Hip Joint Surgery Problems of Crash and Fall Injuries

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Abstract: The paper deals with numerical analysis of hip joint operation effect to changes of acetabulum stress field and implant migration into acetabulum area. Pelvic bone geometry was obtained from computer tomography by semi-automatic generation. There are two main input parameters for the stress analysis: The CE angle describing the shape of acetabulum and the direction of loading substitutes the femoral replacement.

The numerical analysis compares shapes and peak values of stress field in the acetabulum area. Ultimate values of the first principal stress, the third principal stress and total displacements were used as reference magnitudes. These ultimate values predict probable migration process. Numerical analysis results correspond with after surgery clinical reports well.

Key words: migration, acetabulum, FE model

3. Introduction

Especially for seniors, injury of the hip joint is frequent effect of crashes and falls. The weakest part of the joint is a femoral neck. Femoral neck fracture is painful and causes immobility. In many cases the hip joint replacement is the only way to recover human mobility and live standards.

There are two basic surgical methods for the hip joint replacement. The total hip replacement is a surgical procedure whereby the diseased cartilage and bone of the hip joint is surgically replaced with artificial materials.

Hemiarthroplasty is a surgical procedure which replaces one half of the joint with an artificial surface and leaves the other part in its natural (pre-operative) state, which article deals with. The most common problem of hip hemiarthroplasty is migration of the replacement head which is observable more or less after couple of months in all cases of after-surgery patients. There are two dominant directions of the replacement head migration: median migration into pelvis minor or migration in acetabular lumbrum direction. These migration directions are represented in [Fig. 1]. The aim of this work is to analyse the migration of the replacement head into the pelvic bone under various types of loading and shapes of acetabulum.
2. Models

There are volumetric based models used for our analysis. Pelvic bone geometry was obtained from computer tomography by semi-automatic generation in two basic steps. The first step was tissue segmentation by thresholding in each scan. The second step was surface mesh definition. Factors that could have influence to the migration are considered as parametrical inputs. The development of the model is described in details in (Vyčichl J. & Jiroušek O. 2005) and (Kytýř D., Jírová J. & Jiroušek O., 2005). The main geometrical factors which may influence the migration of the implant are the CE angle and the direction of loading force. Boundary conditions were represented by fixation of all surfaces in addition to the area close to acetabulum. The loading of the acetabulum is modelled by assigning acceleration to the mass steel replacement head. The loading resultant intersects the centre of the replacement head. The plane of interest of the model is 19° inclined from the frontal plane. The model was solved in 4 loading steps with loading direction -45°, -10°, 0° and 10°. This loading range is a little bit greater than the range of physiological loading.

3. FE Modelling

There are three different materials used in the FE model: steel replacement head, cortical bone on the surface and cancellous bone inside the pelvis. Steel and cortical tissue are considered as homogeneous, linear and isotropic materials.
Material properties of the cancellous bone [Graph 1] are taken from literature as well as from experiments made out at our institute (Kytýř D., Kunecký J., Zelenková K, Jiroušek O. & Jírová J., 2006). Range of material characteristics is wide, material with lower value of Young modulus was chosen for our model to get the most unfavourable situation.

**Fig. 2: Sum and vector of displacement of planar model**

### 4. Conclusion

There are three different materials used in the FE model. The stress and displacement fields showed that primary migration of the replacement head followed the direction of the loading. Decreasing of the CE angle and increasing of the loading direction angle concentrate the stress to the acetabular labrum area. This very unfavourable situation probably initiates the migration; therefore the natal predispositions of acetabular CE angle and higher fitted prostheses have significant influence on the lateral migration. Analogically, in the case of median loading the consequence of the mechanical load is the migration of the implant into pelvis minor region.

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References