INFLUENCE OF BIOMECHANICAL LOADING ON THE PHYSICAL BEHAVIOR OF A HYDROGEL AFTER INJECTION INTO NATIVE HUMAN KNEES

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Introduction

The treatment of knee osteoarthritis ranges from non-operative, early interventional concepts up to operative joint replacement [1]. A new method under research is the injection of a gelatinous hydrogel, which can be loaded with agents like ibuprofen, other suitable NSAIDs or cartilage-protective ingredients [2]. As the hydrogel is injected into the knee joint capsule, there is potential risk of granulation and accumulation during knee articulation. The objective of this biomechanical *in-vitro* study is to investigate the physical behavior of the hydrogel after short-time physiological loading, when injected into native human cadaveric knees.

Methods

For this study, 15 fresh frozen, native human cadaveric knees with intact capsule, including all relevant tissues in the area of the knee joint, were used. The specimens were prepared, embedded and aligned with a six degrees of freedom joint motion simulator (Advanced Mechanical Technologies Inc., Watertown, MA) following a complex workflow. To restore joint fluid, 9 ml of human serum was injected into the capsule prior to testing. Native kinematics were recorded for level walking and stairs ascending activities (AVER75, [3], reduced to 25 % of the absolute load values [4]). 2.5 ml hydrogel, enriched with 0.03 % fluorescein, was injected retro patellary into the joint capsule (Fig. 1). To simulate short-term activities of the knee, the previously recorded kinematics were applied to the specimens in displacement control, leaving only axial load in force control. The specimens were exposed to 1800 cycles of level walking and 900 cycles of stairs ascending. After the loading, the capsule was opened using a medial parapatellar approach. For detection of the hydrogel, the articulating surfaces were visually inspected under ultraviolet light for fluorescein reaction. In addition to this, the articulating surfaces and the joint fluid were analyzed for a chemical polyethylene glycol reaction with Dragendorff reagent.

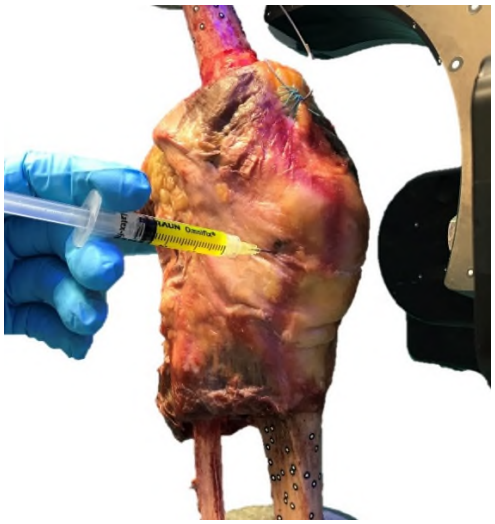

Figure 1: Retro patellar injection of the Hydrogel.

Results

The analysis of injected hydrogel was possible in 10 of 15 specimens, 5 specimens had to be excluded from the study because of leaking knee capsule or hydrogel injection into surrounding tissue as e.g. hoffa's fat body. For all included specimens, except two, an even fluorescein distribution within the whole knee capsule was observed under ultraviolet light (Fig. 2). The Dragendorff reagent application to the articulating surfaces also showed no granulation nor accumulation of the hydrogel. For the extracted joint fluid, a reaction of the Dragendorff reagent was observed.

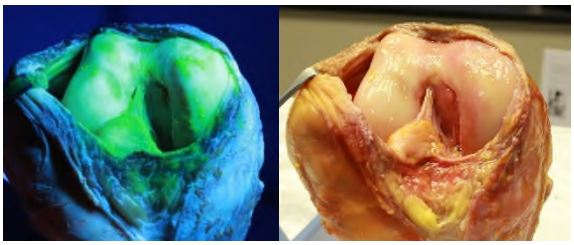

Figure 2: left: Fluorescein distribution within the knee joint; right: Joint surface after Dragendorff application.

Discussion

The observed fluorescein detection and Dragendorff reagent reaction show, that no granulation or accumulation of the injected hydrogel occurs after short-term dynamic loading of the knee specimens. The hydrogel mostly dissolves in the joint fluid.

References

1. Richards et al, Phys Sportsmed, 44(2) : 101-108, 2016.
2. InGel-NxG, German BMBF funding code 13XP5086
3. Bergmann et al, PLoS One 9 (1) : e86035.
4. Willing et al, JOR, 2172–2181, 2019.

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