INVESTIGATION OF MECHANICAL PROBLEMS IN THE APPLICATION OF ACETABULUM CUPS FOR HIP-PROSTHESIS

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Introduction

Fig. 1

An acetabula-cup is the counterpart of an endoprosthesis and is mounted in the pelvis. There are different designs of such cups. The difference is given only by the kind of applying the forces for mounting the cup (like a screw) in the pelvis. In the realization shown in Fig. 1 the forces are applied in 4 notches at the upper border of the cup, whereas in second realization Fig. 2 the mounting forces affect 3 cuts in the bottom-plate of the cup. In both cases the mounting stresses may lead to plastic deformations of the contact area. The question is, which solution influences the lifetime prediction more.

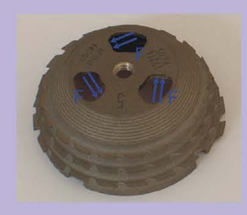


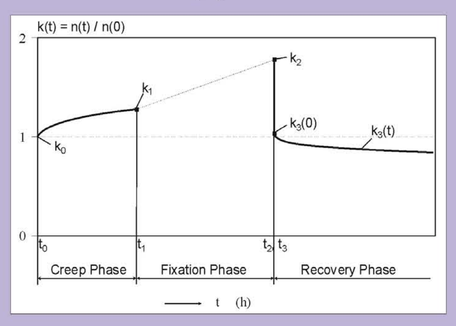
Fig. 2

Experimental procedure

Casting mould

Machined according to original form except the threads

Fixing procedure of the photoelastic information by gamma irradiation



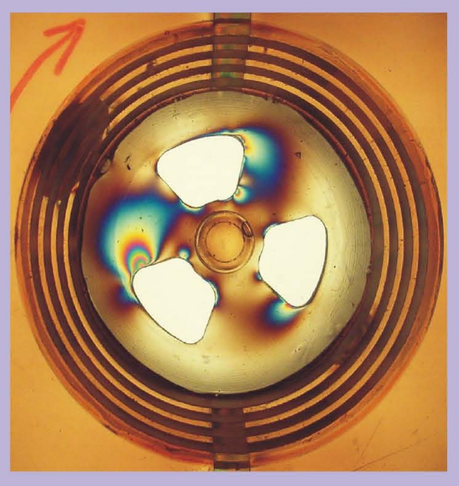
n(0) initial (loading) information
n(t) final information after fixation and unloading

Photoelastic model of the acetabulum cup

made of semi polarized Araldit B hardened with maleic anhydride

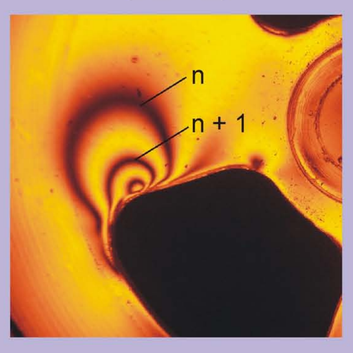
Preparation for the fixing procedure of the mounting stresses
(with loading part for applying the torque momentum)

Fringe-distribution (light-field) due to the mounting-procedure after fixation and unloading

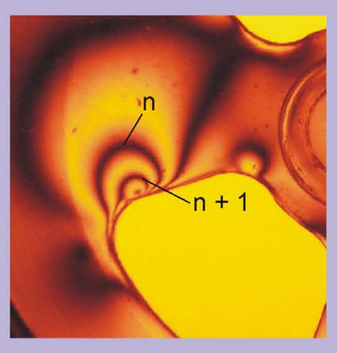


Apparatus for the fixing procedure. The torque moment is applied by a hydraulic device

Mounting stresses detail (dark field)



Mounting stresses detail (light field)



Dedermination of the Stress-optical coefficient Base on FEM - Analysis

$$f_\sigma / t = f_\sigma^*$$

$$(\sigma_1 - \sigma_2)_n = f_\sigma / t \quad n = f_\sigma^* \, n$$

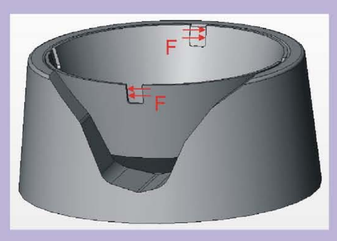
$$(\sigma_1 - \sigma_2)_{n+1} = f_\sigma^* (n + 1)$$

$$(\sigma_1 - \sigma_2)_{n+1} - (\sigma_1 - \sigma_2)_n = f_\sigma^*$$

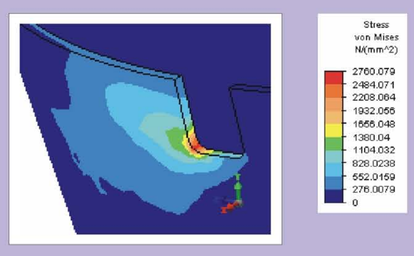
Numerical solution - initial situation

Mounting-forces applied to the notches at the upper border of the cup

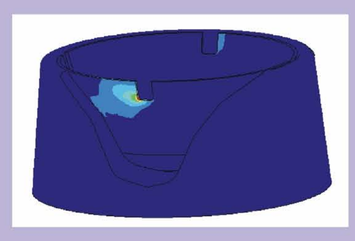
Model for calculating the stress-distribution caused by the mounting forces when applied to the notches on the upper border of the cup (Fig. 1)



Mounting-stresses (Mises) in the near vicinity of a notch

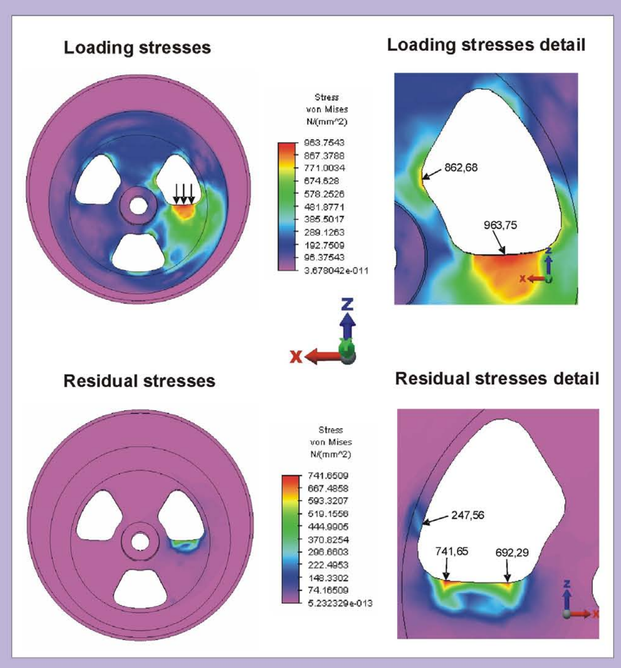


Mounting-stresses in the pelvis

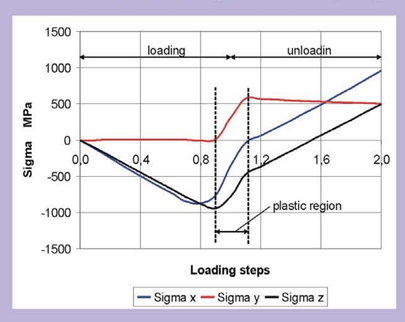


Mounting stresses in the bottom plate

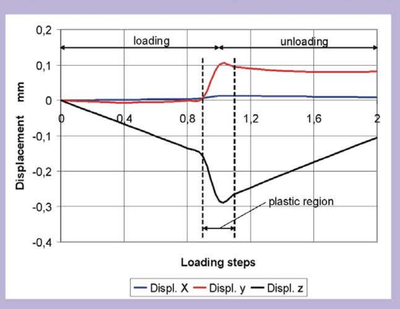
Mounting-forces applied to the cuts in the bottom-plate of the cup (torque moment M = 150 Nm)



Stresses in the loading center σ = f (ΔM)



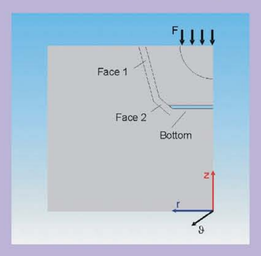
Displacement in the loading center δ = f (ΔM)



Design variation of the cup

Stesses in the cup due loading simulating a lifetime-force as a function of contact-areas between the cup and the pelvis

Model IV
Contact between face 1 and the pelvis only



Model I:Contact according to medical praxis

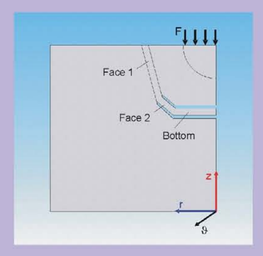
Model II: Contact of face 1 and 2 only

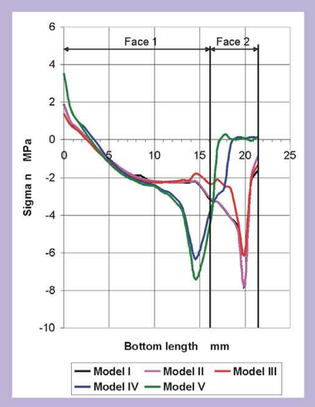
Model III: No contact between face 2 of the cup and inlay

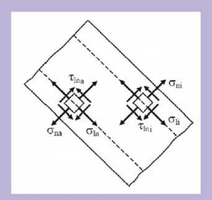
Model IV: Contact of face 1 only

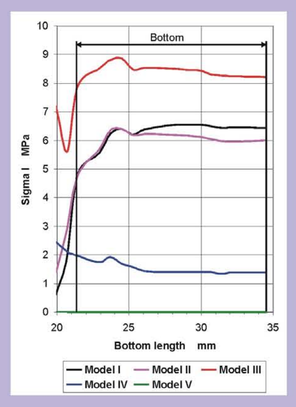
Model V: Cup without bottom

Model I
Full contact between cup and pelvis









Conclusions

Investigations have shown that the load transfer from the endoprosthesis through the cup to the pelvis is strongly influenced by the direct contact between the cup and the pelvis. In any case (model I V) the loading stresses in the bottom are negligible small compared to that at the upper border. That means that, even in cases of a plastic deformation caused by mounting the mounting procedure due to Fig. 2 is preferable.

References

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Schraubpfannen. State of the Art, Editor H. Effenberger, MCU, 2004.