Post-Traumatic Osteoarthritis Following a Sub-Critical Impact by µMRI

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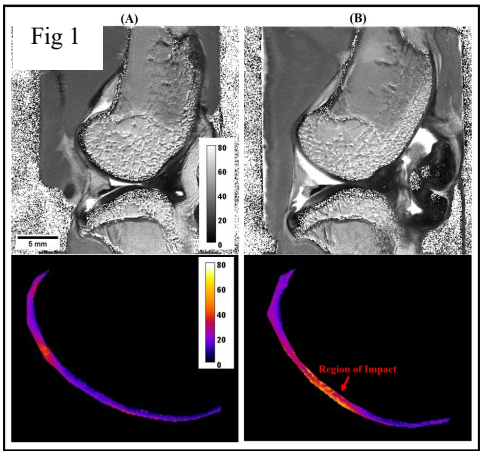
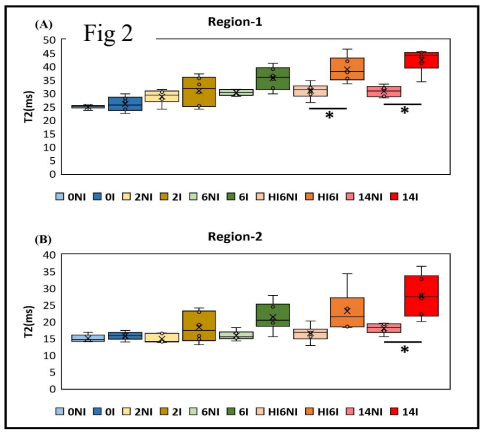
Introduction: Osteoarthritis (OA) is a degenerative joint disease affecting millions of people, leading to pain and disability due to the degradation of articular cartilage [1]. Since treating OA becomes challenging if it is not diagnosed early, it is essential to understand the progression of the disease. This study focuses on the progression of post-traumatic osteoarthritis (PTOA) from the early stage through 14 weeks after a single sub-critical impact (~30MPa) to the femur in rabbits.

Methods: A total of thirty NZW rabbits were used to track OA progression following a controlled mechanical injury to the right knee femur while the non-impact left femurs served as a control for comparison. After the impact, the rabbits were divided into five groups of six and sacrificed at 0, 2, 6, and 14 weeks to assess OA progression in the femur articular cartilage (AC). At the 6-week timepoint, two groups were compared to evaluate the severity of cartilage damage, with one group receiving the sub-critical impact and the other with an impact ~65MPa. The intact rabbit knees were imaged using a 7T µMRI and cartilage damage was monitored using MRI T2 mapping where T2 values tracked the deterioration of the cartilage. To better study the effects of impact on cartilage the total cartilage thickness was divided into two equal regions (upper and lower) for analyzing T2 values.

Results and Discussion: After a sub-critical impact to the femur AC, a gradual increase in T2 values was observed in both regions of impact cartilage over time, indicating progressive cartilage degradations through 0, 2, 6, and 14 weeks. At 2 and 6 weeks, the changes in T2 values between non-impact and impact AC were slightly elevated when compared to the baseline (week 0), suggesting the onset of OA with early tissue damage. By 14 weeks, statistically significant changes were observed in T2 values for both regions between non-impact and impact AC indicating continued degradation of cartilage (Fig 1). At the 6-week timepoint, notable differences were seen between the 30MPa and 65MPa groups. Gradual increase in T2 values of femur AC following a sub-critical impact indicates that a direct minor injury to the cartilage can lead to significant cartilage degradation and OA development over time (Fig 2). Higher T2 changes between non-impact and impact AC for the 65MPa group suggests that a stronger mechanical force can speed up cartilage degradation [2, 3].





Conclusion: This study demonstrates the effectiveness of MRI T2 imaging for successfully tracking OA progression following a mechanical injury to the knee joint. The findings of this study can contribute to a better understanding of OA progression, biomechanical factors involved in OA progression, and the need for early OA diagnosis to plan for successful treatments.

References: [1] Xia, Bone Joint Res. (2013). [2] Mantebea, et al, J. Ortho. Res. (2024). [3] A Singh, et al, Connective Tissue Res. (2024).