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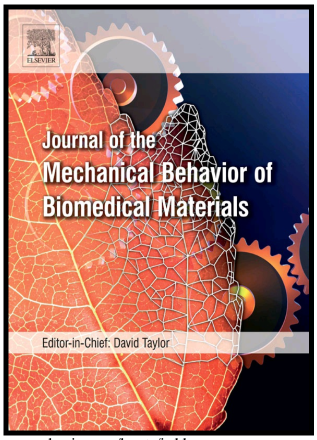

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An adaptive finite element simulation of fretting wear damage at the head-neck taper junction of total hip replacement: The role of taper angle mismatch

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Abstract

An adaptive finite element simulation was developed to predict fretting wear in a head-neck taper junction of hip joint implant through a two dimensional (2D) model and based on the Archard wear equation. This model represents the most critical section of the head-neck junction which was identified from a 3D model of the junction subjected to one cycle of level gait loading. The 2D model was then used to investigate the effect of angular mismatch between the head and neck components on the material loss and fretting wear process over 4 million gait cycles of walking. Generally, junctions with distal angular mismatches showed a better resistance to fretting wear. The largest area loss in the neck after 4 million cycles of loading was 1.86E-02 mm^2 which was found in the junction with a proximal mismatch angle of 0.124º. While, the minimum lost area (4.30E-03 mm^2) was found in the junction with a distal angular mismatch of 0.024º. Contact stress, amplitude of sliding and contact length were found as the key parameters that can influence the amount of material loss and the process of fretting wear damage. These parameters vary over the fretting wear cycles and are highly dependent on the type and magnitude of the taper angle mismatch. This study also showed that lost area does not have a linear relationship with the mismatch angle of taper junctions.

Keywords: Fretting wear; Material loss; Taper junction; Hip implants; Finite element simulation.

1. Introduction

In spite of its several advantages, modularity at the head–neck junction of total hip replacement (THR) implants may result in fretting wear which occurs when two contacting metallic components are subjected to oscillatory tangential movements with small amplitudes [1]. The presence of body fluids all around the implant provides a corrosive environment at the head–neck interface. This combined failure mechanism is known as fretting corrosion [1]. The metallic debris caused by fretting corrosion can have adverse effects on local tissues [2-4]. Hence, the amount of material loss in the head-neck junction over the life of implant inside the body

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