An in vitro study of cartilage–meniscus tribology to understand the changes caused by a meniscus implant

Sara Ehsani Majd1, Aditya Iman Rizqy1, Hans J. Kaper1, Tannin A. Schmidt2, Roel Kuijer1, Prashant K. Sharma1
1University Medical Centre Groningen, The Netherlands; 2University of Calgary, Canada
p.k.sharma@umcg.nl

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ABSTRACT INTRODUCTION: Active lifestyles increase the risk of meniscal injury. A permanent meniscus implant of polycarbonate-urethane (PCU) is a promising solution to prevent total knee arthroplasty. The purpose of this work is to study the changes in articular cartilage tribology in the presence of PCU, which is essential in developing the optimum meniscus implant.

METHODS: A cartilage–meniscus reciprocating, sliding model was developed mimicking the stance and swing phases of the gait cycle, in simulated physiological conditions. The meniscus was replaced with PCU to study the changes. Coefficient of friction (COF) was measured during sliding, and wear of cartilage was determined histologically and quantified according to a custom-made scoring system. In addition, three surface modifications of PCU were evaluated: PCU with C18 chains, mono-functional polydimethylsiloxane and mono-functional polytetrafluoroethylene groups.

RESULTS SECTION: Cartilage–meniscus sliding resulted in low COF during both stance and swing (0.01<COF<0.12) and low wear of cartilage (scores<1). Cartilage–PCU sliding, during stance, revealed similar low COFs. But during swing, the COFs were high (~1) with a maximum value of 1.6 (Figure 1). COF increased with increasing the sliding time and decreased with increasing the contact pressure (according to a power equation) up to 1MPa. The tested biomaterials and meniscus occasionally damaged the cartilage. Changes in the lubricant solution or surface modification of PCU did not affect PCU’s tribological performance.

DISCUSSION: The increase in COF during the swing phase of the gait cycle, measured at the cartilage–PCU interface, indicates breakdown of interstitial fluid pressurization lubrication and non-effective activation of the boundary lubrication. Therefore, permanent meniscus implants made of PCU may result in patient discomfort and wear of cartilage in the long term. No systematic correlation was found between the damage and the experimental condition. The wear of cartilage against biomaterial was not higher than its wear against meniscus under experimental conditions.

SIGNIFICANCE: (1-2 sentences): Chondroprotective and low friction performance of biomaterials is essential for their application for meniscus implant. We showed that a change in lubrication mechanism takes place going from stance (low COF) to swing phase (high COF) in cartilage–biomaterial interface but not at the cartilage–meniscus interface. These findings are necessary to be noted before modifying the biomaterials to achieve similar performance from the prosthesis as natural meniscus.

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IMAGES AND TABLES:

Figure 1. The COF of friction is plotted against the Contact Pressure. It can be noticed that the value of the COF is higher for the biomaterial in the swing phase when compared to the one of the native meniscus. In the stance phase the COF of the biomaterials and the native meniscus show the same range of values.