The displacement of the femoral head by rotational acetabular osteotomy

A radiographic study of 97 subluxated hips

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To determine the limits of medial and inferior displacement of the subluxated femoral head by rotational acetabular osteotomy, we studied the acetabular coverage and position of the femoral head radiographically before and after surgery in 97 hips. The median age of the patients at the time of surgery was 33 (18–54) years. The position of the femoral head was represented by its center and medial and upper borders. The average increase and decrease in the CE and the AC angle were 39° and 27°, respectively. The average medial displacement of the head was 8 (–12 to +19) mm measured from its center, and 7 (–10 to +21) mm measured from its medial border. The average inferior displacement was 5 (–6 to +19) mm from its center and 4 (–10 to +15) mm from the upper border. These results indicate that concentric reduction by rotational acetabular osteotomy is limited and that medial displacement of the subluxated femoral head is within similar ranges obtained by other conventional pelvic osteotomies.

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Various methods for pelvic osteotomy in the treatment of the dysplastic hip have been used over the past 30 years. These include innominate osteotomy (Salter 1961), medial displacement osteotomy (Chiari 1974), triple osteotomy (Steel 1973), and double osteotomy (Sutherland 1977). These pelvic osteotomies aim not only at the construction of a congruent shelf above the femoral head, but also at optimum correction of the superolaterally subluxated femoral head. The position of the femoral head is important for the mechanics of the joint, and long-term results show the lack of a concentric reduction to be a cause of degenerative changes in the hip (White and Sherman 1980).

Rotational acetabular osteotomy (Ninomiya and Tagawa 1984) includes an en-bloc circumferential osteotomy around the acetabulum and rotatory shift of the acetabulum to improve coverage of the femoral head. Spherical acetabular osteotomy (Wagner 1978) and dial osteotomy (Eppright 1975) are also designed to achieve this end. However, evaluation of the anatomic correction of the dysplastic acetabulum obtained by these procedures has not been sufficient (Ninomiya 1989). Since 1980, we have performed more than 190 rotational acetabular osteotomies on the dysplastic adult acetabulum.

This study delineates the limit of medial and inferior displacement of the subluxated femoral head obtained in our surgical series.

Patients and methods

Totally, 192 procedures on 186 patients were performed between January 1980 and December 1990. We selected 97 cases with more than 3 years' follow-up. The median age of the 29 males and 68 females at surgery was 33 (18–54) years. All the cases had dysplastic acetabuli (Figure 1), and arthrotic changes had already developed in 62 cases—early in 26, advanced in 30 (Figure 2), and at an end stage in 6 (Figure 3).

The operation

Our techniques have been described by Ninomiya and Tagawa (1984) and Yano et al. (1990). Briefly, with the patient in the lateral position, we used a combination of anterior iliofemoral and posterior approaches through a single anteriorly convex skin incision. After circumferential exposure of the acetabulum, the line of the osteotomy was designed to follow the attachment of the capsule to the pelvis, approximately 1.5 cm from the acetabular ridge. The osteotomy uses a specially curved osteotome, designed by Tagawa, and was performed anteriorly, posteriorly and superiorly. On completion, the acetabulum is raised and the posterior ridge of the acetabulum is sufficiently thinned, as this portion approximates the medial

Figure 1. Case 1. Acetabular dysplasia. Left: Preoperatively at aged 16 years. Right: 3 years after surgery.

Figure 2. Case 2. Dysplastic acetabulum developing arthrosis of the hip. Left: Preoperatively at aged 23 years. Right: 5 years after surgery.

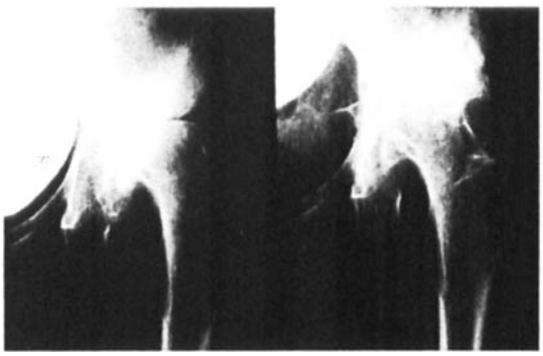

Figure 3. Case 3. Dysplastic acetabulum with arthrosis of the hip. Left: Preoperatively at aged 32 years. Right: 5 years after surgery.

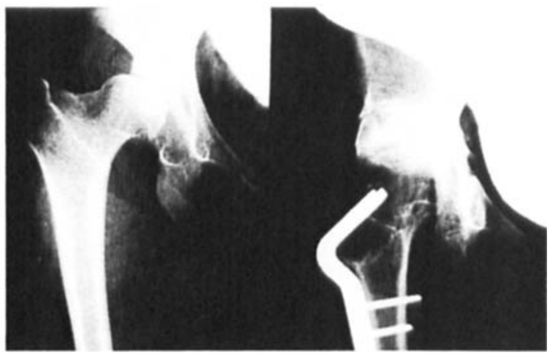

Figure 4. Case 4. Dysplastic acetabulum with varus deformity of the femoral head. Left: Preoperative radiograph at aged 22 years. Right: 4 years after combined rotational acetabular osteotomy and valgus osteotomy of the femur.

portion of the acetabulum when it is rotationally transferred to cover the anterolateral part of the femoral head. One or two pieces of cortical plate and many pieces of cancellous bone chips taken from the external wall of the iliac wing are used to fill the gap between the ilium and the acetabulum. The size of the gap depends on the degree of the acetabular transfer. The acetabulum is transfixed to the cortical bone graft and the pelvis using two Kirschner wires. In 12 cases, a valgus osteotomy of the femur (Figure 4) was performed at the time of the pelvic surgery. Postoperative care includes lying supine in bed with a pillow between the legs for 3 weeks, and the start of touch-gait walking with the aid of bilateral crutches at 6 weeks.

Radographic evaluation

Acetabular coverage and position of the femoral head were determined by regular anteroposterior radiographs of the pelvis. Radiographs taken before and 6 to 9 months after surgery were used, by which time union had been completed.

Acetabular coverage. The CE and AC angles were used as indices of acetabular coverage (Figure 5).

Displacement of the femoral head. We employed two different methods to describe the position of the femoral head. In the first measurement, the center of the head was defined; and in the second measurement, the upper and medial borders of the head were defined (Figure 5).

The correlation between the indices of acetabular coverage and values of femoral head displacement in

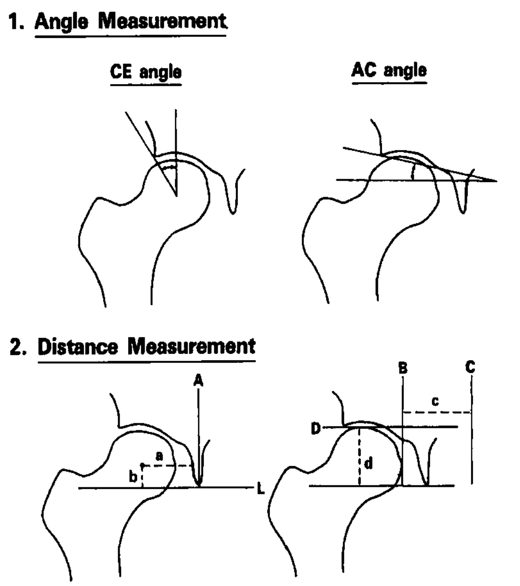

Figure 5. A line (L) connecting the right and the left tips of the teardrop was made, perpendicular to which line (A) was drawn at the tip of the teardrop. The horizontal (a; mm) and vertical distances (b; mm) from the center of the femoral head to these lines were measured. To line (L), the perpendicular line (B) at the medial margin of the femoral head and line (C) at the middle of the symphysis pubis were drawn. At the upper margin of the head, line (D) was placed parallel to line (L). The horizontal (c; mm) and the vertical distances (d; mm) were measured. Magnification was corrected from the distance between the right and the left tips of the teardrop. Horizontal and vertical displacements of the head were obtained from the difference of these corrected values. Only the first measurement was performed in hips that underwent surgery on both the pelvis and the femur.
(1) Measurement of the acetabular coverage. (2) Measurement of the position of the femoral head.

each direction was analyzed. For the difference in CE and AC angle values before and after surgery, paired *t*-tests were employed. Regression analyses were used for correlation study.

Results

Acetabular coverage

Acetabular coverage was markedly improved in all the cases (Table 1). In the cases of rotational acetabular osteotomy alone, the average increase in the CE angle was 39° and the average decrease in the AC angle 27°. A similar improvement was obtained by combined surgery of the pelvis and femur.

Table 1. Acetabular coverage before and after surgery. Mean *SD*

	Angle	Before surgery	After surgery
Rotational acetabular osteotomy (RAO)	CE	−4.7 *11***	35 *8.9*
	AC	31 *11***	4.2 *5.6*
RAO + femoral valgus osteotomy	CE	−12 *13***	41 *5.8*
	AC	33 *12***	2.5 *4.2*

** $P < 0.01$.

Table 2. Rotational acetabular osteotomy (RAO) and medial shift of the femoral head. Mean *SD*

	Before surgery	After surgery	Medial shift
Distance "a" (mm)[a]			
RAO	45 *7.8*	38 *6.9*	8.2 *4.5*
RAO + femoral valgus osteotomy	48 *3.6*	39 *4.0*	9.3 *4.4*
Distance "c" (mm)[a]			
RAO	86 *6.8*	79 *6.7*	7.2 *6.3*

[a]See Figure 5.

Table 3. Rotational acetabular osteotomy (RAO) and inferior shift of the femoral head. Mean *SD*

	Before surgery	After surgery	Medial shift
Distance "b" (mm)[a]			
RAO	24 *5.9*	18 *6.0*	4.8 *4.8*
RAO + femoral valgus osteotomy	20 *7.0*	15 *7.8*	4.9 *4.7*
Distance "d" (mm)[a]			
RAO	52 *7.2*	47 *8.7*	4.3 *4.8*

[a]See Figure 5.

Displacement of the femoral head

The average medial shift measured from the center of the femoral head to the center of the teardrop was 8 (−12 to +19) mm and from the medial border of the head to the center of the symphysis pubis 7 (−12 to +21) mm (Table 2).

Fifty-eight hips had a medial displacement of 2.5 to 12.5 mm, 22 hips did not have any relevant displacement, 12 hips had shifted more than 12.5 mm medially, and five hips had displaced more than 2.5 mm laterally. The displacement obtained in combined surgery did not differ from that obtained in rotational acetabular osteotomy alone.

The average inferior shift was 5 mm and 4 mm, respectively (Table 3). The distance from the center of the femoral head to line L ranged from –6 to 19 mm, and from the upper border of the femoral head –10 to 15 mm.

Forty-two hips had an inferior shift of only –2.5 to 2.5 mm, 27 hips of 2.5 to 12.5 mm, six hips more than 12.5 mm, and 23 hips were displaced 2.5 to 7.5 mm superiorly.

Both medial and inferior displacement of the femoral head obtained by surgery showed a positive correlation with the postoperative CE angle (medial shift, $r = 0.580$, $P < 0.01$; and inferior shift, $r = 0.405$, $P < 0.01$), but not with the AC angle (medial shift, $r = 0.270$; and inferior shift, $r = 0.310$).

Discussion

Chiari's medial displacement osteotomy can shift the laterally located femoral head 15 to 20 mm medially (Reynolds 1986). Salter's innominate osteotomy tends to displace the femoral head laterally and inferiorly (Utterback and MacEwen 1974); and by modifying this procedure, the head can be moved medially by approximately 15 mm (Kalamchi 1982). A 15-mm medial displacement is possible also by Sutherland's (1977) double osteotomy. Considerable mechanical improvement is obtained by medialization of the femoral head. According to Chiari's (1974), a 1.5-cm medialization relieves about one third of the resultant load. Rotational acetabular osteotomy is, therefore, expected not only to improve coverage of the femoral head, but also to decrease the resultant joint load.

The results of our series indicate that the medial shift of the femoral head obtained by rotational acetabular osteotomy was almost the same as those obtained by other methods, and that anatomic correction of the dysplastic acetabulum by the operation has inherent limits. These limits appear to depend on the volume of grafted bone filling the gap between the ilium and the rotated acetabulum. Sufficient bone stock for grafting and also the removal of the excessive bone in the posteromedial surface of the acetabulum appear to be important factors for optimal surgical positioning of the femoral head.

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