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THE LOAD CASES IN NUMERICAL MODEL OF PELVIC BONE WITH ARTIFICIAL ACETABULUM

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Summary The numerical modelling makes possibilities to account the stress and strain distribution in every points of model. It is particular important when the THA operation is performed and the artificial acetabulum is fitted. Very often before and after operations the knowledge of the stress and strain distribution in the pelvic bone is needed. For checking the influence of the forces acting in acetabulum on the stress and strain distribution in the surroundings of the artificial acetabulum a simple bench-mark was proposed, with force acting in acetabulum by ceramic ball.

INTRODUCTION

Bioengineering concerns many important problems apply to human body. The pelvic joint and its correct working is one of them. The pelvic bone is one of the most important supporting elements in human pelvic joint but it is liable to suffer an injury. Very often before and after operations the knowledge of the stress and strain distribution in the pelvic bone is needed. It is particular important when the THA operation is performed and the artificial acetabulum is fitted. Because the safety of patient should be taken into account there are only two possibilities: model testing and numerical calculations. Before numerical calculations the numerical model should be prepared.

In the paper the numerical model is prepared on the ground of the geometrical data from 3D scanning or CT. The accuracy of geometrical model depends on number of scanning levels. A numerical routine (numerical code) was built to translate the geometrical data (the set of coordinate points) to the Patran/Nastran code. The layer structure of bone tissues is taking into account. Using an in-house numerical code the inner surface in numerical model is implemented (between cortical bone tissue and trabecular bone tissue). Separate solid elements layers are modeled by cortical and trabecular bone. At present homogeneous elastic properties within a certain group of tissue are assumed.

NUMERICAL MODELING

In the aim to creating an artificial acetabulum a few procedures were done. All procedures were written in the C++ language. The procedures create the flange (*width*), the spherical cap (*radius*), and the bolts of artificial acetabulum (*2 angles in spherical coordinates*, *width*, *height*). On the basis of the above parameters the whole geometry of the structure is created. Next on the ground of the geometry, the finite element model is created and put into the bone finite element model. The surfaces are modeled using triangular elements and the solids are modeled using tetrahedral elements.

There is possible to model cemented and cementless acetabulum, with contact element and without. At present MSC.Patran/Nastran and MSC.Patran/Marc systems are applied. Here, boundary conditions are given in two area: in contact area with sacral bone and in pubic symphysis. Stress and strain distribution of human pelvic bone is a result of external load coming from upper body part's weight and muscles forces. Referring to earlier works, the model takes up 23 muscle tensions influencing through pelvic bone and tendons on insertions' surfaces. For checking the influence of the forces acting in acetabulum on the stress and strain distribution in the surroundings of the artificial acetabulum a simple bench-mark was proposed, with force acting in acetabulum by ceramic ball. Fig. 1 shows the model of artificial acetabulum and Fig. 2 shows the model of pelvic bone with fitted artificial acetabulum.

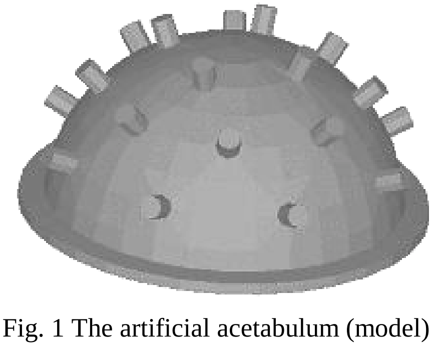

Fig. 1 The artificial acetabulum (model)

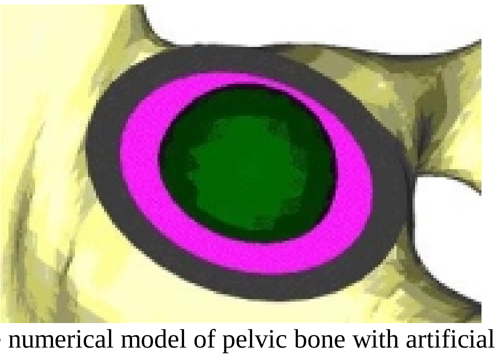

Fig. 2 The numerical model of pelvic bone with artificial acetabulum and ceramic ball

NUMERICAL CALCULATIONS

The calculations were performed for 5 schemes of acting forces (Fig. 3). The scheme 1 represents force acting perpendicularly to base plane of artificial acetabulum. The schemes 2 – 5 represent forces acting at an angle of 30° to force from scheme 1, in given direction. All the forces acting in the center of ceramic ball, inwards of acetabulum. The highest effort of constituent elements were obtained for the 5th scheme of load. The stress distribution show the Fig.Fig. 4 – 6 for the cortical bone, artificial acetabulum and cement layer, respectively.
Obtained results can be useful to planning and quality assessment of THA. The surgeons can observe which state of load are dangerous for the patients.

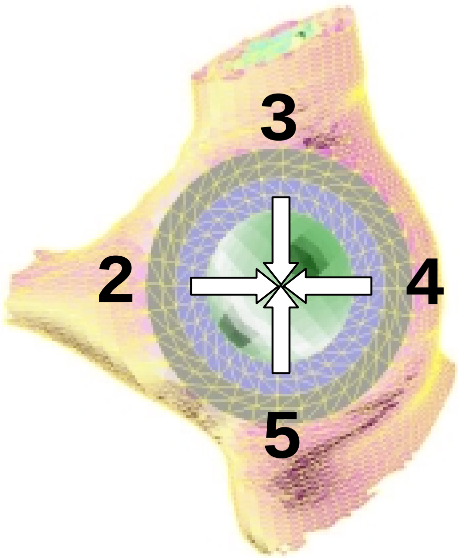

Fig. 3 The Scheme of acting forces

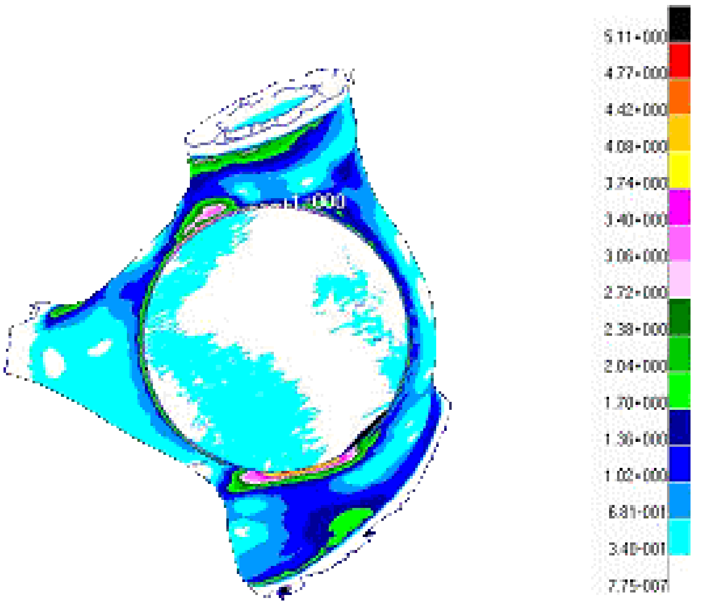

Fig.4 The reduced stress distribution in cortical bone (scheme 5)

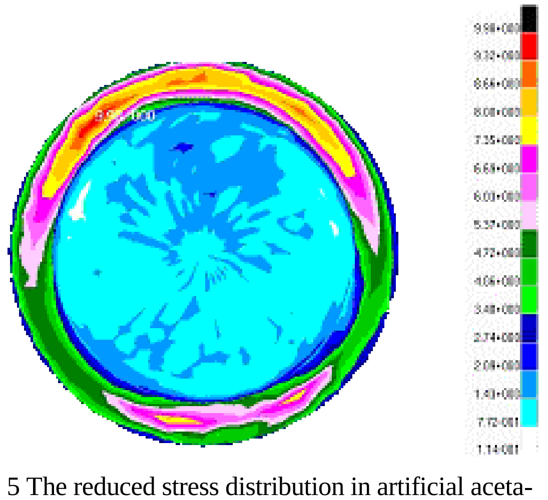

Fig. 5 The reduced stress distribution in artificial acetabulum (scheme 5)

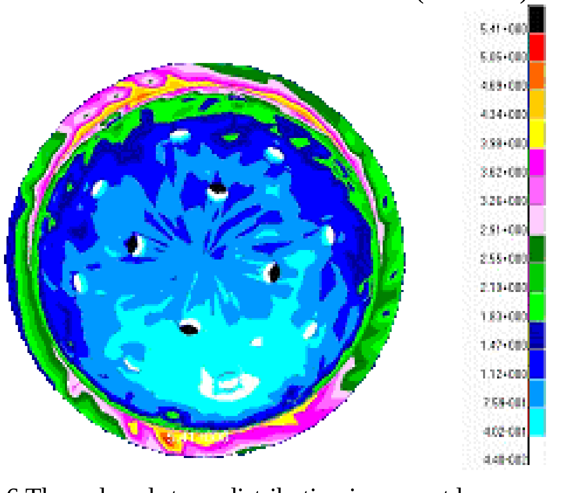

Fig. 6 The reduced stress distribution in cement layer (scheme 5)

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