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PILOT STUDY OF CARTILAGE CREEP AND RECOVERY DETERMINED WITH NONINVASIVE MAGNETIC RESONANCE IMAGING AND CLASSICAL MECHANICAL TESTING

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INTRODUCTION

Knee osteoarthritis (KOA) is commonly diagnosed by pain and radiographic findings, but these may not be present in the early stages [1,2]. Alternatively, tissue response to mechanical loading has been suggested as a potential biomarker for early OA [2]. Recently, a magnetic resonance imaging (MRI) stress test was proposed to measure cartilage creep [3]. However, the accuracy of this approach has not been tested. Therefore, this study aimed to develop and test a fast-imaging sequence to quantify *ex vivo* creep and recovery response and compare it to a classical mechanical test performed in a controlled environment.

METHODS

A 4.5% weight/volume agarose plug (9 mm diameter) was prepared and underwent unconfined creep and recovery test using MRI and classical mechanical testing. For the MRI test the sample was loaded in a custom-made MRI-compatible device within a knee coil. Sagittal plane images were generated using a multiphase FIESTA sequence (FOV: 12 cm; resolution: 160x200; slice thickness: 4 mm; flip angle: 45°; TR: 4.3 ms; TE: 1.8 ms) with a 3T scanner sampling at 1.62 Hz. After 5 minutes of preloading (0.01N), the initial thickness was determined from reference images. Subsequently, a compression creep load (0.982N) and recovery load (0.01N) were applied, and both imaged for 5 minutes, respectively. Thickness changes were manually segmented from selected MRI images in both phases, and a power fit was performed separately in each phase. Finally, the sample underwent an identical loading scenario using a DMA850 sampling at 3Hz.

RESULTS AND DISCUSSION

Mechanically loading the sample resulted in a time-dependent creep and recovery response (Figure 1), but differences were observed between the response. The initial elastic contribution showed great agreement, but the creep strain was overestimated with the MRI (Table 1). Strain calculations based on sub-millimetre changes of voxels are highly sensitive, and one voxel difference would result in an average error of 3.47%. Thus, accounting for partial volume artifacts and limited spatial resolution is necessary for accurate estimations.

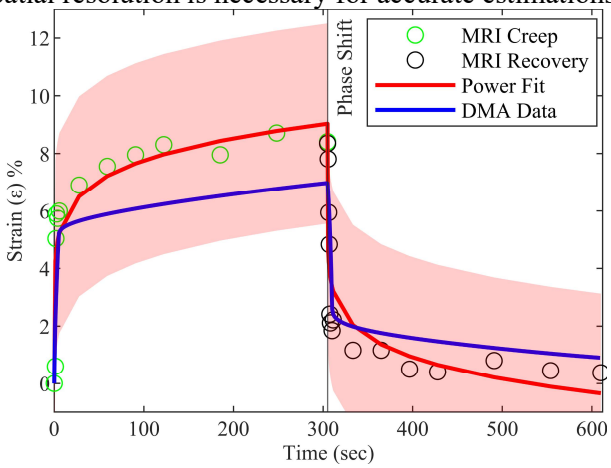

Figure 1 Creep and recovery response of the sample, including error estimates of one voxel.

CONCLUSIONS

The agarose gel sample showed a time-dependent creep and recovery behaviour during compressive loading, indicating that fast imaging MRI sequences may pose as a tool to determine *in vivo* creep and recovery response. Nevertheless, future work is needed to validate the accuracy and reliability of this approach.

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Table 1: Comparison of the equilibrium and initial strains for the creep and recovery response of the sample with the MRI and DMA.

	Initial sample thickness	Creep strain after 4 min	Initial loading strain after 5 sec	Recovery strain after 4 min	Initial unloading strain after 5 sec
MRI-measurements	6.62 mm	0.58 mm (8.7%)	5.14% (1.02%/s)	0.0 mm (0.0%)	5.65% (1.13%/s)
DMA-measurements	6.68 mm	0.45 mm (6.8%)	5.20% (1.04%/s)	0.07 mm (1.08%)	4.4% (0.88%/s)