Investigation of artificial hip joint lubrication

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INTRODUCTION: Under physiological conditions, natural hip joints are lubricated by synovial fluid, an aqueous electrolyte solution produced by the synovial membrane and cartilage and containing proteins, lipids and hyaluronic acid. After a hip implant surgery, the synovial membrane eventually reforms, producing a liquid similar to synovial fluid (SF) which lubricates the implanted device [l,2]. The interaction of this fluid, known as pseudo synovial fluid (PSF), with the bearing surfaces of hip implants, is of great importance. Nevertheless this area has so far been scarcely explored. The aim of this work is to investigate the interactions of PSF components, such as proteins and glycoproteins with materials used for hip implants.

METHODS: To analyze if PSF components adsorb on the implant's sliding surfaces, and to which extent they contribute to lubrication, a novel approach based on fluorescence labeling was used. Bovine serum albumin (BSA) and alpha-acid glycoproteins (AGP) were fluorescently labeled and were analyzed for their adsorption and exchange during friction tests onto CoCrMo and Ultra High Molecular Weight Polyethylene (UHMWPE) surfaces. Fluorescence microscopy was used to visualize sample surfaces and to investigate protein adsorption and exchange. As for the tribological analysis, CoCrMo discs and UHMWPE pins were used for friction tests, which were carried out with a pin-on-disc tribometer. BSA, AGP and phosphate buffered saline (PBS) were used as lubricants.

RESULTS: The type of friction tests performed show a dynamic situation, in which BSA and AGP, previously adsorbed onto the bearing surfaces, are replaced during sliding by labelled BSA and AGP present in the lubricant solution. In addition, it was observed that AGP also replaces previously adsorbed BSA. Friction results show that the two proteins have different lubricating behaviours for the tribopair CoCrMo-UHMWPE. The use of an AGP solution as lubricant significantly reduces the friction coefficient in comparison with BSA (Fig.1). The fluorescence labelling method reveals that UHMWPE transfer from the pin to the metal disc is occurring during sliding (Fig.2).

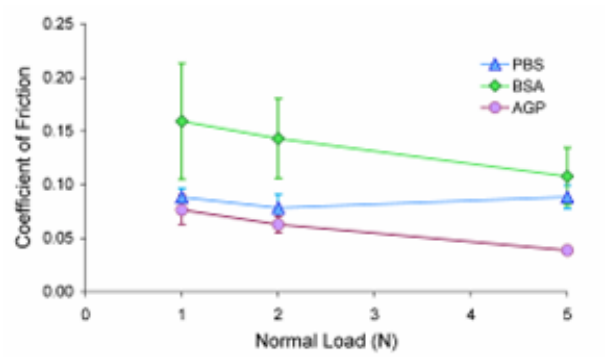

Fig. 1: Friction coefficients for UHMWPE sliding against CoCrMo using BSA, AGP and PBS as lubricants.

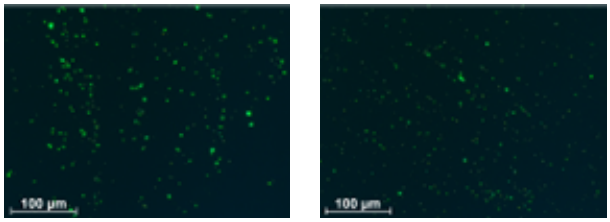

Fig. 2: Fluorescence images showing the wear tracks of CoCrMo discs after pin-on-discs tests carried out using UHMWPE pins and BSA (left) and AGP (right) solutions as lubricant.

DISCUSSION & CONCLUSIONS: Even in the presence of a protein solution, UHMWPE transfer onto the CoCrMo discs occurs during friction tests. In fact, it is possible to visualize labelled proteins on the discs using fluorescence microscopy, since no quenching of fluorophores occurs due to the presence of transferred UHMWPE. As for the lubricating behavior of the investigated proteins, AGP reduces the friction coefficients for UHMWPE-CoCrMo tribopair possibly due to its higher hydrophilicity, thus capability of retaining water improving the lubrication.

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