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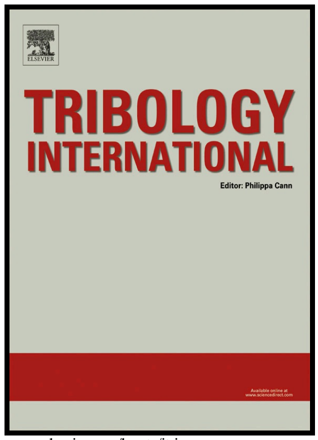

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A Patient-specific Wear Prediction Framework for an Artificial Knee Joint with Coupled Musculoskeletal Multibody-dynamics and Finite Element Analysis

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Abstract

A novel wear prediction framework was developed by coupling a patient-specific lower extremity musculoskeletal multibody dynamics model with the finite element contact mechanics and wear model of total knee replacement. The tibiofemoral contact forces and kinematics were influenced by articular surface wear, and in turn, the variations from the knee dynamics resulted in increases in the volumetric wear of 404.41 mm^3 after 30 million cycle simulation from 380.86 mm^3 from the traditional wear prediction using fixed load/motions. The developed patient-specific wear prediction framework provided a reliable virtual platform for investigating articular surface wear of total knee replacements.

Keywords: *Wear prediction, Finite-element method, Musculoskeletal multibody dynamics, Total knee replacement*

1. Introduction

Total knee replacement (TKR) is effective to replace the damaged cartilage tissues and help the patients to restore daily activities [1]. Although the survivorship of knee implants may extend beyond two decades [2], wear debris of ultra-high molecular weight polyethylene (UHMWPE) in TKR induced aseptic loosening is still a major limitation to longevity [3-6]. Laboratory knee wear simulator testing is invaluable for understanding polyethylene wear mechanisms and pre-clinically evaluating new implant designs and materials [7-14]. However, the experimental testing is associated with substantial cost and time, as a large number of low frequency gait cycles are required [8, 15], while computational wear modeling is an alternative attractive solution [1, 16].

Patient-specific load/kinematics play an important role *in vivo* wear behavior [6, 17], however, the majority of previous computational wear studies [1, 15, 18, 19] have adopted the load/motions specified in ISO 14243 (2009) [20] as the input condition. Although some studies [21] have adopted a patient-specific kinematics, the load was not from the same patient. *In vivo* contact forces and joint motions are essential for patient-specific wear prediction [6]. Although *in vivo* knee contact forces