Analysis of Stresses on a Pre-cracked Cup of a Total Hip Prosthesis (THP)

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ABSTRACT

Zirconia is known as a bioceramic having properties which could make it a substitute material in prosthesis manufacturing field, in the other hand it presents a weak fracture toughness which is the main disadvantage. This work aims to analyze the mechanical behavior of a pre-cracked cup of a total hip prosthesis in severe circumstances by using numerical simulation. ABAQUS-6.8 as a numerical simulation software was used. It is assumed that the prosthesis was implanted in an adult subject under an excessive load. The obtained results were satisfied.

1. Introduction

Hip prostheses usually consist of a stainless steel head and a UHMWPE (polyethylene) cup. But stainless steel as a metal has some disadvantages that we can cite as following: a high weight compared to the human biological environment, a significant thermal conductivity and possibility of oxidation by other agents that may exist in the human body.

In the other hand UHMWPE also presents disadvantages among them we can cite: the creep and debris which can cause reactions with the biological environment.

All of these can be factors causing or promoting postoperative pain. Zirconia presents properties making it a candidate material to be used in the biological human environment : - Compressive strength close to 6000 MPa - Purity up to 95.6% - Fine grain approximately 1.5µm - Fine roughness ~ 0.02µm - Poor thermal and electrical conductivity - A considerable hardness - Good biocompatibility with the biological environment - Good resistance to corrosion.-Some lightness (volume density ~ 6g/cm^3)

In addition to previous advantages the zirconia presents a weak fracture toughness (K_{IC}=*7MPa.m$^{1/2}$*).

The friction couple considered in this work was Zirconia/Zirconia

The numerical simulation was performed using Abaqus 6.14. **[1]**

2. Materials and methods

a) Load

The subject is a person having undergone a total hip arthroplasty and weighing 100 Kg, the position of study is such that the person presses on only one foot. According to Pauwels, in this position, the head is subjected to 4 times the weight P. (Fig.2) [2], [4]

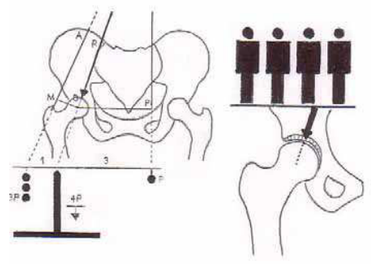

Fig.2 The applied load to the hip articulation. [2], [3]

b) Mesh

The used finite element was tetrahedron C3D10

c) Used materials

Table 1. Characteristics of used materials

Components	Material	Young Modulus (GPa)	Poisson's Ratio	Fracture toughness (MPa.m$^{1/2}$)
Head	Zirconia	201	0.31	7
Prism	Bone	20	0.33	-
Cup	Zirconia	201	0.31	7
Stem	Stainless steel	197.5	0.27	