BIOMECHANICAL ANALYSIS OF CHIARI OSTEOTOMY

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Abstract: The decrease in contact hip joint stress after Chiari osteotomy is studied using a mathematical model. In the model, additional coverage of the femoral head by the ala ossis ilei segment is taken into account. It is shown that this additional coverage significantly decreases stress, mostly by the indirect effect caused by the shift of the stress pole.

Key Words: Chiari Osteotomy, Hip Stress, Biomechanical Parameters

INTRODUCTION

The Chiari osteotomy [1] was recommended for treating dysplastic hips without osteoarthritis, congenital subluxations in young adults, coxa magna in Perthes disease and paralytic dislocations caused by muscular weakness and spasticity. The aim of the operation is to increase the acetabular roof, i.e. the coverage of the femoral head. Mathematical modelling of the Chiari osteotomy was undertaken in order to test the hypothesis that an increase in the weight bearing area due to the osteotomy importantly decreases contact hip stress.

METHODS

The basic mathematical model for determining the contact hip stress [2] was adapted for the specific shape of the weight bearing area. The original weight bearing area was described as a portion of the articular sphere. On the lateral side, this area is bounded by an intersection of the articular sphere with a plane inclined by the center-edge angle J_{CE}, thereby simulating the acetabular rim, while on the medial side the weight bearing area is bounded by the condition that the contact hip joint stress vanishes. The additional coverage of the femoral head by the ala ossis ilei segment was simulated by an extension of a given width and length located symmetrically with respect to the original-weight bearing area.

RESULTS AND DISCUSSION

Fig.1 shows the top view of the simulated weight-bearing area and the corresponding stress distribution [3]. The top row represents hips with different center-edge angles, while the bottom row represents hips with different additional femoral head coverage by the ala ossis ilei segment. The new center-edge angle defined by the most lateral extension as viewed on the X-ray is assigned J_{CE2}. The position of the stress pole is marked by the dot. It can be seen that larger coverage in the intact hip shifts the stress pole in the medial direction and simultaneously decreases stress and increases the weight-bearing area on the medial side. Although the additional coverage formed due to Chiari osteotomy contributes a relatively small additional area on the lateral side, the increase of the weight-bearing area on the medial side and the corresponding decrease in stress is considerable.

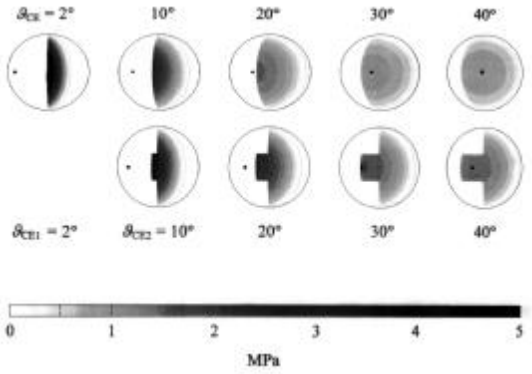

Fig. 1. The top view of the simulated weight-bearing area and the corresponding stress distribution. The model parameters: the resultant hip force R = 1560 N, direction of the R being J_R=10° (pointing in a frontal plane distally and 10° laterally), and the radius of the femoral head r = 2.7 cm. The anteroposterior (AP) width of the ala ossis ilei fragment is 1.88 cm.

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