Validation of rheo-markers in ex-vivo human cartilage for early OA detection using multiscale MRI.

Early diagnosis of OA using current imaging methods rarely happens prior to symptom onset. This is due to the biochemical changes occurring before macroscopic morphological changes as seen on x-ray or conventional MRI protocols. Supinated MRI does not load the knee joint which potentially masks a potential a novel source of MR contrast, here termed rheo-markers. It is hypothesised that when OA cartilage responds to mechanical loading following degradation, it creates specific contrast in MR images, indicative of microstructural change that may be used for earlier OA detection.

Tibial plateau cubes containing subchondral bone and cartilage were sectioned from total knee replacement surgeries, vacuum sealed and placed in a custom-made compression cell. Imaging and spectroscopy were conducted for both proton and sodium nuclei on a Bruker 9.4T Ultra-high field microimaging system.

Proton T2* relaxation increases in OA cartilage during compression across the depth of the cartilage, with formation of a thin band of shorter T2* close to the articular surface. This suggests the generation of more structural disorder in the collagen fibres deeper beneath the cartilage surface, however greater structural order towards the articular surface. When compression is released, cartilage surface T2* increases back towards that of uncompressed cartilage. This dynamics in fibre re-organisation within the cartilage, induced by mechanical loading might highlight potentially clinically promising underlying mechanism by which physiotherapy aids OA symptoms by increasing articular surface order. Heterogeneity of T2* decreases on the articular surface during compression but returns toward baseline following release. Bulk changes in bound and free sodium by Multiple Quantum Filtered (MQF) sodium ($^{23}\text{Na}$) spectroscopy during compression shows that bound sodium is decreased during compression (p<0.006), but does not recover to baseline after release indicating disruption of collagen fibres and glycosaminoglycan unit's capacity to bind $^{23}\text{Na}$. This shift in $^{23}\text{Na}$ release will be investigated in healthy cartilage to ascertain if this effect is specific to disease tissue.

This novel investigation of rheo-markers has shown the potential for multi-nuclear MRI biomarkers in mechanically loaded joints with good evidence of a dynamic $^{23}\text{Na}$ environment during compression which may be useful for early OA detection before symptoms occur.