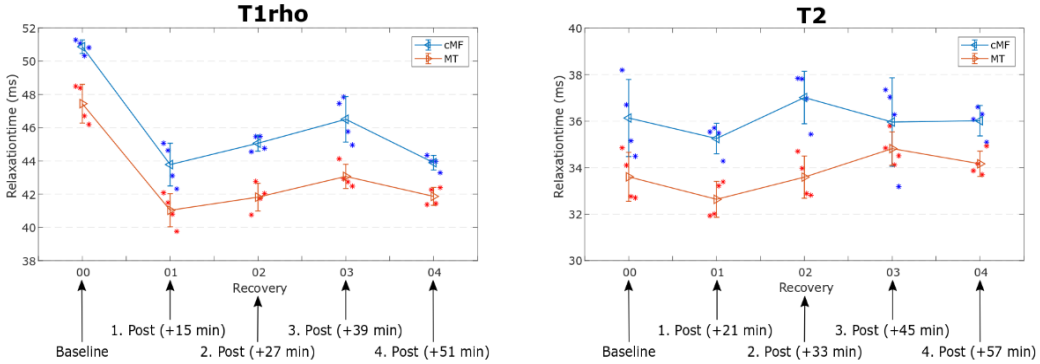

Figure 1 – Plots showing the means and SDs for T1rho and T2 values in medial femoral (blue) and medial tibial (red) compartments of one volunteer at baseline and four time-points post-exercise.

DISCUSSION AND CONCLUSION

This study was limited to few volunteers because the exercise performed was experimental, and we were uncertain whether the magnitude of joint loading would be sufficient to have an effect. We used an exercise which we thought was feasible for use in patients with joint pain.

The results demonstrate an exercise-related response in two subjects, however this requires further confirmation in more healthy subjects, as these effects of exercise can impact clinical studies. The mean T1rho changes after exercise were similar or greater than those seen between osteoarthritic and healthy patients (~6.5ms [4]), which suggests that these effects should be determined in order to improve the reliability of T1rho measurements for detecting disease. These results strongly encourage avoiding any exercise prior to imaging.

REFERENCES: [1] S. Van Rossom et al. *PLoS One*. 2017, 12(1); [2] F. Eckstein et al. *Anat. Embryol. (Berl)*. 1999, 200(4); [3] M.A. Kessler et al. *Am. J. Sports Med*. 2008, 36(5); [4] X. Li et al. *Osteoarthr. Cart*. 2007, 15(7)