LUBRICATION EFFECT OF METAL-ON-METAL IN HIP JOINT REPLACEMENT

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ABSTRAK

Pengunaan bahan *keras-keras* merupakan satu kaedah alternatif untuk menggantikan bahan *lembut-lembut* atau *lembut-keras* yang telah lama digunakan dalam penggantian sendi pinggul. Antara jenis bahan *keras-keras* yang biasa digunakan dalam penggantian sendi pinggul adalah logam-logam. Walaubagaimanapun, rangka pinggul yang menggunakan logam-logam boleh menghasilkan zarah penghakis yang kecil hasil daripada pergeseran permukaan sentuhan di antara kepala femoral dan acetabulum. Oleh sebab itu, prestasi pelincir di antara permukaan kepala femoral dan acetabulum adalah penting untuk mengurangkan zarah penghakis. Objektif kajian ini adalah untuk mengkaji kesan pelinciran terhadap penggantian sendi pinggul logam-logam. Dua jenis analisis sentuhan telah dijalankan, iaitu sentuhan tanpa pelinciran dan sentuhan dengan pelinciran. Dalam analisis sentuhan tanpa pelinciran, tekanan sentuhan yang maksima ialah 32.887 MPa sementara analisis bagi sentuhan dengan pelinciran, tekanan sentuhan yang adalah rendah. Hal ini berlaku kerana di antara kepala femoral dan acetabulum mempunyai satu lapisan pelinciran filem bendalir penuh. Hal ini menyebabkan penghakis yang dihasilkan melalui rangka pinggul logam-logam dapat dikurangkan kerana keberkesanan pelincir filem berupaya untuk mengurangkan penghakis dengan ketara. Di samping itu, kajian ini tertumpu kepada parameter rekabentuk iaitu kelegaan jejari dan saiz kepala femoral. Didapati bahawa tekanan sentuhan yang maksima adalah meningkat apabila kelegaan jejari meningkat dan tekanan sentuhan yang maksima adalah menurun apabila saiz kepala femoral meningkat.

ABSTRACT

The use of *hard-on-hard* material is one of alternative methods to replace the *soft-on-soft* or *soft-on-hard* material which has long been used in hip joint replacement. The common type of *hard-on-hard* material used in hip joint replacement is metal-on-metal. However, the metal-on-metal hip implants produce the small wear particle as a result of attrition of the contact surface between femoral head and acetabulum cup. Therefore, the lubrication performance between the surface of the femoral head and acetabulum cup is essential to reduce wear particle. The objective of this study was to determine the effect of lubrication on metal-on-metal hip joint replacement. Two types of contact analysis were performed, without and with lubrication. In the contact analysis of without lubrication, the maximum contact pressure was 32.887 MPa while lubrication contact analysis, maximum contact pressure was lower. It was occurred because between the surface of femoral head and acetabulum cup has full fluid film lubrication. This causes the wear that produced by metal-on-metal hip joint implants can be reduced because an effective lubricant film is able to reduce wear significantly. In addition, this study focused on the design parameters, radial clearance and femoral head size. It was found that the maximum contact pressure increased when the radial clearance also increased and the maximum contact pressure decreased when the femoral head size increased.

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CHAPTER 1

INTRODUCTION

1.0 Introduction

Before the production of artificial hip joint replacement, patients with injured joint often suffered from continuous pain and cause the performance of their joints is decreased. Nowadays, the total replacement of hip joint is commonly used in treatment for many cases such as osteolysis and similar disable conditions. It can improve the life-quality of millions of patients. But the hip joint replacement can produce the wear and corrosion performance by material configurations and human movement or activity such as walking, running, jumping and others. Therefore, the design parameters and development of the hip joint is very important things in improvement of wear and corrosion performance.

The hip joint replacement material configurations that are commonly used are metal-on-Polyethylene (UHMWPE), metal-on-metal, and ceramic-on-ceramic. The selection of the hip joint material is depends on the surgeon's preference, the patient's age group and their activity level (Dan Sun, 2009). Since the hip joint replacement was first introduced, the metal-on-Polyethylene bearing design has been leading in surgery. But, it can cause the osteolysis effect induced by high level polymeric particle release from bearing surface. In order to reduce the wear rate, alternative *hard-on-hard* material configurations have been prompted such as metal-on-metal and ceramic-on-ceramic. However also these configurations have drawbacks namely in metal-on-metal, the main problem is related to the presence of potentially cancerous metal ions, produced from wear particles and in ceramic-on-ceramic, its properties is brittle. But, the metal-on-metal is the best material configuration compared with metal-on-polyethylene because the metal-on-metal configuration exhibits much lower volumetric wear than metal-on-polyethylene. Table 1.0 shows that summarizes of the advantages and disadvantages of material configuration that used in hip joint replacement.

Table 1.1: The Advantages and Disadvantages of the Material Configuration that Used In Hip Joint Replacement

Material	Advantages	Disadvantages
Metal-on-Polyethylene	-Low cost -High manufacturing precision not required	The production of large number of wear particles with higher risk of osteolysis
Ceramic-on-Polyethylene	-Low cost -Low toxicity	
Metal-on-Metal	-High wear resistance -Can self-polish moderate surface scratches	-Metal sensitivity -Long-term and systematic reactions to metal debris and ions not known
Ceramic-on-Ceramic	-Higher wear resistance than metal-on-metal -High biocompatibility	-Sometimes high wear -Higher cost -Technique-sensitive surgery -Risk to fracture (brittle)
Ceramic-on-Metal	-Highest wear resistance -Lowest wear rate (100 times lower than metal-on-metal)	-Latest development -Undergoing clinical trials

In metal-on-metal hip implants, the metal-on-metal component have been commonly used are conventional and resurfacing total hip joint replacement. Conventional total hip joint replacement is all of the bone of femoral head is replaced by the metal implant. Resurfacing total hip joint replacement is the replacement of femoral head and acetabulum cup, where the femoral head is retained and a hollow of metal cup is placed over it, while a metal cup that same is placed in the acetabulum. It can remove very little femoral bone compared with the conventional hip joint replacement. Besides that, the usage of resurfacing of hip joint replacement can allow better a stress transfer to the proximal femur and optimal range of movement (Dan Sun, 2009). Figure 1.1 shows that the conventional total hip joint replacement and resurfacing hip joint replacement.

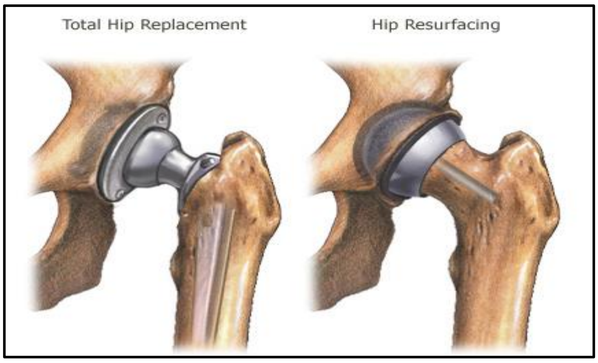

Figure 1.1: The Conventional Total Hip Joint Replacement and Resurfacing Hip Joint Replacement

In order to produce the best and good quality of hip joint implants, the concept of tribology must be studied in detail. Tribology means the study of friction, wear, lubrication and bearing design in relative motion. It relates to the subject of engineering such as solid mechanics, fluid mechanics, material science, heat transfer and others. The aspect of tribology that related to the biological system called biotribology. Biotribology is the concept of tribology science applied to functional biological systems, especially the synovial joints and their artificial replacement. The main of tribology aspect, such as friction, wear and lubrication is very important parameter to increase the hip implants' performance in the long-term usage.

1.1 Objective of the Study

The objective of this study is to investigate the effect of lubrication on contact pressure metal-on-metal in hip joint replacement.

1.2 Scope of the Study

To achieve its objective, the scope of study should be carried out as follows:

a) Understand the problem of wear on the metal-on-metal (MoM) hip joint replacement.
b) Construct the ball and socket representing acetabulum cup and femoral head.
c) Carry out contact pressure analysis using Finite Element Method analysis without lubrication as a control specimen.
d) Perform contact pressure analysis using Finite Element Method in the fluid as lubrication medium.
e) Analyse the effect of radial clearance and femoral head size on contact pressure

1.3 Problem Statement

When the original hip joint implant is loosening and cannot be used anymore, it needs to replace with the new hip implants by surgery. Most surgeons prefer to choose the metal-on-metal as material configuration in hip joint replacement because the metal-on-metal hip implants are contains lower volumetric wear. However, metal-on-metal still produces the wear and friction as a result of the movement between the femoral head and acetabulum cup. Even a little wear produced by metal-on metal, but the wear still exists and can affect the performance of hip joint implants in a long term. If this problem not be taken seriously, then there will be inflammation of the hip joint implants.

Besides that, the enhancement of wear particle has related to the applied load. It will lead to the existence of contact pressure between femoral head and acetabulum cup. Therefore, this project focuses to analyse contact pressure between femoral head and acetabulum cup using finite element method in dry and lubrication contact. In addition, this project was focused more on the effect of design parameters on the maximum contact pressure at the contact surface. This analysis was also involved the two different contacts, namely dry contact and lubrication contact.

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