Evaluation of the contact pressure of the acetabular cartilage in dysplastic hips using the finite element analysis.

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INTRODUCTION:
Curved periacetabular osteotomy (CPO) is performed for patients with developmental dysplasia of hip (DDH) to prevent progressive osteoarthritis. DDH type was classified into four types, Mild, Anterior, Posterior and Global deficiency. The morphology of the acetabulum vary in each DDH type, therefore, three-dimensional (3D) preoperative plan is necessary in CPO. However, the optimal rotation angle of osteotomized bone was unclear. In this study, we aimed to evaluate the contact pressure (CP) of the acetabular cartilage in each CPO model in each DDH type using the finite element analysis.

METHODS:
This retrospective study was approved by our Institutional Review Board. Twenty-three patients (a total of 24 hips) with DDH undergoing CPO between February 2006 and March 2014 were included in this study. We classified the DDH type using the radar chart we reported previously, one patients from each type, four patients was selected in this study. We analyzed the preoperative CT data of each patient using the finite element analysis software (Mechanical finder ver.12). Four CPO models were created in each DDH type, the preoperative model, the model rotated 30˚ laterally, the model 30˚ laterally 10˚ anteriorly, and the model 30˚ laterally 10˚ externally (Figure 1). The acetabular cartilage, and the femoral head cartilage were also created. The mesh model based on a 2mm tetrahedron was generated from the CPO model. The load was set in a one leg standing position (femur: 500N, grater trochanter: 1000N), the medial pubic bone, the distal femur and the superior rim of the ilium were restrained. The CP of the acetabular cartilage and the number of contact surface were evaluated in each model, the rotation angle that reduced the most contact pressure was examined (Figure 2).

RESULTS SECTION:
In Mild deficiency, the mean CP of the 3D-CPO model, the preoperative model, the model rotated 30˚ laterally, the model rotated 30˚ laterally 10˚ anteriorly, and the model rotated 30˚ laterally 10˚ externally, was 1.24MPa, 1.19MPa, 1.19MPa and 1.17MPa, the number of contact surface was 1954, 2078, 2131 and 2164 respectively. In Anterior deficiency, the mean CP was 1.36MPa, 1.13MPa, 1.19MPa and 1.19MPa, the number of contact surface was 962, 1118, 1019 and 1072 respectively. In Posterior deficiency, the mean CP was 1.79MPa, 1.55MPa, 1.33MPa and 1.39MPa, the number of contact surface was 1809, 2208, 2200 and 2109 respectively. In Global deficiency, the mean CP was 1.35MPa, 1.09MPa, 1.03MPa and 1.05MPa, the number of contact surface was 896, 1036, 1158 and 1177 respectively. The contour diagram shows the any CPO models reduced the mean CP and increased the number of contact surface (Figure 3).

DISCUSSION:
We could confirm that CPO reduced the mean CP and increased the number of contact surface using the finite element analysis. In the model rotated 30˚ laterally 10˚ anteriorly and rotated 30˚ laterally 10˚ externally, the stress concentration of the acetabular cartilage surface was reduced.
Therefore the osteotomized bone should be rotated not only laterally, but also anteriorly or externally in any DDH types. This finite element method might be helpful for 3D preoperative planning.

SIGNIFICANCE/CLINICAL RELEVANCE: CPO is performed to preserve the hip joint in patients with DDH. Therefore, 3D preoperative planning is necessary to ensure safety and a stable postoperative outcome. Preoperative evaluation using finite element analysis can assist in this process.

IMAGES:

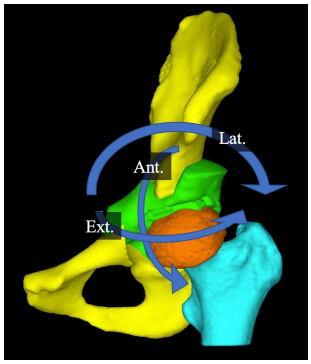

Figure 1

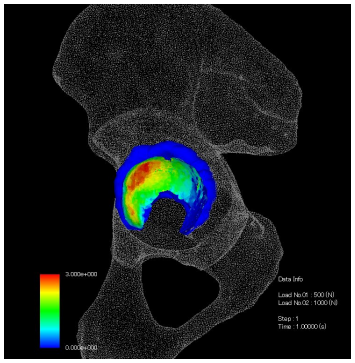

Figure 2

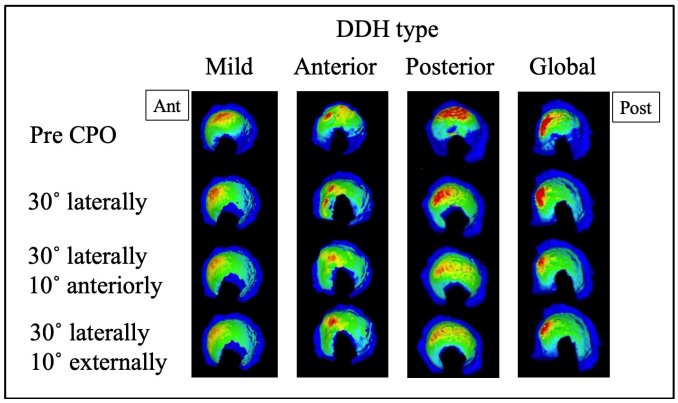

Figure 3