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FRICTION COEFFICIENT DURING THE RECIPROCATING SLIDING OF UHMWPE IN DIFFERENT ENVIRONMENTS

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Dynamic friction coefficient (COF) of the reciprocating sliding contact of UHMWPE, was investigated in four different environments (dry contact; distilled water; pure Ringer's solution and with PMMA particles), at five values of low normal load (0.1 – 1 N) and three values of sliding speed (4 – 12 mm/s). Significant differences of COF values occurred at low load (0.1 N), whereas sliding speed did not influence COF values. Addition of PMMA particles in Ringer's solution produced significant increase of COF values, especially at the lowest load of 0.1 N.

Keywords: *UHMWPE, water, Ringer's solution, PMMA particles, friction coefficient.*

1. INTRODUCTION

Ultra-high-molecular-weight polyethylene (UHMWPE) is a common biomaterial [1,2] where tribology is important [3,4], such as a liner in contact with femoral head [5]. In synovial cavity of the freely moving joints, synovial fluid acts as a lubricant and shock absorber [3]. Wear is critical for the implant loosening and failures, whereas wear debris within a lubricating fluid increase it [6]. Different lubricating fluids have been investigated [3,4]. Viscoelasticity and time-dependent material properties exhibit complex synergies [5]. Surface modifications are investigated in order to improve tribological responses [7] and some results showed 40 % decrease in friction for UHMWPE [8]. In this paper, we compared the dynamic friction coefficient between UHMWPE and alumina (Al_2O_3), in four different contact environments.

2. METHODOLOGY

Tribological tests used a ball-on-flat setup with static flat UHMWPE samples and alumina ball (1.5 mm diameter) performed a reciprocating linear motion. Normal load Fn (100, 250, 500, 750 and 1000 mN) and maximum sliding speed v (4, 8 and 12 mm/s) were varied; duration of 3000 cycles (1.6 mm cycle). Calculated maximum elastic contact stresses: 28.5, 38.6, 48.7, 55.7 and 61.3 MPa. Different conditions were tested: dry contact, sliding in Ringer's solution with and without PMMA bone cement particles, and distilled water.

3. RESULTS AND DISCUSSION

Average values of dynamic friction coefficient (COF) are shown in Figure 1.

Significant differences of COF values occurred at low loads, and with load increase these differences were rather small. Contact environment showed significant influence, especially in the case of Ringer's solution with bone cement particles, and under the lowest load (0.1 N). In general, low loads produced higher COF. Sliding speed did not influence COF values. We can assume that the softening of thin surface layers of UHMWPE due to frictional heat, in dry contact increased COF, while lubricated contacts (distilled water and pure Ringer's solution) lowered that temperature and decreased COF (Fig. 1). This lubricating effect was negligible when PMMA particles were added in Ringer's solution and very high COF was produced, especially at low load (0.1 N). Influence of the contact environments has been proven [3,9,10].

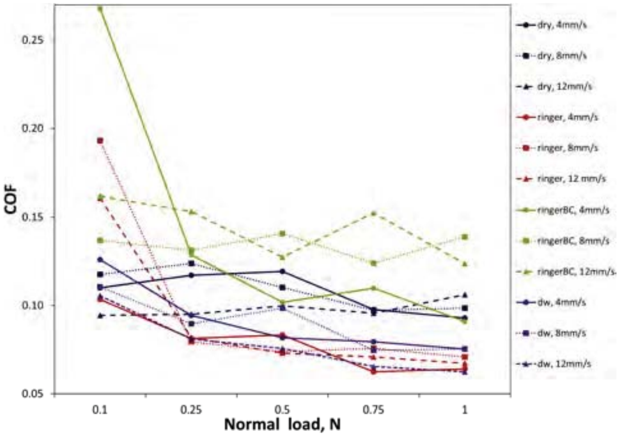

Figure 1. Average dynamic friction coefficient at different normal loads, sliding speeds and contacts

In our tests, pure Ringer's solution and distilled water similarly decreased COF values, in comparison to the dry contact. Water absorption under pressure has been demonstrated to increase wear and promote transitional wear behaviour [11]. Slight oscillations of COF values are noticeable in Figure 1. Water absorption and wear simultaneously develop, thus indicating dynamic changes in surface roughness during the test, with additional effect from PMMA particles. Surface modifications have complex interlinked influence on the contact behaviour, as proven in [12].

4. CONCLUSIONS

Lubricated contact with pure water-based fluids decreased the friction coefficient of UHMWPE in comparison to dry sliding, but addition of PMMA particles produced significant increase of COF values, especially for low loads where high COF values were obtained. Load increase had slight effect on COF values at higher loads. Sliding speed did not influence COF values in greater extent.

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