THE STABILITY OF ACETABULAR CUP UNDER SCREW FIXATION

[1]Jui-Ting Hsu, [1]Chih-Han Chang, [1]Heng-Li Huang, [1]Guan-Liang Chang, [2]Kuo-An Lai, [3]Weng-Pin Chen
[1]Institute of Biomedical Engineering, National Cheng Kung University, Tainan, Taiwan
[2]Department of Orthopaedics, Medical Center, National Cheng Kung University, Tainan, Taiwan
[3]Department of Biomedical Engineering, Chung Yuan Christian University, Chungli, Taiwan

INTRODUCTION

The total hip replacement is a common surgical procedure in orthopaedics. However, the acetabular cup loosening is one of the major failure modes of cementless acetabular cup. Many researches point out that an unstable cup would induce a large micromotion under dynamic loading. This large micromotion would reduce the bone ongrowth on the cementless cup surface and prohibit the osseous integration [1, 2]. Besides the press fit fixation, the screw-fixation is a widely employed approach. However, how to achieve a better fixation effect with screw is still unclear. The objective of this study was to evaluate the effects of screw numbers and position on the initial stability of acetabular cup.

METHODS

Three dimensional finite element model of pelvis was established from the saw bone.(model and brand names) which included the cancellous bone, cortical shell and subchondral bone. The Osteonic Omnifit (Allendale, New Jersey) acetabular components (including five screw holes, titanium cup, polyethylene liner and ceramic head) were also modeled (Figure 1). The interface of cup and pelvis was simulated with surface–to-surface contact elements with coefficient of friction 0.5 [3]. All the other component interfaces were assumed to be bonded.

To evaluate the fixation, loadings of the five stages of a gait cycle [4] were applied at the center of the femoral head while the cup was fixed on the pelvis with one, two, three, four or five screws respectively. (To simplify the computational aspect, each screw was modeled as a cylinder.) The nodes on sacroiliac joint and pubic symphysis were fixed in all degree of freedom as the boundary condition. The maximum relative micromotion between cup and pelvis was used as the evaluation index for stability. All the finite element analyses were performed using the ANSYS (Swanson Analysis Inc., Huston, PA, USA) software package.

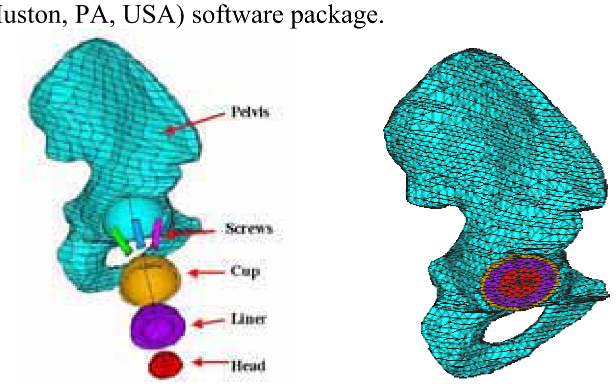

Figure 1: (a) Solid model (3 screws) and (b) Mesh model

RESULTS AND DISCUSSION

In general the maximum relative micromotions between cup and pelvis occurred at the inferior edge of the acetabular cup; that is the opposite side of the screw fixation region (Figure 2). For the same number of fixation screw, different combinations (e.g., five different choices of one-screw fixation) produced various stability effect and the differences could be large. For different number of fixation screw, the five-screw fixation, most stable one, only reduced 16% of peak relative micromotion compared with the best one-screw fixation (Figure 2). What this indicated is that screwing position is more important than screw number and inserting several screws closely together is unnecessary. However, the selection of screw position depends on both absolute location (relative to the loading location) and relative location (area size covered by multiple fixation-screws).

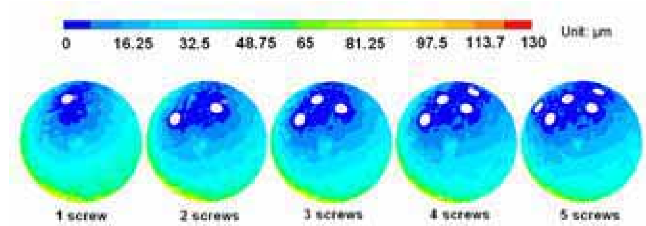

Figure 2: The micromotion distributions of different location screw fixation.

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CONCLUSIONS

This study suggests that selection of screwing location for acetabular cup is an important factor to achieve better cup stability. The selection of better screw location depends mostly on the loading modes of the cup (the activities of the patient). The general principle is to spread the screw as far as possible so that it can cove most loading cases. However, the bone quality and anatomic consideration were neglected in this research.

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