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Effect of counter-face material on the tribological characteristics of UHMW polyethylene under synovial fluid lubrication

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ABSTRACT

UHMW polyethylene is widely used for cartilage replacement in joint Arthroplasty. This study is focused on the tribological characteristics of UHMW polyethylene against biomedical grade 316L SS and TiA6V4 counter-face materials under Synovial fluid lubrication. The Friction Co-efficient and wear rate of the UHMWPE was obtained from the tribological tests performed on the recipro-cating tri-bometer. Lower Friction Co-efficient and specific wear rate was achieved for UHMWPE against TiA6V4 counter-face material than 316L SS under Synovial fluid lubrication. From the in-vitro tribological tests, it was demonstrated that the UHMWPE/TiA6V4 is a good tribo-pair for artificial joints.

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1. Introduction

Human hip and knee are the largest synovial joints present in our body. Daily activities like walking, running and stair climbing, synovial fluid plays an important role in taking these activities with smooth movement even under high loads which takes place during these activities. Natural synovial joints have this excellent durability of very low friction which is maintained by the lubrication mechanism [1,2]. These joints work under boundary/mixed lubrication during sleep and rest which causes starved lubrication by the natural lubricant synovial fluid and with the passage of time leads to arthritis resulting from the wear of joints due to starved lubrication. Osteoarthritis, a joint disease which is related to the cartilage degeneration. The degeneration of the cartilage is due to wear and also due to the degradation of the synovial fluid of these joints. This results in the reduction of the mechanical performance of the joint and thus affects the functioning of the joint [3–5]. When this joint disease is at its first stages, the patient receives an intra-articular injection dose of hyaluro-nic acid (HA), commonly known as visco-supplementation, which helps in the reduction of pain and helps to improve the mobility of the joint [6]. But for acute situation, a surgical process is required which result in the implant of an artificial prosthesis. The cartilage in the human joint is replaced by UHMWPE which is done by the procedure known as total joint arthroplasty (TJA) [7–9].

TJA is the surgical procedure which has improved the life of millions of patients during last couple of decays. The procedure of TJA are increasing in younger patients as compared to 40–50 years earlier, this has also increased the interest in the researchers to increase the lifespan of these implant material [10,11]. However many material pairs have been used for implants, but the most successfully used implant material is Ultra-high-molecular-weight polyethylene (UHMWPE) [12–15]. However UHMWPE is of gold standard in the field of orthopaedic industry, with its excellent biocompatibility and outstanding physical, chemical and mechanical properties, it is the material of choice for the bearing material in (TJA) [16–23]. Due to many excellent properties of UHMWPE, it has been used for total hip and knee replacement from last many years. Many material pairs have been used for TJR. One of the pair successfully used is UHMWPE against metallic substrate [24–29].

In this work, the tribological behavior of UHMWPE against biomedical grade 316L stainless steel and TiA6V4 was investigated under the synovial fluid lubrication. The tribological tests were carried out using a recipro-cating pin on disc tribo-meter. The friction-coefficient and wear of the UHMWPE pins against biomedical grade 316L stainless steel and TiA6V4 were measured.

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