Acetabular Changes in Coxa Vara

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Abstract The purpose of this study was to define the acetabular changes associated with coxa vara and determine how these acetabuli differ from those of a normal hip. Charts and radiographs of 33 patients with coxa vara with a mean age of 6 years (range, 2–15 years) were retrospectively reviewed. The diagnosis was developmental coxa vara in 21 patients and congenital femoral deficiency in 12. Radiographic measurements, including acetabular index, sourcil slope, center edge angle, migration index, and medial joint space, were compared with those of 29 hips in the control group. The inclination of the acetabulum or acetabular slope (as measured by the acetabular index and sourcil slope) was significantly increased in the hips with coxa vara as compared with those in the control group.

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Each author certifies that his or her institution has approved the human protocol for this investigation, that all investigations were conducted in conformity with ethical principles of research, and that informed consent for participation in the study was obtained.

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Both parameters have a statistically significant inverse correlation with the degree of varus, ie, the greater the varus of the proximal femur, the greater the upsloping of the acetabulum. Joint subluxation, as measured by the center edge angle, migration index, and medial joint space, showed little difference from that of control subjects.

Level of Evidence: Level III, diagnostic study. See the Guidelines for Authors for a complete description of levels of evidence.

Introduction

Coxa vara is a rare condition that is defined as a decrease in the femoral neck shaft angle less than normal. Coxa vara is classified into subtypes, congenital, developmental and acquired [1]. Although there are studies that have identified acetabular dysplastic changes associated with coxa vara [3, 4, 9], none describes the acetabular morphologic features.

An understanding of the acetabular morphology is important in children with coxa vara. Residual dysplasia may place a hip at risk for osteoarthritis as the child becomes a young adult. In addition, femoral acetabular impingement may develop acting as a cause of pain and early arthrosis in these patients. Just as important, many children with coxa vara undergo reconstructive procedures such as limb lengthening, which puts added stress across the hip and potentially exacerbates mild, otherwise clinically silent, hip dysplasia. Understanding abnormal morphology of the hip with coxa vara may provide insight into why and which patients are at risk for hip subluxation. Early recognition of acetabular dysplasia is critical to identify which patients need radiographic surveillance and may identify candidates who would benefit from acetabular reconstructive procedures.

Our primary hypothesis is children with coxa vara will have greater acetabular dysplasia as described by increases in the acetabular index (AI) and sourcil slope (SS) than control groups with normal proximal femoral anatomy.

Our secondary hypotheses are: (1) the degree of acetabular dysplasia will be correlated to the magnitude of the coxa vara as measured by the neck shaft angle (NSA), articular trochanteric distance (ATD), and Hilgenreiner's epiphyseal angle (HEA); and (2) hip subluxation in children with coxa vara as measured by the migration index (MI) and center edge angle (CEA) will not be significantly greater than control groups with normal proximal femoral anatomy.

Materials and Methods

This is an Institutional Review Board-approved retrospective review of all patients with congenital (proximal femoral focal deficiency [PFFD]) and developmental coxa vara identified consecutively at our institution from 1982 to 2000. Inclusion criteria were: (1) the diagnosis of congenital or developmental coxa vara as determined from the chart and record review. Patients with coxa vara resulting from acquired, syndromic, or metabolic etiology were excluded from the study because of the great variability in the etiologies; (2) adequate radiographs taken before any surgical treatment; and (3) proximal femoral varus as determined radiographically by a NSA less than 125° . Although most patients had a considerably smaller NSA, we believed if the NSA was greater than 125° , the diagnosis of coxa vara would be inaccurate. No patients in the coxa vara group had a NSA greater than 125° and therefore none were excluded by these criteria, although five patients were excluded because of lack of adequate radiographs. The control group was selected from a consecutive series of patients who presented in a general pediatric orthopaedic clinic. Inclusion criteria included: (1) the absence of any hip disorder on examination determined from history or by radiographs; and (2) a NSA greater than 125° . No patients were excluded as a result of these criteria. The diagnosis for the control group included scoliosis, intoeing, leg-length inequality, and idiopathic toe walking. Demographic information included the patient's age at the time of the radiograph, affected side, gender, and presence of any underlying condition such as developmental or congenital coxa vara. Thirty-three patients met the inclusion criteria. In 12 patients, the diagnosis was congenital coxa vara associated with congenital femoral deficiency and in the remaining 21, the diagnosis was developmental coxa vara. Forty-seven hips in 15 boys and 18 girls were studied. Fourteen patients had bilateral involvement, and 19 patients had only one side involved. Their ages ranged

from 2 to 15 years with a mean of 6.4 years. Twenty-nine hips (22 patients; 12 boys, 10 girls) were included as a control group. Their mean age was 9.7 years (range, 18 months–16 years; p = nonsignificant between children with coxa vara and control subjects).

We performed standing anteroposterior radiographs of the pelvis, including both hips in a neutral position, for all patients meeting the inclusion criteria. Eleven radiographic parameters were measured in the proximal femur and acetabulum divided into three groups: (1) measurements of the acetabulum; (2) measurements of subluxation (ie, measurements that describe the relationship between the proximal femur and acetabulum); and (3) measurements of the proximal femur.

Measurements of the acetabulum included the AI [12] and SS [2] (the angle formed by a line joining the two ends of the sourcil with the horizontal line) (Fig. 1). Measurements for subluxation included MI [8], medial joint space [10], Shenton's line [11], and CEA [7, 14].

Measurements of the proximal femur included NSA (the angle formed between the anatomic axis of the femoral shaft and the axis of the femoral neck); the ATD (measured from the top of the greater trochanter to the level of the articular surface on top of the femoral head along a line parallel to the long axis of the femoral shaft [5]) (Fig. 2); and HEA as described previously [13] (Fig. 2). These measurements were used to: (1) correlate the degree of

Fig. 1 Measurement of the sourcil slope (SS) is shown.

Fig. 2 Measurement of articulo-trochanteric distance (ATD) and Hilgenreiner's epiphyseal angle (HEA) is shown.

coxa vara to indices of acetabular dysplasia (ie, the AI and CEA); (2) ensure the patients with coxa vara had radiographic evidence of coxa vara by a NSA less than 125° ; and (3) ensure other measures of coxa vara (ie, HEA and ATD) correlated with the NSA.

We compared mean values for all measurements between the normal and affected hips using a paired *t* test with $p < 0.01$ considered statistically significant. The correlation index was applied to determine if the degree of varus as measured by the NSA was related to the acetabular morphology as measured by the AI and SS.

Results

In the coxa vara group, acetabular dysplasia as measured by both parameters, the AI and the SS, was considerably greater than in the control group, indicating a greater upsloping of the roof of the acetabulum. The mean AI was 33° in the coxa vara group compared with 13° in the control group ($p < 0.01$). The sourcil slope was 19° in the coxa vara group compared with -18° in the control group ($p < 0.01$).

There was an inverse correlation between the NSA and the AI and SS of -0.5 . In other words, the greater the varus of the proximal femur, the greater the upsloping of the acetabulum.

Table 1. Radiographic measurements

Measurement	Coxa vara (47 hips)	Control (29 hips)
Measurements of proximal femur		
Neck shaft angle (degrees)	91	139
Articulotrochanteric distance (mm)	-6	22
Hilgenreiner's epiphyseal angle (degrees)	67	20
Acetabular architecture		
Acetabular index (degrees)	33	13
Sourcil slope (degrees)	19	-18
Subluxation indices		
Center edge angle (degrees)	22	30
Migration index (percent)	6.7	11
Medial joint space (mm)	8.3	6.9
Shenton's line (percent broken)	9	31

Measurements of hip subluxation showed a statistically significant but clinically small difference in only one measure of hip subluxation (CEA) between the coxa vara group and the control group. The mean CEA was 22° in the coxa vara group, which was smaller than the mean of 30° in the control group ($p < 0.01$). However, there was no statistical difference in the other hip subluxation measurements (MI and medial joint space); in fact, the MI was smaller for the coxa vara group (ie, greater femoral head coverage). Subluxation indices show no correlation with degree of varus.

As one would expect, measurements of the proximal femur, the NSA, the ATD, and HEA differed significantly from the control group with normal proximal femoral anatomy (Table 1). The ATD correlated inversely with the NSA ($r = -0.8$), and HEA correlated positively with the NSA ($r = 0.65$).

Discussion

Coxa vara is believed to be associated with acetabular changes, but previous studies have not described the radiologic features in any detail [3, 4, 9]. Specifically, acetabular parameters associated with coxa vara and their relation to the degree of femoral varus remain unknown.

This study indicates measures of acetabular slope (AI and SS) are significantly greater in hips with coxa vara than normal hips (control group). These acetabular changes in coxa vara are inversely related to degree of varus of the proximal femur. Because the acetabulum requires the spherical femoral head as a stencil around which it forms during its development [6], hips with coxa vara theoretically should be at risk of having dysplasia develop as a result of altered femoral head development. Patients with a

Table 2. Comparison of radiographic measurements for developmental coxa vara and congenital focal deficiency

Measurement	Developmental coxa vara (21 hips)	Congenital coxa vara (12 hips)	p Value
Acetabular index (degrees)	21	28	0.042
Sourcil slope (degrees)	16	27	0.06
Center edge angle (degrees)	25	16	0.0004

dysplastic acetabulum in coxa vara are asymptomatic. These radiologic findings are particularly important in patients with PFFD undergoing lengthening. Varus position of the neck is believed to prevent hip subluxation associated with femoral lengthening. An associated dysplastic acetabulum can lead to hip subluxation.

The current study shows the acetabulum is abnormal in coxa vara. Acetabular index and SS in coxa vara are statistically different than in the normal acetabulum. Both parameters have a statistically significant inverse correlation with the degree of varus. It also shows the acetabular indices are different in congenital and developmental coxa vara. If this is to be corrected surgically, surgical procedures that aim to correct the AI should be considered.

Previous authors have described shallow acetabulae in hips with coxa vara [9] and studied acetabular morphology in skeletally mature patients with Type 1 PFFD [4]. Their results show there is posterior and lateral acetabular deficiency. In those series, more than 50% of patients required treatment as a result of a symptomatic hip [4, 9]. Another study in children with developmental coxa vara [3] shows the mean AI was 28° (range, 22°–35°) and the mean CEA was 21.5° (range, 5°–30°) at long-term followup.

Comparison between developmental and congenital coxa vara did not show significance resulting from the small number of patients in this study, nor what is stated in the hypothesis of this study, but post hoc data show a trend toward greater sloping of the acetabulum in children with congenital coxa vara. There is, however, evidence of greater subluxation in children with congenital coxa vara as compared with developmental coxa vara as seen by the CEA of 16° for congenital coxa vara and 25° for developmental coxa vara ($p < 0.01$) (Table 2).

Limitations of our study include the small number of control subjects and evaluation of radiologic parameters in a pediatric age group. Additional studies of coxa vara should take into consideration acetabular changes at skeletal maturity and beyond. A future direction would be to study the natural history of acetabular changes in coxa vara. The acetabulum should be evaluated as part of the radiologic assessment of coxa vara.

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