Arthroscopic Joint Resurfacing: a Tribological Study of Friction and Wear

Joseph A. Gil, Robert Erck, PhD*, **Steven C. Chudik, MD;**
OTRF, Loyola University Chicago Stritch School of Medicine, *Argonne National Laboratory, Energy Systems Division, Hinsdale Orthopaedics

Introduction

Articular cartilage injuries are associated with joint trauma. Following injury, the articular cartilage surface continues to mechanically degenerate, causes accelerated degeneration of the opposing cartilage surface, and leads to functional limitations. Many of the current surgical approaches to treating isolated unipolar articular cartilage injuries fall short of restoring a normal articular cartilage surface. Therefore, we must confront the issue of altered tribological properties, continued degradation of the joint surface, and subsequent arthritis.

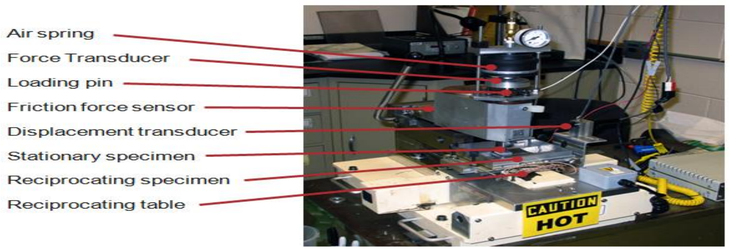
Objectives

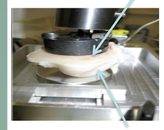
The purpose of our study is to investigate the tribological behavior of bovine cartilage sliding against different artificial surface materials utilized in partial joint resurfacing. We hypothesize that through tribological studies, we will find the artificial material that least damages the opposing cartilage under dynamic loading force, and we will attain a better understanding of the mechanism of cartilage wear.

Methods

The friction and wear tests were conducted with a reciprocating modified pin-on-disc test apparatus. The modified pin consisted of the lateral femoral condyle mounted on a ball-joint fixture, and the disc consisted of the material being evaluated. A section of the lateral tibial plateau served as a native cartilage control surface.

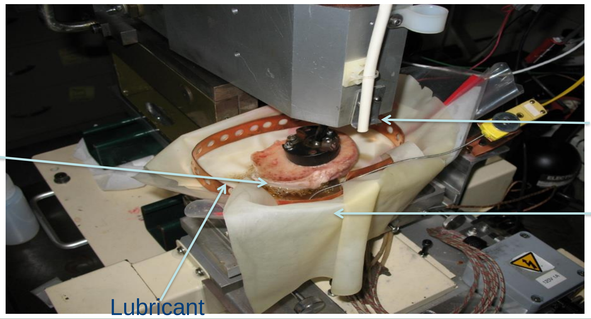
Parameters	
Test:	reciprocating type
Lubricant:	1:3 mixture of Newborn Calf Serum and Ringer's lactate solution
Reciprocating rate:	2 Hz
Temperature:	37 C
Force:	250N





Lateral femoral condyle

CrCo counterface



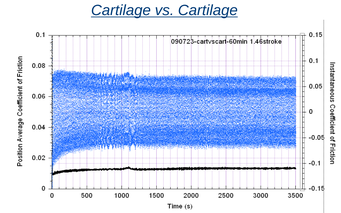
DI Water replenishment tube

Latex fluid container

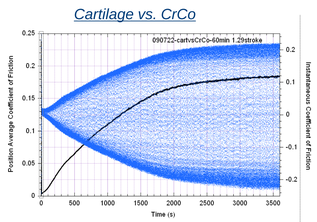
Results

A tibial cartilage counterface produces an average coefficient of friction generally between 0.01 and 0.02. A chrome cobalt counterface produces a coefficient of friction that increases monotonically, as a function of time, and attains a steady state between 0.15 and 0.2. A polyethylene counterface produces a generally decreasing frictional behavior with increasing sliding time and number of strokes. The polyurethane counterface produces a coefficient of friction that is generally between 0.02 and 0.04.

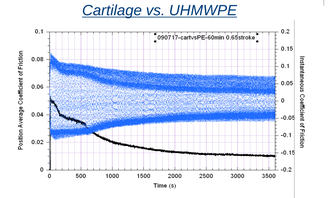
Cartilage vs. Cartilage



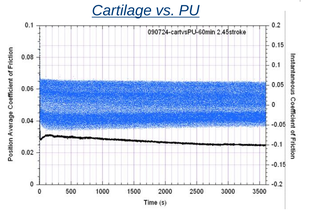
Cartilage vs. CrCo



Cartilage vs. UHMWPE



Cartilage vs. PU



Position average coefficient of friction:

Instantaneous coefficient of friction:

Position Average Coefficient of Friction (all dates)

AVERAGE 0f all dates:	cart v cart	CrCo	PE	PU		
60 (s)	0.009191614	0.009341067	0.079695714	0.025772043		
600 (s)	0.013316757	0.067198857	0.074535429	0.033290286		
1200 (s)	0.013596529	0.101749	0.065971143	0.035009429		
1800 (s)	0.014154757	0.119563429	0.055909714	0.031891286		
2400 (s)	0.014936929	0.127886286	0.048894857	0.029782		
3000 (s)	0.014259214	0.132553857	0.044924571	0.028882286		
AVG	0.013242633	0.093048749	0.061655238	0.030771221		
sd	0.002062888	0.047388233	0.014040931	0.00331967		

t-tests:	cart v cart vs CrCo	cart v cart vs PE	cart v cart vs PU	CrCo vs PE	CrCo vs PU	PE vs PU
p-values =	0.008	0.001	0.000	0.260	0.021	0.003
p < 0.05	(significant difference)					

Position Average Coefficient of Friction (3000s)

AVERAGE of 3000s data:	cart v cart	CrCo	PE	PU		
7/14/2009	0.029605	0.086014	0.028076	0.02458		
7/16/2009	0.018184	0.16321	0.038528	0.038156		
7/17/2009	0.015824	0.050463	0.011297	0.030181		
7/20/2009	0.0070965	0.10724	0.091957	0.024574		
7/22/2009	0.014752	0.18083	0.0355	0.031914		
7/23/2009	0.01304	0.15303	0.07921	0.027825		
7/24/2009	0.010313	0.18709	0.029904	0.024946		
AVG	0.014259214	0.132553857	0.044924571	0.028882286		
sd	0.004555793	0.051976769	0.029318891	0.005009373		
t-tests:	cart v cart vs CrCo	cart v cart vs PE	cart v cart vs PU	CrCo vs PE	CrCo vs PU	PE vs PU
p-values =	0.001	0.046	0.000	0.006	0.002	0.221
p < 0.05	(significant difference)					

Conclusion

We demonstrated that artificial joint resurfacing implant materials produce coefficients of friction that are higher than the coefficient of friction produced by the native cartilage counterface in reciprocation studies. However, all artificial materials do not produce equal coefficients of friction and the selection of material used in surgery should not be arbitrary. We showed that the coefficient of friction produced by the polyurethane counterface is significantly lower, and more equivalent to the coefficient of friction produced by the cartilage counterface, than the coefficients of friction produced by chrome cobalt and polyethylene counterfaces.

References

Forster, H, Fisher, J. The influence of continuous sliding and subsequent surface wear on the friction of articular cartilage. J Proc Instn Mech Engrs Vol 213 Part H

Muller, L.P., Degreif, J., Rudig, L., Mehler, D., Hely, H. Rommens, P.M. Friction of ceramic and metal hip hemi-endoprostheses against cadaveric acetabula. Archives of Orthopaedic and Trauma Surgery (2004) 124: 681–687

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