Osteochondral Replacement Therapy for Knee Articular Cartilage Injury: A Tribological Study

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Introduction

Articular cartilage injuries do not heal and surgical repair still poses a difficult challenge. Following injury, the cartilage surface continues to wear, ultimately leading to arthritis and functional limitations. While significant advancements have been made in reparative procedures, all current methods are still unable to completely restore normal articular cartilage structure and function. As a result, we continue to search for better artificial materials and surgical techniques to restore the articular surface and allow long-lasting, painless joint function.

Objectives

The objective of our study was to compare different potential artificial materials in a cartilage repair model to see which one exhibited the most ideal tribological properties and minimized wear of the opposing native cartilage surface. We also wanted to elucidate mechanisms responsible for articular cartilage wear against these materials in order to develop optimal repair strategies and wear prevention.

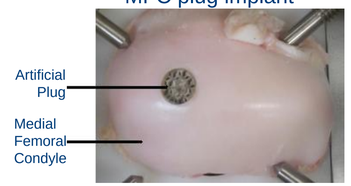
Methods

Three artificial materials, polyurethane, chrome cobalt, and PEEK, were evaluated. 1 by 1 cm round plugs of the artificial material were implanted into separate bovine medial femoral condyles and run against the matching medial tibial plateau counter-surface using a reciprocating modified pin-on-disc test apparatus to measure friction and pressure. Trials were set to run for 1 hour under pre-determined physiological conditions. Images were obtained pre- and post-trial using digital microscopy and optical profilometry to quantify results.

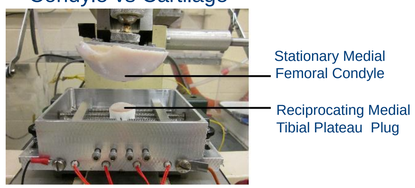
Settings

Parameter	Time
Time	60 min
Stroke Length	2 cm
Frequency	1 Hz
Force	250 N
Temperature	37º C

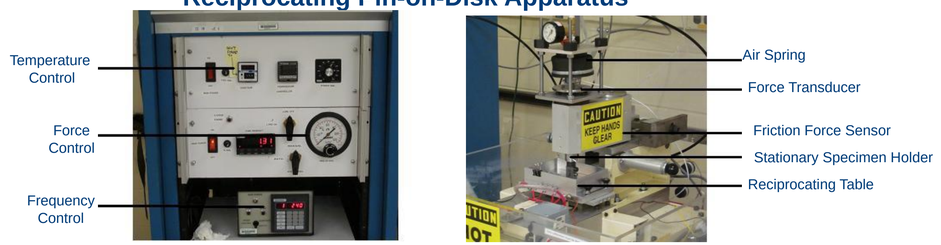
MFC plug implant



Condyle vs Cartilage



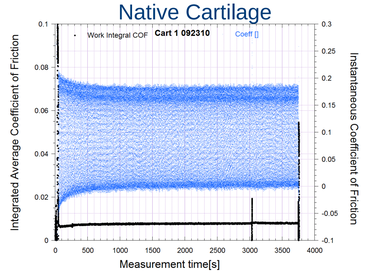
Reciprocating Pin-on-Disk Apparatus



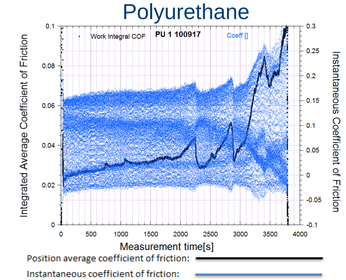
Results

Friction Results

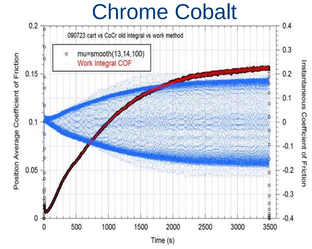
Native Cartilage



Polyurethane



Chrome Cobalt



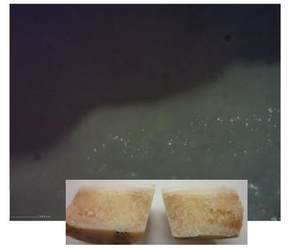
Native femoral condyle cartilage produced a small and constant coefficient of friction of 0.007 against medial tibial plateau cartilage. A polyurethane plug produced a coefficient of friction of 0.025, which was maintained until it increased erratically at the end of the trial. A chrome cobalt plug produced a coefficient of friction that started at 0.01 and increased monotonically until reaching a value greater than 0.2 toward the end of the trial.

Wear Results

Native Cartilage

Polyurethane

Chrome Cobalt



Native cartilage produced negligible wear on the tibial cartilage surface. Polyurethane produced minor noticeable wear upon cross section. Chrome cobalt produced significant wear damage to the cartilage surface, completely wearing the cartilage down to the bone.

Conclusion

The artificial surface materials tested were not able replicate the unique tribological properties of native cartilage. While normal cartilage produces negligible wear and has an inherently low coefficient of friction, the implanted materials resulted in higher coefficients of friction and increased cartilage wear. Polyurethane does, however, produce significantly lower friction and wear than chrome cobalt, which is commonly used for unipolar resurfacing of a joint. Further trials are planned to complete our study and determine if polyurethane is another potential material that can be used for repairing damaged cartilage surfaces.

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