Morphometric Analysis of Acetabular Dysplasia in Cerebral Palsy. Three-Dimensional CT Study

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Introduction: In patients with cerebral palsy (CP), hip joint disorder is common and influences on the activities of daily life, especially on standing and walking. As the causes of hip disorder in CP, muscle imbalance, flexion and adduction contracture, acetabular dysplasia, and femoral growth abnormality have been speculated (1). Acetabular growth is normal till 30 months after birth, after 30 months subluxation of the hip worse in accordance with acetabular dysplasia (2). Therefore, to investigate the extent of acetabular dysplasia and of subluxation of the hip exactly in the infant period is important for prognostication of hip disorder in CP patients.

Although several works have been reported concerning acetabular dysplasia using multislice CT, which can be expected for exact three-dimensional evaluation, three-dimensional quantitative analysis in CP has not been conducted (3,4,5,6).

The aim of this study is to evaluate the three-dimensional geometry of the acetabular dysplasia and subluxation of the hip in CP quantitatively, and to compare the three-dimensional CT evaluation with the two-dimensional radiologic evaluation.

Methods: 124 hips in 62 CP patients, including spastic diplegia (SD) in 51 and spastic quadriplegia (SQ) in 11, without any surgical treatment were investigated. There were 42 boys and 20 girls with the average age of 5.5 years (range: 2.5 to 6.5 years). According to the classification of gross motor functional classification system (GMFCS)(7), there were 14 patients in level II, 29 in level III, and 8 in level IV of SD patients, and there were 5 in level IV and 6 in level V of SQ patients. Axial images of the pelvis and femora were obtained with a multislice CT scanner (Brilliance CT 64, Philips). Both the slice thickness and the pitch were 2 millimeters. All CT image data were recorded as DICOM-format data, and reconstructed to three-dimensional pelvis and femur model using original software.

Anatomical axis was settled according to International Society of Biomechanics (ISB) for pelvis (8). On the articular surface of the ilium, about 200 points were plotted and the acetabular plane matrix, best-fit plane of the articular surface of the ilium, was created automatically (SD; 0.61). The acetabular plane matrix was projected to the coronal plane (YZ plane) and the angle formed with the Z axis was defined as CTα, while it was projected to the sagittal plane (XY plane) and the angle formed with the X axis was defined as CTβ (Figure 1). On the articular surface of the ilium, pubis, and ischium, about 300 points were plotted and the acetabular sphere was created automatically (SD; 0.85). Similarly, the femoral head sphere was produced automatically (SD; 0.60). The center of these two sphere was defined as the center of the acetabulum and the femoral head respectively, and the distance of these centers divided by the femoral head diameter was defined as CT migration percentage (CTMP, %) and the direction of the connecting line between these two centers were evaluated three-dimensionally (Figure 2). The relationship between CTα, CTβ, and CTMP, and the correlation between these values and the various factors including GMFCS level, the type of CP (SD and SQ), age, and gender were investigated. Xp angle and migration percentage (XpMP) on anteroposterior radiographs (9) were measured in 80 hips, which were 65% of all materials, and they were compared with CTα and CTMP respectively.

Results: The mean CTα was 23.4° (range; 11.4° to 41.7°). The mean CTβ was 2.4° (range; -17.6° to 18.8°), and 82 hips (66%) showed CTβ>0°, which showed the ilium opened anteriorly, while 42 hips (34%) showed CTβ<0°, which showed the ilium opened posteriorly. The mean CTMP was 19.6% (range; 3% to 89%). In 103 out of 124 hips (83%), the femoral head center was located posteriorly, superiorly, and laterally, when the acetabular center was settled as the origin on ISB coordinate system. CTα and CTMP were significantly larger in the cases with GMFCS level IV/V and SQ, than in the cases with GMFCS level II/III and SD. Although the sample size was small, this limitation was compensated by useful computer simulation and by ensuring accurate digital measurements of various angles. As the limitation of this study, articular cartilage was not evaluated in this CT study.

Our data support that three-dimensional evaluation was exact and useful for CP hip analysis, and that the extent of acetabular dysplasia and subluxation was more severe in the patients with GMFCS level IV/V and SQ.

Discussion: This study investigated quantitatively three-dimensional morphometry of acetabular dysplasia and the extent of subluxation in 124 hips of CP cases using three-dimensional reconstructed pelvis model. The femoral head center was located posteriorly, superiorly, and laterally when the acetabular center was settled as the origin on ISB coordinate system. CTα and CTMP were significantly larger in the cases with GMFCS level IV/V and SQ, than in the cases with GMFCS level II/III and SD. Although the sample size was small, this limitation was compensated by useful computer simulation and by ensuring accurate digital measurements of various angles. As the limitation of this study, articular cartilage was not evaluated in this CT study.

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