LUND UNIVERSITY

Topology-Based Optimum Design Method for Artificially Replaced Cementless Hip Joints

Kharmanda, Mohamed Ghias; Ibrahim, Haisam

2013

Citation for published version (APA):
Kharmanda, M. G., & Ibrahim, H. (2013). *Topology-Based Optimum Design Method for Artificially Replaced Cementless Hip Joints*. Abstract from The Tenth World Congress on Structural and Multidisciplinary Optimization, Orlando , Florida, United States.

Total number of authors:
2

LUND UNIVERSITY

PO Box 117
221 00 Lund
+46 46-222 00 00

Topology-Based Optimum Design Method for Artificially Replaced Cementless Hip Joints

Kharmanda G. and Ibrahim M-H.*
Faculty of Mechanical Engineering, Aleppo University, Aleppo, Syria
*Invited Researcher, Mechanics Laboratory, Polytechnic School of Lille, France
mgk@scs-net.org

Abstract

The technology of artificial joint replacements has evolved rapidly over the last forty years and has become an overwhelming success. Such an artificial replacement can lead to a dramatic relief of pain and restoration of the joint functions for patients suffering from osteoarthritis, rheumatoid arthritis, congenital deformities or post traumatic disorders. The most frequently afflicted joint is the hip, which is replaced quite often with a metallic joint. This artificial replacement represents the major success story in orthopedic surgery in the twentieth century; there is much interest in extending research on hip joint even further, early in the twenty first century. The success of a total hip arthroplasty is strongly related to the initial stability of the femoral component and to the stress shielding effect. In fact, for cementless stems, initial stability is essential to promote bone ingrowths into the stem coating. The use of a hollow stemmed hip implant is an important way for reducing the effects of stress shielding. The integration of topology optimization into hip prosthesis design allows generating holes to enhance fixation, and to reduce the volume for light stem structure. To design the hip prosthesis, two ways can be used: The first one consists in studying the hip system as an implant in the adjacent bone regions. Here, it is generally believed that the elastic properties of bone can be characterized by an anisotropic material but in the previous works, the material properties of bone have been assumed as linearly elastic and isotropic within the range of smaller deformation (Kabel et al. 1999). However, in the second way, only the stem part is modeled replacing the others with some equivalent boundary conditions (Radu and Rosca 2007). In this paper, a new definition of boundary conditions for a shouldered stem shape is presented. In the literature, three different loading cases for hip prosthesis have been described by Kowalczyk (2001) which are a stance phase of gait and two extreme situations during normal activities. Topology optimization of hip prosthesis stems is motivated as a practical case. Stress shielding is an important factor for stem design. This often occurs in the cortical bone adjacent to the femoral stem due to the difference in the elastic modules of bone and prosthesis. Any large difference in stiffness causes a reduction of the tension/compression load or bending moment to the part of the bone and decreases bone masses. This weakens fixation between the bone and prosthesis, and can be a cause of a revisiting surgery. At this stage we use the topology optimization in order to find the optimum hollow stem design to succeed an excellent enhance fixation. The basic tool used in our previous strategy was finite element method (FEM) using ANSYS software. Numerical applications show the importance of the proposed design method.
Key Words: Hip joint, artificial prosthesis, Finite Element Analysis, Topology Optimization.

References

Kabel J.; Rietbergen B-V.; Dalstra M.; Odgarrd A.; Huiskes R. (1999): The Role of an Isotropic Tissue Modulus in the Elastic Properties of Cancellous Bone, *Journal of Biomechanics*, vol 32, 1999, pp 673-680.

Kowalczy, P. (2001), Design optimization of cementless femoral hip prostheses using finite element analysis, J. Biomechanical Engineering - *Transaction of the ASME* 123, 396-402

Radu, C.; Rosca, I-C. (2007): Modeling of the hip joint, Annals of the Oradea University, Fascicle of Management and Technological Engineering, Vol. 6 (16), 2007.