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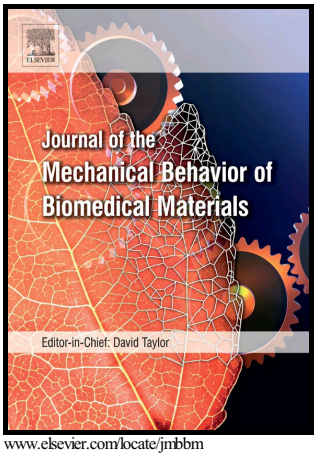

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A testing protocol combining shocks, hydrothermal ageing and friction, applied to Zirconia Toughened Alumina (ZTA) hip implants

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Abstract

Ceramics are materials of choice for hip joint implants because of their excellent biocompatibility and mechanical properties. Wear of the bearing couple (femoral head and cup) remains one of the main concerns of hip implants. Although ceramics are known for their good tribological properties, shocks due to micro-separation, friction and hydrothermal ageing in physiological environment remain the three main sources of wear. It has been recently suggested that shock effects dominate but the three degradation mechanisms were so far simulated separately. We developed a procedure that combines sequences of shocks, hydrothermal ageing in an autoclave and friction on hip-walking simulator to investigate their combined effects on Zirconia Toughened Alumina (ZTA) implants. Our results confirm that shocks can be considered as the key phenomenon causing wear, and that their effect is independent of friction and hydrothermal degradation. The analysis of retrieved femoral heads reveals wear features comparable to the ones created experimentally by shocks. Standards (ASTM or ISO) could be improved by including shock tests, which are more relevant than wear tests currently performed on hip simulators at least for Ceramic-on-Ceramic couplings.
Keywords: Ceramics; Shocks; Wear; Hip implants; Zirconia phase transformation; Explants

1. Introduction

In an ageing world population, increasing the implant lifetime to minimize the number of revision surgeries is a major goal in orthopaedics, both in terms of health and economic issues. For this purpose, materials properties and designs are continuously improved in order to approach the ideal goal of one implant for life. Orthopaedic surgeries aim also at improving patient's daily life activities and socializing, and implants bearer should not be submitted to excessive cautions. Thus, in particular among young and active patients, implants are subjected to severe mechanical solicitations in addition to the naturally aggressive in vivo bio-chemical environment.