Low Friction Visco-Elastic Polymers as Future Materials for Articulation with Native Cartilage

Sague, J., Andreatta, B., Egli, R., and Luginbühl, R.
RMS Foundation, Bettlach, Switzerland

Introduction

Osteoarthritis (OA) has been mainly affecting elderly people. Onsets of early degeneration are, however, also found more frequently in younger patients. Therefore, novel early intervention surgical concepts are developed aiming to preserve functional native cartilage tissue. In our study we met concern that traditional orthopedic materials are not suitable for that approach.

Goal: **to investigate the tribological behavior of six traditional orthopedic material families versus cartilage tissue and to compare to three classes of visco-elastic materials**

Methods

- The coefficient of friction (CoF) was measured on a custom-made instrument with a normal load of 0.1 MPa at room temperature. The cartilage pins were slided in a reciprocal linear path over the sample surface at 1 Hz. DMEM supplemented with 10% FBS was used as lubricant (Fig. 1).
- Static creep measurements were performed with a Zwicki Z5.0 in an unconfined setup with a load of 0.1 MPa between the pins and the materials
- All experiments were performed at least three times with three pins each.

Table 1: The studied material were divided in four groups according to their mechanical properties

Group I	Group II	Group III	Group IV
CoCrMo	UHMWPE	PCU-I	PHEMA-I
Al_2O_3	PEEK_I	PU-I	PHEMA-II
ATZ	PEEK_II	PU-II	PHEMA-III
	PEKK	PU-III	

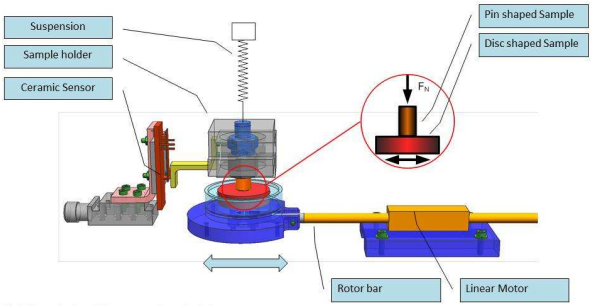

Fig. 1: Schematic representation of the custom-made tribometer used in this study

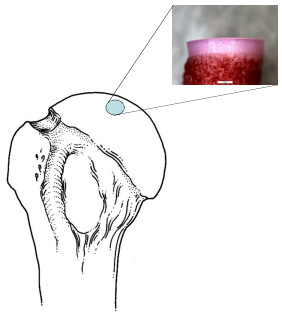

Fig. 2: Design of a humeral porcine head and picture of an osteochondral pins extracted from it

- Materials:
  - Flat discs (Ø 29-32mm) made of CoCrMo, Al2O3, ATZ, UHMWPE, PEEK and PEKK were polished according to standard protocols. PCU and PU samples were prepared by injection molding, and PHEMA-co-MMA co-polymers were custom synthesized (Table 1)
  - Osteochondral pins (Ø 5 mm) were harvested using a biopsy punch from humeral heads of intact porcine shoulder joints within 24 hours after death (Fig. 2).

Results

- The CoF of cartilage tissue versus viscoelastic materials were 3 to 8 fold lower as compared to traditional orthopedic materials (Fig. 3).

CoF Group I-II	>>	CoF Group IV	>	CoF Group III
0.3 – 0.6		0.07 – 0.13		0.04 – 0.10

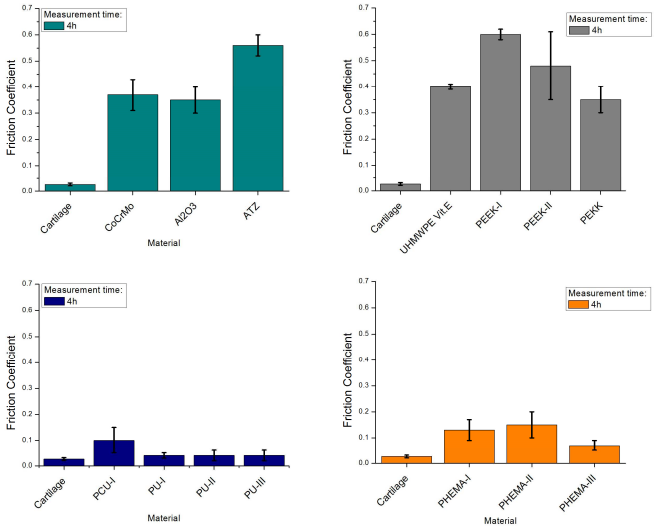

Fig. 3: CoF values versus cartilage for different orthopedic traditional materials

	Displacement values in mm		
Materials	Pin 1 (h=0.81±0.07mm)	Pin 2 (h=1.46±0.12mm)	Pin 3 (h=1.23±0.09mm)
PHEMA-II	1.31	1.61	1.41
PCU	1.03	1.57	1.16
PEEK	0.92	1.60	0.78
ATZ	0.64	1.26	0.86

Table 2: Experimental creep values for the osteochondral pins on different materials at 0.1 MPa during 1h measurement

- The static creep behavior of the cartilage pins was higher in viscoelastic materials as compared to hard materials (Table 2 and Fig. 4).

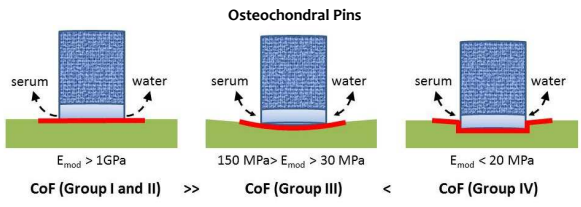

Fig. 4: CoF values versus cartilage for different orthopedic relevant materials

Discussion

The chosen visco-elastic materials showed superior tribological properties as compared to traditional orthopedic materials. This was attributed to the different tribological interaction, i.e. the efficient lubrication and a similar elastic modulus as compared to cartilage tissue. Though the exact role of these factor requires additional elucidation, visco-elastic materials are potential candidates in orthopedic applications when articulating against native cartilage.

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Contact: jorge.sague@rms-foundation.ch