Two Orthopedic Biopolymers Wear Tested with a Visco-supplement Added to the Lubricant

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Introduction: Hyaluronic acid is an important component of synovial fluid. Injections of hyaluronic acid solutions, often known as visco-supplements, into the joints of patients suffering from osteoarthritis are an accepted therapy. Most of these solutions are avian derived but those produced by biological fermentation may provide a safety advantage (1). For most replacement joints, wear of the biomaterials used in them is a critical concern. When wear testing such orthopedic biomaterials the recommended lubricant is one based on bovine serum, which contains proteins similar to those in synovial fluid. However, it is recognized that bovine serum is not identical to synovial fluid. Previously only two studies have reported wear tests under multi-directional motion of biomaterials in the presence of lubricants, where hyaluronic acid has been added to bovine serum. In a hip simulator study no difference in wear rates was reported (2). In a knee simulator study a seven-fold increase in wear was reported (3). The aim of the work reported here was to take a clinically used hyaluronic acid solution, Ostenil®, and to investigate its influence on the wear of two orthopedic biopolymers.

Methods and Materials: Two biopolymers were wear tested: poly tetra fluoro ethylene (PTFE) and ultra high molecular weight polyethylene (UHMWPE). The biopolymers were tested in turn using a four-station, multi-directional, pin-on-plate wear test rig which had previously been shown to reproduce clinical wear factors for UHMWPE, PTFE and polyacetal in vitro (4). The polymeric test pins were subject to multi-directional motion through the combination of a rotational and a reciprocating motion. For each biopolymer three lubricants were tested: 33% bovine serum (2 stations); 33% bovine serum + Ostenil® (1 station); and distilled water + Ostenil® (1 station). All polymers were articulated against 316 stainless steel plates which had been polished to a surface finish of better than 0.05µm Ra. Test pins were subject to a load of 40N and the wear test rig ran at a reciprocating speed of 1Hz. A stroke of 30mm was used. A consistent cleaning and weighing protocol was followed, with pins and plates being weighed on a balance with a sensitivity of 10µg. Taking the density of PTFE as 2,160kg/m^3 and UHMWPE as 953kg/m^3 allowed the volume loss to be calculated. In turn wear factors were determined by dividing the volume lost by the product of the load and the sliding distance (units x 10^{-6}mm^3/Nm).

Results: The PTFE tests ran to 10.4km sliding distance, those of UHMWPE to 66.3km sliding distance. The wear test results are given in table 1. The wear of PTFE appeared to be increased by the addition of Ostenil® to bovine serum. For UHMWPE the addition of Ostenil® to bovine serum caused a non-significant reduction in wear.

Table 1 - wear of biopolymers in presence of different lubricants (units x 10^{-6}mm^3/Nm)

Material Lubricant	PTFE	UHMWPE
33% Bovine Serum	44	1.50
33% Bovine Serum	36	1.69
33% Bovine Serum + Ostenil®	59	1.42
Distilled Water + Ostenil®	10	0.018

Discussion: PTFE provides an accelerated wear test with clinical validity. For explanted PTFE acetabular cups a wear factor of 37 x 10^{-6}mm^3/Nm has been calculated (5). This number shows good agreement with the mean value of 40 x 10^{-6}mm^3/Nm in the presence of 33% bovine serum reported here. With distilled water plus Ostenil® PTFE wear was lower. Previous wear tests of PTFE with distilled water as a lubricant have shown lower wear than when bovine serum is used (6). For failed UHMWPE acetabular cups a wear factor of 2.1 x 10^{-6}mm^3/Nm has been reported (7) which again shows good agreement with the mean of 1.6 x 10^{-6}mm^3/Nm in the presence of dilute bovine serum reported here. The addition of Ostenil® to dilute bovine serum, resulting in a wear factor of 1.42 x 10^{-6}mm^3/Nm, made little difference compared with when dilute bovine serum alone was used as a lubricant. This result therefore supports those of Wang et al (2) rather than those of DesJardins et al (3). In these tests, the lowest wear of UHMWPE was found in the presence of a lubricant of distilled water plus Ostenil®. However, as has been seen, such low wear factors are not clinically relevant.

Conclusions: These preliminary results indicate that the addition of Ostenil®, a non-animal source hyaluronic acid solution, to a dilute bovine serum lubricant had little influence on the wear of the most important biopolymer, UHMWPE.

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