ACETABULAR COVER IN CONGENITAL DISLOCATION OF THE HIP

S. OGATA, H. MORIYA, K. TSUCHIYA, T. AKITA, M. KAMEGAYA, M. SOMEYA

From Chiba University, Japan

The exact measurement of femoral head cover is essential for an assessment of reduction of congenital dislocation of the hip. We have compared standard anteroposterior radiographs with computerised tomograms and thereby classified the shape of the acetabular roof into four types.

We found that the CE angle of Wiberg is a more reliable measure of head cover when the lateral point of bony condensation of the roof is chosen as the reference point rather than the edge of the bone, where these two points do not overlap. We conclude that head cover can be more accurately determined in younger children with dysplastic hips by our 'refined' CE angle, than by the original method of Wiberg.

After the closed or open reduction of a congenital dislocation of the hip (CDH), it is important to know whether the hip will develop normally; femoral head coverage is the most significant factor in this prognosis. Computerised tomography (CT) can be used to assess the relationship between the femoral head and acetabulum in three dimensions, but we could find no report which quantified head cover in the transverse plane.

Of the many radiographic indicators reported, the CE angle of Wiberg is one of the most valuable indices of lateral coverage of the femoral head in the coronal plane (Wiberg 1953; Fredensborg 1976; Wientroub et al 1981). Wiberg's CE angle is defined by two lines from the centre of the head, one parallel with the long axis of the body and the other running through the edge of the acetabulum. The most lateral point of the acetabular roof seen on an anteroposterior (AP) radiograph is taken as the edge of the acetabulum, but, in some young patients with dysplastic hips, this point is difficult to define. In these patients, we have paid attention to the subchondral

bony condensation in the acetabular roof which is also seen on AP radiographs, and have located its most lateral point. We found that in some young patients with a normal CE angle who later developed poor acetabular coverage, this lateral point of bony condensation of the acetabular roof did not reach the lateral rim of the acetabular roof as seen in AP radiographs, but was situated more medially. In these patients the classical CE angle was not reliable, so we modified the method, using the lateral margin of bony condensation.

We now describe a quantitative assessment of femoral head cover in the transverse plane using CT scans; we compare these results with both the classical CE angle and with our 'refined' angle.

PATIENTS AND METHODS

We studied both hips in 27 children with CDH, 24 with unilateral and three with bilateral involvement. All children had either closed or open reduction, but no surgery on the acetabulum itself. Standard radiographs and CT scans were used, one child (case 3) being examined twice within two years. Details are given in Table I. There were two boys and 25 girls with ages ranging from 2 years 10 months to 14 years 3 months (mean 6.3) at the time of investigation.

For CT scanning the children were placed supine with legs together and the knees in neutral rotation. Two scanning slices were used, one through the acetabular roof, and the other through the centre of the femoral head (Fig. 1). If both sides were not at the same level, they were scanned separately. Thus, two to four separate cuts were made in each case.

S. Ogata, MD, Senior Registrar
H. Moriya, MD, Professor of Orthopaedics
K. Tsuchiya, MD, Lecturer
T. Akita, MD, Senior Registrar
M. Someya, MD, Senior Registrar
Department of Orthopaedic Surgery, School of Medicine, Chiba University, 1-8-1 Inohana, Chiba-City, Chiba 280, Japan.

M. Kamegaya, MD, Pediatric Orthopaedic Surgeon
Chiba Children's Hospital, Division of Orthopaedic Surgery, 579-1 Heta-chou, Chiba-city, Chiba 280-02, Japan.

Correspondence should be sent to Dr S. Ogata.

© 1990 British Editorial Society of Bone and Joint Surgery
0301-620X/90/2059 \$2.00
J Bone Joint Surg [Br] 1990; 72-B: 190-6.

The cut showing the acetabular roof was then superimposed on that of the femoral head, using the image of the couch as a reference. The percentage of acetabular cover of the femoral head was measured using a semi-automatic image analyser (LEITZ-ASM) and was

termed the acetabular head coverage (AHC). Acetabular anteversion was also measured as shown in Figure 2.

Using the standard AP radiographs, we then compared the relative positions of the lateral end of the 'sourcil' of bony condensation and the most lateral

Fig. 1

Fig. 2

Levels of the CT slices obtained and tracings to show the method of measurement of acetabular head coverage (AHC) and of the angle of acetabular anteversion.

Table I. Details of the hips of 27 children after treatment for CDH

Case	Sex	Side	Method of reduction	Age at scan y m	CT scan				Radiographic CE angles		Type of acetabular roof	
					Acetabular head coverage (per cent)		Acetabular anteversion (degrees)		Classical (Refined)*		R	L
					R	L	R	L	R	L		
1	F	R	Closed	5 8	29.4	65.8	19	18	-16 (-27)	16 (6)	IV	III
2	F	L	Closed	4 5	59.5	42.8	16	15	12 (3)	6 (-4)	III	IV
3	F	R	Open	8 11	47.2	55.7	12	17	18 (-2)	24 (19)	IV	III
				10 11	44.6	81.3	4	16	10 (-10)	29	IV	I
4	M	R	Open	4 7	0.0	48.5	15	11	10 (-10)	18	IV	I
5	F	L	Closed	4 9	60.7	60.4	16	17	14 (8)	9	III	II
6	F	B†	Closed (R)	4 3	59.0	57.2	24	21	9 (0)	7	III	II
			Open (L)									
7	F	L	Closed	4 0	84.7	44.1	7	14	13	0	II	II
8	F	L	Closed	4 4	100.0	9.0	15	13	25	-10 (-22)	II	III
9	F	R	Open	4 4	28.0	72.9	16	13	0 (-4)	11	IV	II
10	F	L	Closed	3 6	72.4	0.0	12	19	15 (6)	-10 (-23)	III	IV
11	F	L	Open	3 6	85.4	14.9	13	7	10	-2 (-19)	II	III
12	F	B	Closed	5 9	82.4	66.6	18	17	22	14	II	II
13	F	R	Closed	10 2	21.6	70.8	23	19	-22 (-26)	23	III	I
14	F	B	Closed	7 4	62.7	57.2	14	17	6 (-13)	7	III	I
15	M	L	Closed	4 10	86.2	59.0	-4	14	20 (11)	20 (-2)	III	IV
16	F	L	Closed	12 6	88.3	0.0	20	12	20	-132 (-136)	I	IV
17	F	R	Closed	2 10	30.6	52.4	26	24	-18	0	II	II
18	F	L	Closed	14 3	81.3	74.8	19	18	22	22	I	II
19	F	L	Open	8 3	70.9	35.8	18	15	5	-25	I	II
20	F	L	Closed	4	72.3	16.1	20	11	12	-10 (-37)	II	IV
21	F	L	Closed	5 6	78.1	7.4	15	21	13	-66 (-70)	II	IV
22	F	L	Closed	11 5	77.9	23.2	28	22	25	-13 (-16)	I	IV
23	F	L	Closed	6 8	72.7	59.3	9	12	14	15	I	II
24	F	L	Closed	3 11	58.3	32.1	15	15	15 (4)	-7	III	II
25	F	R	Closed	5 4	46.9	53.7	20	16	4 (-6)	12 (5)	III	III
26	F	R	Closed	6	49.8	60.3	17	17	0 (-11)	16 (11)	IV	III
27	F	R	Closed	4 11	39.0	79.9	15	17	15 (3)	20	IV	II

* refined CE angle measured only in type III and IV acetabula

† bilateral

projection of the acetabular roof with the outline of the acetabular rim seen on the CT scans, in an attempt to classify the various shapes of acetabular roof. The CE angle of Wiberg was then measured on standard pelvic radiographs. Where, in young children, the lateral point of the bony condensation differed from the most lateral point of the roof, we measured from both points. Both the classical and the 'refined' CE angles were recorded.

Statistical analysis was performed by Student's *t* method, and linear regression analysis was used to estimate the relationship between acetabular head coverage and the CE angles.

RESULTS

Detailed data are given in Table I. In the 24 unilateral cases, we found a significant difference between acetabular head coverage (AHC) on the affected and the unaffected sides ($p < 0.01$), but there was no significant difference in acetabular anteversion between these sides (Table II).

Comparison of the position of the two radiographic reference points with the outline of the acetabular rim on the CT scan made it possible to classify the shape of the acetabular roof into one of four types (Fig. 3):

Type I – bony condensation in the acetabular roof overlaps the most lateral point of the roof: an acetabular beak is clearly delineated. In this type, the CT scan showed a round acetabular rim with its most lateral point halfway between its anterior and posterior ends.

Type II – the bony condensation overlaps the most lateral point of the acetabular roof but no definite acetabular beak is seen. On the CT scan, the outline of the acetabular rim is straight, lying in the sagittal plane.

Type III – there is a small interval between the lateral

edge of bony condensation and the most lateral point of acetabular roof, and the bony condensation is uniform, well defined and smooth. On the CT scan, the edge of the acetabular rim is oblique, and it is narrower posteriorly. *Type IV* – there is a considerable distance between the most lateral point of bony condensation and the most lateral point of the acetabular roof, and the bony condensation is ill-defined, irregular and not uniform. On the CT scan, the outline of the rim is oblique and irregular, often showing a defect halfway between anterior and posterior margins.

The number of hips and the average age of the

Table II. Results in 56 hips

	Affected side (n = 31)	Unaffected side (n = 25)	Significance of difference
	Mean $\pm$ s.d.	Mean $\pm$ s.d.	
Acetabular head cover (per cent)	38.8 $\pm$ 22.4	71.6 $\pm$ 12.8	$p < 0.01$
Acetabular anteversion (degrees)	16.2 $\pm$ 4.6	15.5 $\pm$ 5.9	NS

Table III. Type of acetabular roof (see text) related to the average age of the patients

	Type of acetabular roof			
	I	II	III	IV
Number of hips	9	18	15	14
Average age (Mean $\pm$ s.d.)	9.6 $\pm$ 2.9*	5.2 $\pm$ 2.5	5.5 $\pm$ 1.9	6.5 $\pm$ 2.9

* difference from others significant at $p < 0.05$

Classification of the acetabular roof, measurement of the classical CE angle in types I and II, and of the 'refined' angle in types III and IV.

Fig. 3

patients in these four groups are given in Table III. All but one of type I acetabula were seen on the unaffected side, and all of the type IV acetabula were seen on the affected side. The average age of children with type I was significantly higher than those of the other types ($p < 0.05$). The acetabular head coverage (AHC) of type

IV was significantly lower than that in the other types (Fig. 4). In types III and IV the 'refined' CE angle was consistently lower. The difference between the classical and refined CE angles was larger in type IV (mean 12.9°) than in type III (mean 9.4°), but the difference was not significant.

The relationship between the acetabular cover measured by CT scan and the classical CE angle measured radiographically was studied by regression analysis. The slopes of the regression lines calculated separately for affected and unaffected hips were fairly different (Fig. 5), but the slope of the regression lines for types I and II together and for types III and IV together (Fig. 6) were almost parallel with that for types III and IV below the other. This shows that, in types III and IV, the classical CE angle overestimates the head coverage.

In contrast, the relationship between acetabular cover and the refined CE angle in types III and IV shown in Figure 7, where the regression lines almost coincide, reveals a very high correlation.

Fig. 4

Bar graph showing acetabular head coverage (AHC) in each type of acetabulum, and the significance of differences.

ILLUSTRATIVE CASE REPORTS

Case 3. This girl had an open reduction of congenital dislocation of the right hip. At 8 years 11 months the classical CE angle was 18° (left side 24°) an apparently satisfactory cover. The refined CE angle, however,

Fig. 5

Fig. 6

Fig. 7

Figure 5 – Relationship between the classical CE angle and acetabular head coverage. Regression lines calculated separately for unaffected and affected sides. Figure 6 – Regression lines calculated separately for types I and II as against types III and IV. Figure 7 – Relationship between the 'refined' CE angle and acetabular head coverage. The regression line for types III and IV has been recalculated for the new angles.

Fig. 8

Fig. 9

Case 3. Figure 8 – Radiograph of an 8-year-old girl. In the right hip the contour of the bony condensation is ill-defined and there is some distance between its most lateral point (arrow head) and the edge of the apparent acetabular roof. Figure 9 – The CT scan of the acetabular roof shows irregularity and a defect in the osseous acetabular rim on the right. Figure 10 – Acetabular head coverage was 47.2% on the right and 55.7% on the left.

Fig. 10

Fig. 11

Fig. 12

Figure 11 – Radiograph of same patient as Figs 8 to 10 (case 3) two years later. The right acetabulum is shallow. Figure 12 – The CT scan shows persistence of the defect in the acetabular rim of the right hip, especially when compared with the well-formed left acetabular roof. Figure 13 – Acetabular head coverage was 44.6% on the right and 81.3% on the left.

Fig. 13

measured only -2° (left side 19°) (Fig. 8) and the CT scan showed an irregular acetabular edge (Fig. 9). Acetabular cover was 47.2% on the affected side as against 55.7% on the other (Fig. 10). The right hip was classified as type IV.

Two years later, dysplasia of the right hip was apparent (Fig. 11); a repeat CT scan showed an osseous defect of the acetabular edge on the affected side in contrast to the normal edge on the unaffected side (Fig.

12). Acetabular cover was 44.6% on the affected side and 81.3% for the unaffected side (Fig. 13).

Case 15. This boy had had closed reduction and a cast for congenital dislocation of the left hip. At 4 years 10 months, standard AP radiographs showed an acceptable reduction, but there was a considerable distance between the zone of bony condensation and the lateral rim of the acetabulum. The refined CE angle was -2° (Fig. 14). A CT scan showed an osseous defect in the lateral edge of

the acetabulum (Fig. 15). The acetabular cover was 59.0% on the left and 86.2% on the right (Fig. 16). This hip was classified as type IV: further treatment will be necessary.

DISCUSSION

The use of computerised tomography in paediatric hip problems has been reported (Lasda et al 1978; Peterson et al 1981; Visser, Jonkers and Hillen 1982) but mainly for the detection of dislocation or subluxation when a cast obscures details on standard radiographs, or when measurements of femoral torsion and acetabular anteversion are needed. We have used it to make quantitative assessments of femoral head coverage in the transverse plane.

Wiberg (1939) originally described the CE angle in adults, and Severin (1941) applied it to children over six years of age. Massie and Howorth (1950) also used it in children and, later, Wiberg (1953) studied the development of the acetabular roof and applied his index to children over four years of age, but there has been little discussion on the reference point to be used. We found this easy where the lateral point of bony condensation of the acetabular roof overlies the most lateral point of the acetabular roof (our types I and II). It is more difficult when the points are not superimposed (our types III and IV).

The type I acetabulum, with a lateral beak, is seen in older children. In type II the osseous rim lies in a sagittal plane (as seen in the CT image) so that its

anterior, middle and posterior edges are superimposed on an AP radiograph and easily localised. In type III acetabula, by contrast, the distance between the lateral point of the bony condensation and the lateral edge of roof is due to the oblique orientation of the acetabular rim. In type IV acetabula, the irregularity and defects in the bony rim show up as a considerable distance between the two points. In types III and IV acetabula, the most lateral point of the acetabular roof on AP radiographs is actually anterior and lateral to the most superior part of the acetabulum (see Fig. 3). Measurement of the CE angle from the most lateral classical reference point may seriously overestimate the femoral head cover.

It is therefore imperative to distinguish between the two points of reference, and use the refined CE angle in types III or IV acetabula. In our case 3, a type III acetabulum on the left developed into type I in two years, but the type IV acetabulum on the right failed to develop normally. It is well known that subchondral bony condensation in the acetabulum outlines the area of high compressive stresses even in young children (Tachdjian 1982), but it seems that the difference in contour and consistency of the bony condensation between our types III and IV may explain the difference in the potential of acetabular development. In a type IV acetabulum, with an appreciable distance between the apparent lateral rim and the edge of bony condensation, careful follow-up should include CT examination to establish the shape of the defect. This will allow proper treatment to prevent later subluxation and secondary osteoarthritis. Where the classification into type III or IV is doubtful, CT

Fig. 14

Fig. 15

Case 15. Figure 14 - Radiograph of a 4-year-old boy. In the left hip, the most lateral point of the bony condensation (arrow head) is well short of the apparent edge of the acetabular roof. Figure 15 - The CT scan confirms a defect in the osseous acetabular rim. Figure 16 - Acetabular head coverage was 86.2% on the right and 59.0% on the left.

Fig. 16

examination may also be helpful. In all other young children with CDH, the use of the refined CE angle, measured to the lateral edge of the bony condensation, will be sufficient to determine the femoral head coverage; routine CT scans are not necessary in these cases.

The authors would like to thank Dr H. K. Uhthoff of the University of Ottawa for help in the preparation of this manuscript.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

REFERENCES

- Fredensborg N.** The CE angle of normal hips. *Acta Orthop Scand* 1976; 47:403-5.
- Lasda NA, Levinsohn EM, Yuan HA, Bunnell WP.** Computerized tomography in disorders of the hip. *J Bone Joint Surg [Am]* 1978; 60-A:1099-102.
- Massie WK, Howorth MB.** Congenital dislocation of the hip: Part 1. Method of grading results. *J Bone Joint Surg [Am]* 1950; 32-A: 519-31.
- Peterson HA, Klassen RA, McLeod RA, Hoffman AD.** The use of computerised tomography in dislocation of the hip and femoral neck anteversion in children. *J Bone Joint Surg [Br]* 1981; 63-B:198-208.
- Severin E.** Contribution to knowledge of congenital dislocation of hip joint: late results of closed reduction and arthrographic studies of recent cases. *Acta Chir Scand* 1941 [Suppl 63]; 84: 1-142.
- Tachdjian MO.** Treatment of hip dysplasia in the older child and adolescent: factors in decision making. In: Tachdjian MO, ed. *Congenital dislocation of the hip*. New York, etc: Churchill Livingstone, 1982; 625-46.
- Visser JD, Jonkers A, Hillen B.** Hip joint measurements with computerized tomography. *J Pediatr Orthop* 1982; 2:143-6.
- Wiberg G.** Studies on dysplastic acetabula and congenital subluxation of the hip joint: with special reference to the complication of osteoarthritis. *Acta Chir Scand* 1939; 83:Suppl 58.
- Wiberg G.** Shelf operation in congenital dysplasia of the acetabulum and in subluxation and dislocation of the hip. *J Bone Joint Surg [Am]* 1953; 35-A:65-80.
- Wientroub S, Tardiman R, Green I, Salama R, Weissman SL.** The development of the normal infantile hip as expressed by radiological measurements. *Int Orthop* 1981; 4:239-41.