The acetabular opening angle in Perthes' disease

Radiographic study of 62 unilateral cases

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Pelvis AP radiographs in 62 patients with unilateral Perthes' disease were studied in search of changes of the acetabulum throughout the active stages of this disease. The length of the acetabular roof, the diameter of the acetabulum, and the opening angle of the acetabulum, were compared with the contralateral hip. The length of the acetabular roof did not change, but the opening angle and the diameter of the acetabulum increased. This increase began in the earliest stage of the disease in half of the cases; it reached a maximum during the resorptive and the reconstructive stages, then it decreased to reach normal values at skeletal maturity. These changes were related to the extent of the epiphyseal necrosis. Probable causes were local hyperhemia and a mechanical adaptation of the acetabulum to a cartilaginous coxa magna. The opening angle has a prognostic value and influences our choice of therapy.

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The acetabular involvment in Perthes' disease has only recently been described (Katz 1968, Gershuni et al. 1978, Danielson et al. 1982, Yngve and Roberts 1985, Joseph 1989). The acetabulum becomes wider, the articular cartilage thicker, and the Y growth plate fuses prematurely with the adjacent pelvic bone (Joseph 1989). These acetabular changes may originate both in a local hyperhemia (Danielsson et al. 1982, Yngve and Roberts 1985) and in a mechanical acetabular adaptation to the changes in shape or volume of the proximal femoral epiphysis (Siffert and Feldman 1980). Such modifications could have an indirect prognostic value since their magnitudes are related to the extent of epiphyseal involvement. We defined an acetabular index that would reflect the acetabular evolution throughout the disease and studied its variations in respect to the patient's age, to the successive stages of the disease as defined by Waldenström (1922), and to Catterall's topographic groups (Catterall 1971).

Material and methods

Straight AP radiographs of the pelvis of 62 patients affected by Perthes' disease were analyzed from the earliest necrotic stage to the reconstructive one. We selected only unilateral cases in order to have a normal contralateral hip as reference. We also selected only non-operated cases, since surgery has an obvious influence on acetabular evolution. Of these 62 patients, 35 were followed to the end of skeletal growth.

We used Catterall's classification of degree of necrosis. All of Catterall's topographic groups were present: 17 in Group I, 20 in Group II, 16 in Group III, and 9 in Group IV. The average age of onset was 5 (2–11) years. The nonoperative treatment consisted of initial bed rest and consecutive deambulation with a device of the Chicago type preventing weight-bearing. The mean duration of treatment was 17 months and the mean follow-up time 9 (3–19) years. The result of this treatment was radiographically assessed at skeletal maturity using Mose's circles to appreciate the regularity of the femoral head, and the radius quotient. Final results were divided into three groups: good, fair, and poor.

At each stage of the disease (necrosis, resorption, reconstruction), the length of the acetabular roof (L), the acetabular diameter (D) and the opening angle of the acetabulum (A) were measured in the affected and in the normal hip (Figure 1). Measurements of the opening angle were made in the following way: the lines that outline the opening angle were drawn with a pencil on the radiograph and then measured with a protractor. The measurements were made by only one person (the second author).

These data were analyzed with respect to the age at onset of the disease, to its successive stages, and to Catterall's groups.

A statistical analysis of the results was performed using Mann and Withney's *t*-test for paired data.

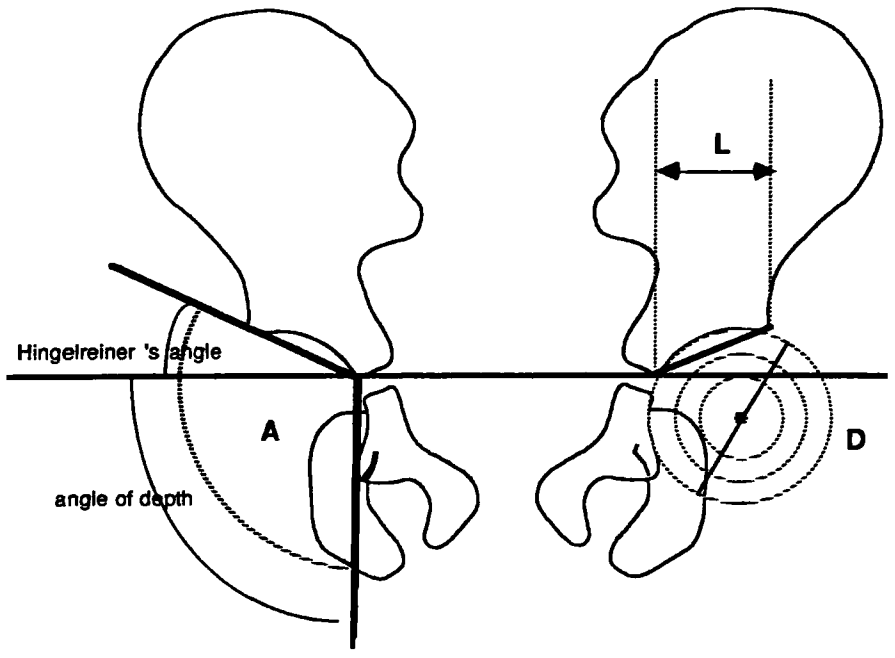

Figure 1. Measured data.
A. Opening angle of the acetabulum. It is the angle between the line indicating the length of the acetabulum and the line joining the superior and external edges of the Y growth plate to the most inferior point of the pelvic tear drop. The opening angle is the sum of two angles: Hilgenreiner's acetabular angle (Hilgenreiner 1925) and the inferior angle that we named the angle of depth.
D. Diameter of the acetabulum. It is measured using Mose's circles.
L. Length of the acetabular roof. It is the distance between the external osseous edge of the roof and the superior and external edges of the Y growth plate.

Table 1. Average results throughout the stages of the disease

	Acetabular roof's length (mm)			Opening angle (degrees)				Acetabular diameter (mm)			
Stage	Affected	Normal	ΔL	Affected	Normal	ΔA	Range	Affected	Normal	ΔD	Range
Necrosis	27	26	0.4	119	115	3.7	–8 – 10	51	47	3.4	–2 – 5
Resorption	27	27	0.5	120	116	4.2	–6 – 18	54	49	4.4	–2 – 8
Reconstruction	29	29	0.6	120	115	4.3	–2 – 20	55	51	3.8	–1 – 8
Sequelae	41	41	0.7	114	112	2.0	–4 – 12	69	66	2.6	–3 – 5

Δ difference between the affected and the normal hips.

Results

The mean values of L, D, and A throughout the successive stages of the disease are reported in Table 1 (statistically significant).

The length (L) of the acetabular roof did not change, the difference being less than 0.7 mm.

The diameter (D) of the acetabulum always exceeded the diameter of the normal side. This difference occurred early (+ 3.4 mm) in the earliest stage, reached a maximum during the resorptive stage (+ 4.4 mm) and decreased gradually until the end of skeletal growth (+ 2.6 mm).

The opening angle (A) always exceeded the normal side (3.7°) and had its maximum in the resorptive (+ 4.2°), and the reconstructive (+ 4.3°) stages. It remained greater than the normal side angle at skeletal maturity.

The asymmetry in A and D throughout the stages of the disease is reported in Table 1 (statistically significant). In 58 percent of the cases, the difference in opening angle was 2° or more in the earliest stage of the disease and remained so until the reconstructive stage. At skeletal maturity, only 37 percent had an angle greater than that in the opposite side.

Table 2. Results as a function of Catterall's groups

Stage	Group 1		Groups 2 and 3		Group 4	
	ΔA (degree)	ΔD (mm)	ΔA (degree)	ΔD (mm)	ΔA (degree)	ΔD (mm)
Necrosis	2.5	1.6	3.8	3.9	5.2	5.2
Resorption	1.7	2.4	4.0	4.4	8.6	7.2
Reconstruction	2.1	1.0	4.4	3.6	7.5	8.8
Sequelae	1.0	0.8	2.4	2.5	3.5	3.6

Δ difference between the affected and the normal hips.

Table 3. Results at skeletal maturity correlated to the acetabular opening angle at the fragmentation stage. Percentages

	Good	Fair	Poor
Difference < 2°	67	22	11
Difference >2°	50	32	18
Symmetrical increase[a]	61	28	11
Asymmetrical increase[b]	46	31	23

[a] Hilgenreiner's acetabular angle and angle of depth increase in an identical manner.
[b] The increase in the acetabular opening angle is due to the increase on Hilgenreiner's angle only or in the angle of depth only.

Whatever the age of onset of the disease, the acetabular response was identical. There was an opening of the acetabulum together with an increase of its diameter. These modifications are identical whether the age of onset occurs before or after 5 years.

A and D as a function of Catterall's groups (Catterall 1971) are shown in Table 2. Groups 2 and 3 were combined because of the difficulty in distinguishing between them. In all stages of the disease asymmetry of A and D was increasing in Group I over Groups II and III to Group IV.

The increase in the A angle may be due to an increase in the acetabular angle or in the angle of depth or in both.

The opening angle was correlated to the final result at skeletal maturity (Table 3). The final result was best when the opening angle did not change. When there was an increase in the A angle, the result was better if the increase was due to a symmetrical increase in the acetabular angle and depth angle.

Discussion

Katz (1965) reports 81 percent of unilateral Perthes' disease, Goff 83 percent (1962). However, Harrison and Blakemore (1980) and Arie et al. (1986) in these unilateral cases, report 40 percent of irregular or slightly flattened contralateral femoral heads. 10 percent of healthy children under 5 years of age have these modifications (Harrison et al. 1976). Although they are more frequent in cases of contralateral Perthes' disease, they cannot be considered as limited necrosis because of their constant benign evolution. Their more frequent occurrence could be due to the immaturity of these children (Harrison et al. 1976, de Guembecker and Duriez 1981). We may thus use the contralateral hip as a reference in radiographic assessment.

Concerning acetabular changes in Perthes' disease, Joseph (1989) found an increase in the radius, the width, the angle of Sharp, and in the medial joint space. Katz (1968), by studying arthrograms, found a widening of the acetabulum, which allowed for adaptation to the femoral head. The increase in the A angle reflects this adaptation since the diameter increases, whereas the length of the roof does not vary. All these modifications appear early (Danielsson et al. 1982, Yngve and Roberts 1985, Joseph 1989). The A angle increases as early as in the necrotic stage in 67 percent of the cases, but by the time of skeletal maturity, A is more than 2° greater in only 37 percent. This is due to a remodeling of the acetabulum during growth, comparable to that of the femoral head reported by Mose (1980). Mose reported 35 percent of normal femoral heads at the end of the reconstructive stage, and 65 percent at skeletal maturity. The magnitude of this remodeling may be dependent on the immaturity of these hips. The opening angle seems to be a good index of acetabular modifications in Perthes' disease.

The end result seems to be better when the opening angle does not change. The end result is still good when the increase in the A angle is due to a symmetrical increase in the acetabular angle and in the angle of depth, leading to a concentric and contained hip. The worst results occur when the increase is not due to a symmetrical increase in both angles, leading to an uncontained hip. Therefore the A angle seems to have

a prognostic value. We are beginning to use it along with the classic prognostic factors when choosing our therapy.

The modifications could be due to a synovitis (Yngve and Roberts 1985, Joseph 1989), or a mechanical adaptation (Siffert and Feldman 1980, Danielsson et al. 1982). Danielsson et al. (1982), Yngve and Roberts (1985), and Joseph (1989) believe that the acetabular modifications in Perthes' disease disease are similar to those noted in trauma, infections, or transient synovitis. Hyperhemia could increase the metabolism of the Y growth plate, of the articular cartilage, and of surrounding bone. This assumption, based upon the presence of an increased scintigraphic fixation in the Y growth plate, could explain the overgrowth of the femoral and acetabular articular cartilages noted in arthrograms by Gershuni et al. (1978). Siffert and Feldman (1980) believed that acetabular changes are caused by the changes in the femoral head. Katz (1968) and Gershuni et al. (1978), by studying arthrograms, have shown that there is a very early overgrowth of the femoral articular cartilage.

This cartilaginous coxa magna is laterally uncovered. This may stimulate a widening of the acetabulum. Such an adaptation of the acetabulum to the femoral head has been suggested by Coleman's experimental work (Coleman et al. 1958). The steady increase in the A angle from Catterall's group 1 to group 4 is in favor of a mechanical adaptation of the acetabulum to the severity of the femoral necrosis.

The acetabulum changes early in Perthes' disease. The opening angle is a reliable index of acetabular modifications caused by the epiphyseal necrosis. The acetabulum widers at an early stage. The magnitude of this widening is a function of the extent of the femoral lesion. The acetabular remodeling seems to accompany the femoral remodeling.

The A angle seems to be an interesting prognostic factor and has to be considered in the choice of therapy.

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