

A Reliable Pre-Clinical Impact Model of Posttraumatic Arthritis in Rabbit

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Purpose: Posttraumatic osteoarthritis (PTOA) is responsible for 12% of all OA cases in the US. It can be initiated by a single traumatic event such as a high-impact load acting on articular cartilage. A reliable animal model of PTOA is necessary to better understand the mechanisms by which cartilage injury progresses, and to test novel therapeutics. The goal of this study was to develop a drop tower-based rabbit femoral condyle impact model to generate PTOA.

Methods: IACUC approval was obtained for this study utilizing 25 New Zealand White rabbits weighing 3.0 to 4.2 kg. A posterior approach was used to expose the rabbit posterior medial femoral condyle (MFC). A 1/16" diameter Kirschner wire (K-wire) was inserted through both condyles in the medial-lateral direction and secured to a platform. A drop tower with a carriage on 2 vertical rods was brought over the femoral condyle. A 3-mm-diameter impactor head was mounted on the carriage, with an impacting surface that had radii of curvature approximated to the femoral condyle. The correct MFC location was verified prior to impact. The carriage was dropped 7 cm onto the MFC. Impact data were collected via load and acceleration sensors and calculated using MATLAB. Rabbits were euthanized at 8 and 16 weeks post-impact, and knees were harvested for sectioning and staining with terminal deoxynucleotidyl transferase dUTP nick end labeling (TUNEL), and Safranin-O Fast Green for OARSI (Osteoarthritis Research Society International) scoring to assess cartilage degradation and chondrocyte apoptosis.

Results: The peak load was 660.06 ± 130.24 N, with stress of 93.38 ± 18.42 MPa. The impact duration was 5.57 ± 1.15 ms, while the impulse was 1.79 ± 0.23 N-s and work done was 0.46 ± 0.13 J. There were 4 exclusions, 3 of which were for condylar fracture secondary to errant K-wire placement, and 1 for sensor malfunction. The peak load had a coefficient of variation (CV) of 19.73%. Other impact parameters were also reproducible, with maximum CV of 28.0% for work. Articular cartilage from knees harvested at 8 and 16 weeks had 48.52%, and $67.82\% \pm 7.14\%$ TUNEL-positive cells, respectively. The OARSI score of the 8- and 16-week MFCs were 12.2 ± 3.9 , and 10.0 ± 0.0 , respectively. The highest OA stage of each section was in the zone of impact.

Conclusion: A technique was developed to deliver a consistent impact load to the MFC of rabbits. Accurate pin placement is paramount to prevent osteochondral fracture. This model will allow better understanding of PTOA and potential treatment strategies.