MORPHOLOGICAL DETERMINANTS OF HIP INSTABILITY

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Introduction

The ideal human hip joint is free of instability. The stability of a hip joint may be lost when the morphology and orientation of the acetabulum or femur deviate from normal anatomical values. Common morphological variations include dysplasia (shallow acetabulum) and excessive acetabular anteversion, especially in women. Instability can provoke a translation or dislocation of the femoral head, leading to a focal overloading of the articular cartilage. With repeated overloading of the cartilage, osteoarthritis in the hip joint can result [Ganz 2008].

To date, knowledge of the biomechanical link between hip joint morphology and joint stability is limited. Therefore, the goal of this study was to evaluate the influence of hip joint morphology on joint stability and the internal mechanical response of the joint.

Materials and Methods

Three-dimensional finite element models (Fig. 1) were created with variations in acetabular index (0 - 15°), acetabular anteversion (0 - 30°) and femoral neck anteversion (0 - 30°). The load and motion patterns used for the simulations were derived from in vivo data [Bergmann 2012]. The performed simulations included a full step during a normal gait cycle and a standing-up motion.

The von Mises stress and the contact pressure in the acetabulum, and the relative displacement of the femoral head, were determined.

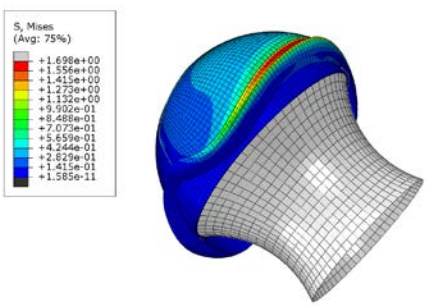

Figure 1: ABAQUS FE simulation model of a normal hip joint at the point of the maximum loading during a gait cycle.

Results

A clear influence of the acetabular index and the acetabular version on joint contact pressure (Fig. 2), stresses and stability was observed. Increased values for both parameters were associated with decreased joint stability. Stresses and contact pressure increased correspondingly. An influence on the impingement risk was mainly observed in the standing-up simulations. The influence of the femoral anteversion showed the same trends, but with a smaller effect.

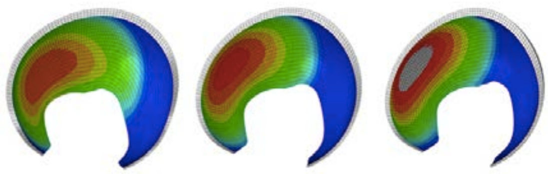

Figure 2: Contact pressure distribution during the mid-stance phase of gait, with AI: Acetabular index = 5°, AV: Acetabular version = (left-right) 0°, 20°, 30°, FA: Femoral anteversion = 30°.

Discussion

The results of the study showed a combinatory effect of the anatomical parameters considered in the study on the mechanical response of the hip joint. It was shown that an increase in the acetabular index and version lead to an unstable hip joint during a normal gait cycle. However, such unstable hips were less prone to dislocation in the standing-up motion cycle, due to the high medial muscle forces, which stabilize the hip joint.

The stresses and contact pressures were highly dependent on the orientation of the acetabulum and the load pattern. Changes in AI shifted the stresses from the acetabular fossa to the rim or vice versa. Hips with a normal geometry and orientation of the acetabulum have an optimal form minimising local stresses, and the risk of dislocation, during normal daily activities. Both acetabular version and acetabular index are key parameters for planning joint preservation surgery.

References

Ganz, R., et al., Clin Orthop Relat Res, 2008. 466(2): 264-72

Bergmann, G., www.orthoload.com, 1998