DEVELOPMENT OF COMPUTATIONAL WEAR PREDICTION ON TOTAL ANKLE REPLACEMENT

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ABSTRACT

The computational wear simulation has been widely used to predict wear generated on hip and knee implant but studies related to wear analysis of the ankle are limited. The purpose of this study is to develop finite element analysis on total ankle replacement (TAR) wear prediction. Three-dimensional (3D) models of a right ankle TAR have been created to represent Bologna-Oxford (BOX) TAR model. The model consist of three components; tibial, bearing and talar representing their physiological functions. The joint reaction force profile at ankle joint has applied 25 discrete instants during stance phase of a gait cycle. It is to determine the distribution of contact stress on meniscal bearing surfaces contact with talar component. The sliding distance was obtained from predominate motions of plantar/dorsi flexion. Parametric studies to reduce wear have been conducted to optimize the design of polyethylene joint. The parameters involved are the thickness of the meniscal bearing, the radius of curvature between talar and bearing component, the width and length of meniscal bearing. The value of linear wear depth is 0.01614 mm per million cycles which is in agreement with other studies (0.0081 – 0.0339 mm per million cycles). The relative difference is 9%. The value of volumetric wear after five million cycles is 30.5 mm^3 which is in agreement with other studies (16 – 66 mm^3). The relative difference is 12%. The best dimension to use for the thickness, radius of curvature, width and length of meniscal bearing are 6 mm, 30 mm, 30 mm and 22 mm, respectively.

ABSTRACT

Simulasi pengiraan haus telah digunakan secara meluas untuk meramalkan haus yang dijana pada implan pinggul dan lutut tetapi kajian yang dilaporkan berkaitan dengan analisis haus di buku lali adalah sangat terhad. Tujuan kajian ini adalah membangunkan analisis unsur terhingga untuk meramalkan haus pada penggantian buku lali (TAR). Model tiga dimensi (3D) buku lali kanan TAR telah dibangunkan menggunakan penggantian buku lali jenis Bologna-Oxford (BOX). Model ini terdiri daripada tiga komponen; tibial, bearing dan talar yang mewakili fungsi fisiologi masing-masing. Beban yang digunakan pada buku lali adalah berdasarkan profil daya yang bertindak pada buku lali iaitu sebanyak 25 peringkat berasingan bagi melengkapkan fasa pendirian kitaran gaya berjalan. Ini adalah bagi menentukan taburan tekanan sentuhan pada permukan meniscal bearing yang bersentuh dengan komponen talar. Jarak gelungsur telah diperolehi daripada pergerakan yang paling dominan iaitu plantar/dorsi flexion. Kajian parametrik dijalankan untuk mengoptimumkan rekabentuk polyethylene di bahagian sendi terutamanya untuk mengurangkan haus. Parameter yang terlibat ialah ketebalan meniscal bearing, jejari kelengkungan antara komponen talar dan bearing, lebar dan panjang meniscal bearing. Nilai kedalaman haus linear adalah 0.01614 mm bagi setiap satu juta kitaran yang mana ianya berada dalam julat persetujuan dengan kajian-kajian lain (0.0081 – 0.0339 mm bagi setiap satu juta kitaran) dengan perbezaan relatif sebanyak 9%. Nilai isipadu kehausan selepas lima juta kitaran adalah 30.5 mm^3 yang mana ianya berada dalam julat persetujuan dengan kajian-kajian lain (16 – 66 mm^3) dengan perbezaan relatif sebanyak 12%. Dimensi terbaik ketebalan, jejari kelengkungan, lebar dan panjang meniscal bearing adalah masing-masing sebanyak 6 mm, 30 mm, 30 mm dan 22 mm.