FEM ANALYSIS IN THE HIP JOINT RECONSTRUCTED BY HIP RESURFACING

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1. Introduction

The solutions which could provide an alternative to total hip replacement have been searched for for several years. One of such solutions is the hip resurfacing. The anatomical setting of the neck and the femoral head in the cup is retained in this operation and the zone of pressure between the femoral and acetabular components is similar to the one in a natural joint. The distant clinical observations and analysis of wear of artificial joints indicate that hip resurfacing has limitations. Contraindication to the surgery is aseptic necrosis of the femoral head, advanced osteoporosis and inflammatory processes in the joint [1]. The aim of the work is personalized strength analysis using finite element method (FEM), carried out in the virtual hip joint supported by the hip resurfacing. On its basis, before the planed hip resurfacing, it is possible to predict the biomechanical condition in the complex of operated hip.

2. Material and methods

The material for the procedure was the clinical case of patient (male, l. 62 with a diagnosed osteoarthritis of the left hip joint), recommended to the resurfacing operation. The preoperative strength analysis was carried out on a numerical model of the patient's hip belt, reconstructed on the basis of computed tomography. Due to the differences between individuals in a osteoarticular system, the primary issue before implantation of the hip is the identification of the geometric-anatomical parameters, [3,4]. On the basis of this identification, the selection, modeling and targeting applications of the Durom Hip Resurfing (DHR) of Zimmer Companies were made. Spatial constraints and quasi-static loads was put on the global model. The strength analysis was carried out using Femap NE / Nastran v.8.3. Huber-Mises-Hencky hypothesis (HMH) was assumed to determine and evaluation of stress and displacements in the structure of the prosthesis and periarticular tissues. This hypothesis as a measure of effort assumes the energy shear. The specific energy shear is the magnitude which decides about efforts of the material and tissues.

3. Results of tests

The distributions of reduced stresses and resultant displacements were designated after discretization of object and performing calculations. The circumferential asymmetry of stresses was characteristic in the elements of load prosthesis: in the acetabular component fixed on the basis of osseointegration in the pelvic bone and in the femoral component fixed using the cement on the head of the femur and stabilized by pin (Fig 1a). It should be noted that in the upper middle part of the pin inserted into the neck of the femur, the greatest stress concentrations were found. The stress distribution in the bone tissue surrounding the implant zone may also indicate areas where the stress concentrations affecting the prognosis of operation exist (Fig. 1b). In the head of a femur, in the area contacting with the femoral component – in the layer of cement and bone tissue – the circumferential stress concentrations existed. They may cause crumbling of cement and become a potential outbreak of aseptic loosening [2]. The analysis of stresses in the femoral neck indicates an asymmetric distribution. Two areas of maximum stress are located in the upper and lower parts of the neck. Such distribution and values of stresses exceeding the physiological capacity of tissues increase the risk of fractures of the neck.

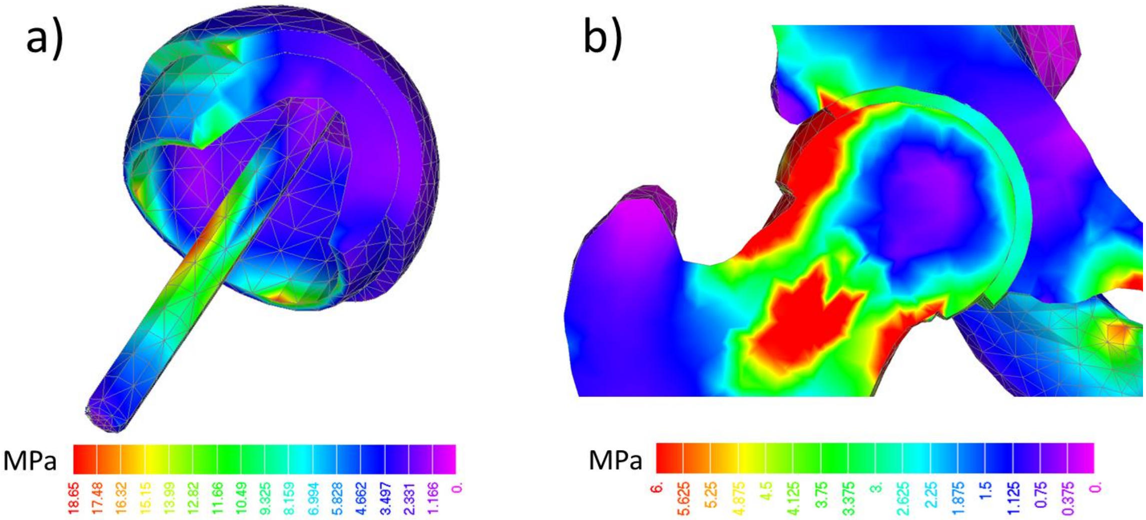

Fig. 1. The maps of distribution of reduced stresses: a) in contacts: acetabular component and femoral component, b) in the prosthesis and the fixing area

4. Summary

Summing up the obtained results of analysis, it can be seen that the distributions of the stresses in the prosthesis and the surrounding tissues after resurfacing operation have not too large values. In the case under consideration, they do not exceed the physiological resistance of tissues and can stimulate bone formation processes. The peripheral asymmetry of stresses is dangerous both for the construction of prosthesis where the uneven wear may occur as well as for tissue structures where the effort process may occur especially during walking, running, jumping or in other unintended extreme situations. One might conclude that this type of hip prosthesis should be performed at young patients who experience pathological changes on articular surfaces while the bone structures of the neck are immune to strength. The simulations carried out using this procedure before resurfacing operation can predict the state of endurance in the operated hip and to answer the question what will be the outcome distant.

5. References

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