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ORIGINAL STUDY

Acetabular coverage in bladder exstrophy : Role of 3-dimensional computed tomography

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We studied the acetabular coverage in bladder exstrophy patients and normal control children. The study included 13 patients with bladder exstrophy, who were divided according to their ages into group I below 5 years, group II between 5 and 10 years, and group III above 10 years of age. Four normal children served as controls, 2 were below 5 years, one was 7 and one was 12 years old. We measured the acetabular coverage (AC) and the center-edge-angle (CEA) by utilising the reconstructed 3-dimensional CT images. The mean right and left AC angles were 82 +/- 12 and 82 +/- 20 degrees in group-I, 107 +/- 15 and 103 +/- 17 in group-II and 119 +/- 24 and 116 +/- 22 in group-III, respectively ($p < 0.05$). The mean right and left CEA angles were 33 +/- 4 and 32 +/- 4 degrees in group-I, 30 +/- 4 and 29 +/- 5 in group-II and 25 +/- 2 and 24 +/- 1 in group-III, respectively ($p < 0.05$). In controls, the mean right and left AC angles were 151 +/- 2 and 153 +/- 2 degrees for children below 5 years, 166 and 165 degrees in the 7 year-old child and 180 and 180 degrees in the 12 year-old child. The CEA angle ranged from 15 to 25 degrees. Acetabular coverage in bladder exstrophy patients is deficient during the first 5 years of life. Although it gradually improves over time, it does not reach to normal value.

Keywords : bladder exstrophy ; acetabular coverage.

INTRODUCTION

Hip dysplasia is a developmental disorder that results in anatomic abnormalities leading to increased contact pressure in the joint and eventually coxarthrosis (*7*). In nearly all patients with bladder exstrophy, there are different degrees of pubic diastasis and outward rotation of the hips (*5*). The risk of development of hip dysplasia in these patients is unclear.

The concept of acetabular coverage usually refers to the radiographic relationship of the superolateral roof of the acetabulum to the femoral head. It is frequently quantified by the center-edge angle of Wiberg (CE) (*1*). Because of limited information provided by anteroposterior radiographs, Johnston *et al* (*4*) evaluated the acetabular coverage by determining the anterior edge-center-posterior edge (ACP) angle. More recently, the three-dimensional computed tomographic (CT) studies provided superior information about the fit of the femoral

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Fig. 1. — The three-dimensional (3-D) reconstructed images show deficient acetabular coverage over the supero-lateral part of the head ; A : anteroposterior view, B : right oblique, C : left oblique.

head in the acetabulum, as well as the size, shape and orientation of the acetabulum.

In the present study, we evaluated the acetabular coverage, as measured by 3-dimensional CT, in bladder exstrophy patients as well as normal control children.

PATIENTS AND METHODS

The study included 13 bladder exstrophy patients with a mean age of 8 ± 5 years (range : 2 to 21). There were 8 males and 5 females. All patients underwent either primary or redo bladder exstrophy closure. Supra-acetabular osteotomy was carried out in 9 patients. At the end of the operation the pubis was approximated in the midline by 1/0 PDS sutures. The postoperative course was uneventful in all children and there was no wound dehiscence or infection. Patients were followed up for a mean duration of 3 ± 2 years (range : 6 months to 5 years).

Four children with a mean age of 8 ± 4 years, 2 females and 2 males, with normal bony pelvic anatomy were included in the study, serving as a control group. Their evaluation was performed during CT assessment for Wilms' tumour staging or follow-up.

We measured the acetabular coverage and the center-edge-angle by utilising the reconstructed 3-dimensional CT images for each hip in all patients. The study was done using (high speed pulse, General Electric, Milwaukee, WI) CT using the relatively new multi-slice CT technique that allows acquisition of large volume with narrow collimation in a few seconds. Patients were positioned in the scanner with their hips in extension, then we started scanning just above the iliac bones down to the upper third of both femoral bones using a thin slice section (3-4 mm) with narrow reconstruction index (1-2 mm).

The obtained axial images were then reconstructed in a special console using special software (AW40, General Electric, Milwaukee, WI) to obtain multiplanar reformatted images in different orthogonal planes. Three-dimensional reconstruction with shaded surface display and volume rendering were then performed to visualise bone and joints by using a special bone window (400-900H9) to assess acetabular coverage qualitatively using different projections. Sagittal reformatted images were assessed to measure the ACP angle by drawing a line connecting the anterior and posterior edges of the weight bearing bone with the center of the femoral head.

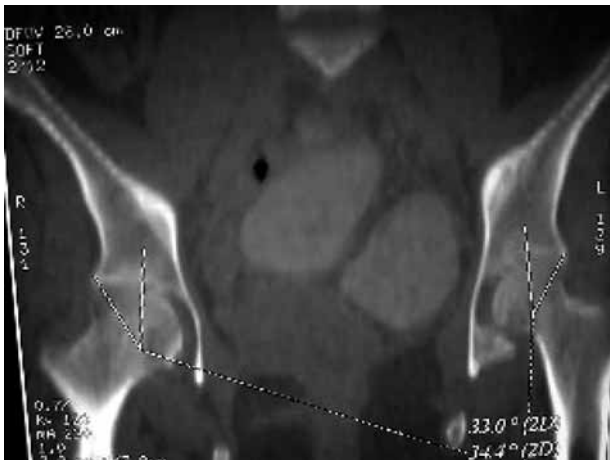

Fig. 2. — Right and left sagittal view with ACP angle

We utilised the Kruskal-Wallis 1-Way Anova test to compare means, and a p value < 0.05 was considered significant.

RESULTS

Degenerative changes in the hip joint were noted in no instance. Patients were divided into 3 groups according to their ages ; group-I below 5-years of age (6 patients), group-II between 5 and 10 years (4 patients) and group III above 10 years (3 patients). In the control group, there were 2 children below 5 years, one was 7 years and one was 12 years old.

The mean right and left acetabular coverage angles were 82 +/- 12 and 82 +/- 20 degrees in group I, 107 +/- 15 and 103 +/- 17 in group II and 119 +/-24 and 116 +/- 22 in group III, respectively ($p < 0.05$). The mean right and left center-edge-angles were 33 +/- 4 and 32 +/- 4 degrees in group I, 30 +/- 4 and 29 +/- 5 in group II and 25 +/- 2 and 24 +/- 1 in group III, respectively ($p < 0.05$). Figures 1 and 2 show the three-dimensional (3-D) reconstructed images that display the deficient acetabular coverage over the superior lateral part of the head.

In the control group, the mean right and left acetabular coverages were 151 +/- 2 and 153 +/- 2 degrees for patients below 5 years, 166 and 165 degrees in the 8-year-old child and 180 and 180 degrees in the 12-year-old child. The center edge angle ranged from 15 to 25 degrees.

Both acetabular coverage and center-edge-angle were significantly worse in patients who underwent osteotomy. However, it appears that this effect is related to age rather than to osteotomy, because patients who underwent osteotomy were relatively younger with a mean age 5 +/- 1 year compared to 14 +/- 2 years for patients who did not undergo osteotomy.

DISCUSSION

Hip dysplasia is a developmental disorder that usually results in severe degenerative changes and eventually coxarthrosis (*7*). Correction of the pathological anatomy before development of degenerative changes may obviate a future need for more complex reconstructive procedures. Patients with bladder exstrophy have a unique pathologic anatomy. There is some degree of pubic diastasis and outward rotation of the hips and deficient acetabular coverage (*5*). Thus, theoretically, these patients are liable to develop coxarthrosis. Surprisingly, however, the risk of development of dysplastic hips in these patients is unclear. In the present study, we evaluated the acetabular coverage in these children as well as in a control group at different ages. We also noted whether there is any minor pathologic anatomy predicting early degeneration.

The concept of acetabular coverage usually refers to the radiographic relationship of the superolateral roof of the acetabulum to the femoral head. It is frequently quantified by the center-edge angle of Wiberg (CE) which is formed by two lines radiating from the center of the femoral head : a vertical line and a line extending to the acetabular margin ; it normally ranges from 25 degrees to 30 degrees (*1*). The anterior acetabular margin is sometimes difficult to identify, however, because the radiopaque line of the acetabular roof tends to fade anteriorly.

Johnston *et al* (*4*) reported that evaluation of acetabular coverage can be made by superimposition of the superior weight-bearing roof over the femoral head. They determined the angle formed by the line that connects the anterior and the

posterior edges of the weight-bearing dome with the center of the femoral head, that is, the anterior edge-center-posterior edge (ACP) angle and reported that it is nearly 180° in normal coverage, while in acetabular dysplasia it is < 180° (*4*). In the present study, the mean right and left acetabular coverage angles were 98 +/- 21 and 97 +/- 23°. It is obvious that it is in the range of dysplasia. However, in no circumstances were degenerative changes noted, and none of the patients had symptoms related to hip dysplasia. Acetabular coverage in exstrophy patients and controls were analysed according to the age group. The coverage was deficient during the first 5 years of life. Although it gradually improves over time, it does not reach to normal value.

The purported benefits of osteotomy in bladder exstrophy patients include facilitation of anterior abdominal wall closure (*3*), penile lengthening (*6*) and improved continence (*2*). In the present study, we thought that osteotomy might prove to be of value to prevent degenerative changes in the hip joint. Surprisingly, acetabular coverage was not improved by osteotomy. In contrast it was significantly worse than in patients who did not undergo osteotomy. However, it appears that this effect is related to age rather than osteotomy because patients who underwent osteotomy were relatively younger with a mean age 5 +/- 1 year compared to 14 +/- 2 years for patients who did not undergo osteotomy.

CONCLUSIONS

Acetabular coverage in exstrophy patients is deficient during the first 5 years of life. Although it gradually improves over time, it does not reach to normal value. Thus a long-term follow-up is required for a possibility of reconstructive surgery for hip dysplasia.

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