Variability of Range of Motion and Femoral Head Coverage within the acceptable parameters of Acetabular Positioning in Periacetabular Osteotomy in Patients with Developmental Dysplasia of the Hip

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INTRODUCTION**:** The Bernese periacetabular osteotomy (PAO) was first performed in 1984 for correction of developmental dysplasia of the hip (DDH) in skeletally mature patients. While various pelvic osteotomy techniques are indicated for specific age ranges and clinical presentations, the PAO has been proven efficacious in the treatment of skeletally mature patients to reduce pain and improve joint function. The PAO works by reorienting the acetabulum through a series of hexagonal cuts to help normalize the loading of the acetabular rim and improve femoral head coverage. As patients with DDH have a shallow acetabulum and therefore, femoral head undercoverage, the PAO procedure allows for correction that can increase the load-bearing surface of the hip joint by a range of 35-70%. However, the increase is greatly affected by positioning of the acetabular fragment during PAO. Currently, there are large variations in the clinical recommendation for optimal correction of the acetabulum fragment. An optimal position of the fragment should allow for not only improved femoral head coverage, but also acceptable range of motion of the hip joint following PAO. Therefore, this study aimed to examine the changes in femoral head coverage and range of motion associated with acetabular fragment placement within the guidelines for preoperative planning for PAOs.

METHODS: With IRB approval, preoperative CT scans were obtained from 44 patients who were diagnosed with DDH. Patient-specific 3-dimensional models were reconstructed in Mimics 23.0 (Materialise, Belgium). Then, the models were placed in a standard coordinate system as recommended by the International Society of Biomechanics (ISB) and pelvic tilt was subsequently adjusted based on the supine pelvis position. A virtual PAO was then performed using a custom Matlab program. Specifically, a total of 252 surgical plans were simulated for each model by adjusting the following parameters (LCEA: 25°, 28°, 31°, 34°, 37°, 40°; version: -9°, -6°, -3, °0°, 3°, 6°, 9°; flexion: 0°, 3°, 6°, 9°, 12°, 15°). For each plan, we measured the 3D coverage area of the femoral head by the acetabulum, the acetabular index, the anterior wall index, the posterior wall index, and the maximum internal rotation at 90° of flexion (Figure 1). The 3D femoral head coverage was further divided into four quadrants to better understand the effect of acetabular positioning. Lastly, those surgical plans were screened based on the following criteria: LCEA: 25-40°; Acetabular Index: ±9°; Ratio of posterior/anterior wall index: 1.5-3.5.

RESULTS: 4067 of 11088 plans met the radiographic criteria defining an acceptable plan, an average of 92.4 plans per hip (range: 3-173). All cases had >1 acceptable plan, and total coverage varied by 14.3±0.8% on average. However, within the posterolateral and anterolateral quadrants, this rose to 97.7±5.5% and 83.6±4.8%, respectively. In all but 15 of the cases, radiographically acceptable plans provided less femoral head coverage than simply adjusting the LCEA to 30° without adjusting flexion or version of the acetabular fragment. Acetabular positioning had a significant effect on hip range of motion, with internal rotation at 90° of flexion varying from 7.4° to 29.5° between surgical plans (average range: 8.8°±1.3°).

CONCLUSIONS: Large differences were measured in posterolateral and anterolateral femoral head coverage in addition to hip range of motion after implementing standard surgical plans for performing a PAO within acceptable radiographic parameters. These findings suggest that additional factors should be incorporated into pre-operative planning for these procedures to optimize both femoral head coverage and range of motion.

SIGNIFICANCE/CLINICAL RELEVANCE: Ideal femoral head coverage is crucial to yield improved outcomes, decrease degree of dysplasia, and decrease risk of future secondary osteoarthritis and serious intra-operative and post-operative complications. The utilization of pre-operative planning to determine ideal degree of correction using various parameters can improve patient outcomes.

IMAGES AND TABLES:

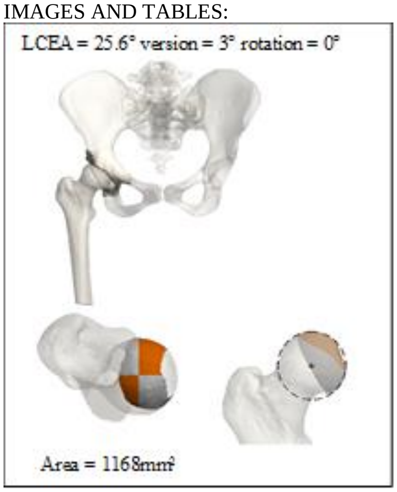

Figure 1. Femoral head coverage near minimum bound of LCEA

Figure 2. Femoral head coverage near maximum bound of LCEA