Rotational acetabular osteotomy for hip dysplasia

61 hips followed for 8–15 years

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ABSTRACT **We operated on 54 patients (61 joints) with rotational acetabular osteotomy (RAO) due to dysplasia of the hip with pre- or early-stage osteoarthritis/arthrosis. The mean follow-up was 11 (8–15) years. The Merle d'Aubigné median score increased from 14 to 15. In 2 patients (2 joints), the score decreased from 15 to 13. Progression of arthrosis was seen in 6 joints on the radiographs at follow-up. Kaplan-Meier survivorship analysis predicted an 89% (95% confidence interval 80–99) prevention of worsening of arthrosis at 10 years. Postoperative joint congruency was a risk factor for progression of arthrosis.**

Dysplasia of the hip is the commonest cause of secondary osteoarthrosis (Murphy et al. 1990, Millis et al. 1995). One treatment in adolescents and adults is repositioning of the acetabulum to improve containment of the femoral head and prevent early onset of secondary arthrosis. The methods employed include Steel's triple osteotomy (Steel 1973), Eppright's dial osteotomy (Eppright 1975), Wagner's spherical acetabular osteotomy (Wagner 1976), Tagawa's rotational acetabular osteotomy (RAO) (Ninomiya and Tagawa 1984), and Ganz's periacetabular osteotomy (Ganz et al. 1988). These procedures have generally produced satisfactory mid- and long-term results in patients with early stages of arthrosis (Trousdale et al. 1995, Hsin et al. 1996, Kleuver et al. 1997, Schramm et al. 1999), but unfavorable results have been reported in a few cases. Presence of preoperative osteoarthrosis, unsatisfactory joint congruency, and severe dysplasia have been reported as negative predictive factors, but no detailed studies have been done (Ninomiya and Tagawa 1984, Trousdale et al. 1995, Kleuver et al. 1997, Nakamura et al. 1998).

We evaluated the 10-year results in 61 RAOs to determine the factors of prognostic importance.

Patients and methods

Since 1987, we have performed the RAO developed by Tagawa (Ninomiya and Tagawa 1984) on 240 hips with arthrosis and acetabular dysplasia. All the operations were performed by one of the authors (YY). 57 patients (64 joints) with prearthritis or early stage osteoarthrosis were operated on between October 1987 and January 1994. 54 patients (61 joints) were available for a follow-up examination. 3 patients (3 joints) had moved and could not be examined. Their mean age at surgery was 35 (13–58) years and mean follow-up 10.5 (8–14.5) years. 48 were women (54 joints) and 6 men (7 joints). According to Charnley's (1979) classification, there were 16 unilateral (A) and 38 bilateral cases (B). Osteoarthrosis was

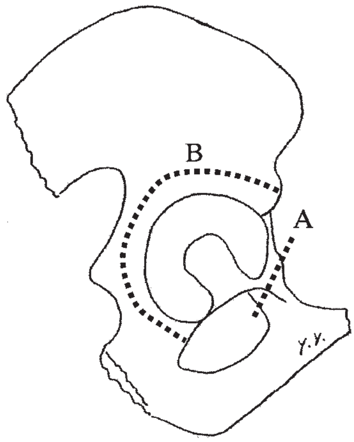


Figure 1. Osteotomy sites of RAO.

divided into 4 stages using the Japanese Orthopaedic Association's classifiction according to the radiographic appearance: 1) prearthrosis with no osteoarthrotic change from acetabular dysplasia; 2) early stage with slight narrowing of joint space associated with sclerosis of the subchondral bone; 3) advanced stage characterized by narrowing of the joint space with cystic lucencies and small osteophytes; and 4) end stage with disappearance of the joint space and marked osteophyte formation. 8 patients (12 joints) had prearthrosis and 46 (49 joints) were in the early stage. In the bilateral cases, RAO was done bilaterally in 7 cases and of the remaining 31 cases, the unoperated side was classified as prearthrosis in 19 joints, early stage in 11, and advanced stage in 1 joint.

The indications for RAO were acetabular dysplasia radiographically characterized by a center-edge angle (CE angle, Wiberg 1939) of less than 20 degrees and pain that interfered with normal activities. The patients who showed improvement in femoral head coverage and joint congruency with abduction on AP radiographs were considered suitable for surgery.

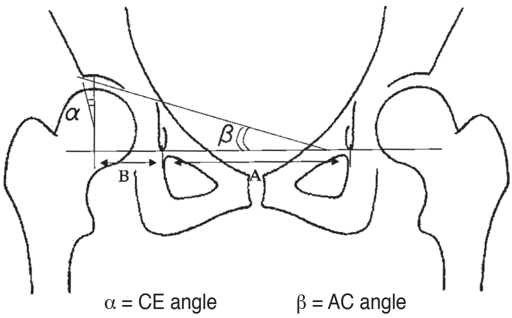
Surgical technique

RAOs were done using Ninomiya and Tagawa's method (1984), apart from fixation of the rotated acetabulum with two sapphire screws (Kyocera, Kyoto, Japan) instead of Kirschner wires. We used an air drill, having a diameter of 4 mm for the osteotomy of the outer cortical bone of the ilium and ischium (Figure 1). With this surgical technique, the cancellous bone could be cut smoothly with a curved osteotome and the inner cortical bone of the ilium and ischium cut precisely. The sound of a hammer permit detection when the tip of the osteotome reaches the inner cortical bone and penetration into the intrapelvic space can be averted. The acetabulum is rotated in an anterolateral direction, while maintaining contact between the osteotomy sites in the pubis and ischium. The rotation provides a more horizontal weight-bearing area, while returning the superiorly subluxated femoral head to a more normal position. One or two trapezoidal bone grafts are taken from the external wall of the iliac wing and used to fill the space between the ilium and the rotated acetabulum. Active range of hip motion exercise was started after the seventh postoperative day. Partial weight-bearing, on two crutches, was allowed in the sixth postoperative week and full weight-bearing was started 5–6 months after surgery, following the disappearance of the Trendelenburg sign.

Clinical and radiographic assessments

The clinical follow-up was done, using the system of Merle d'Aubigné (Merle d'Aubigné and Postel 1954). With this system, pain, mobility and walking ability were assessed with scores from 0 to 6. Standard radiographs were taken postoperatively, at 3 months, 6 months, 12 months and yearly thereafter. The CE angle, acetabular roof obliquity (AC angle) (Massie and Howorth 1950) and modified head lateralization index (HLI), as suggested by Ninomiya (1989), were measured on the anteroposterior view of the radiograph, taken before surgery, 3 months postoperatively and at the last follow-up (Figure 2). Changes in the CE and AC angles were used to describe any medial and lateral expansion of the subchondral bone of the acetabulum caused by joint remodeling (Yasunaga et al. 2001a).

Postoperative joint congruencies were divided into 4 grades (Yasunaga et al. 2001b): excellent—the curvatures of the acetabulum and femoral head are almost identical and the joint space is adequately maintained; good—curvature of the acetabulum and femoral head is not identical, but the joint space is adequate; fair—partial narrowing of the joint space; and poor—partial disappearance of the joint space.



$$HLI = \frac{B}{1/2 \cdot A}$$

Figure 2. Radiographic indices of the hip.

Statistics

We used the Mann-Whitney U-test or Wilcoxon's signed-rank test for the statistical analyses. Cumulative probabilities of the progression of the radiographic stage were estimated with the Kaplan-Meier method. The survivorship curves for various subgroups were compared with the log-rank test. The Cox proportional-hazards model was used to detect risk factors for outcome (Statview software; Abacus Concepts, Berkeley, California).

Results

Intraoperative and early postoperative complications, such as chisel perforation into the joint, infection, postoperative movement of a rotated acetabulum, and delayed union of the osteotomy site did not occur.

Before surgery the mean clinical score was 14.2 (SD1.2) with a range of 12–16. This improved (Wilcoxon sign rank test, $p < 0.001$) to a postoperative mean score at follow-up of 16.8 (1.3) with a range of 12–18. This improvement was mainly an effect of decreased pain and increased walking ability. The pain score increased from 3.1 (0.7) (2.0–5.0) to 5.5 (0.6) (3.0–6.0) ($p < 0.001$) and walking ability increased from 5.2 (0.7) (4.0–6.0) to 5.4 (0.6) (4.0–6.0) ($p < 0.02$), whereas the mobility scores remained unchanged ($p = 0.3$) with a preoperative score of 5.9 (0.3) (5.0–6.0) and a follow-up score of 5.8 (0.5) (4.0–6.0). In only 2 patients (2 joints) did the total score decrease from 15.0 to 12.5 (12.0–13.0). None of the patients has required further surgery.

The CE angle improved from mean –0.6° before to 35° after the operation. The AC angle improved from 29° to a postoperative mean of 2.2°, and HLI from 0.66 to 0.62; no case deteriorated. Statistically significant changes in the CE and AC angles were seen postoperatively due to joint remodeling (Table 1, Figure 3).

Postoperative joint congruency was excellent in 21 joints, good in 35 and fair in 5. Poor joint congruency was not seen in any case.

Progression of osteoarthrosis occurred in 6 joints. Of these, 4 joints progressed to an advanced stage and 2 to end stage. The clinical score was less than 14 at follow-up. The Kaplan-Meier survivorship analysis, using radiographic progression of arthritis as the endpoint, predicted a survival rate of 89% (95% confidence interval (CI) 80–99) at 10 years (Figure 4).

We used nonparametric survivorship analysis with log-rank test to assess 8 variables: preoperative stage, Charnley's category, age at operation, postoperative CE angle, postoperative AC angle, postoperative HLI, postoperative joint congruency, and postoperative joint remodeling (Table 2).

Table 1. Radiographic evaluation of 61 joints. Mean (SD)

	Preoperative	P-value [a]	Postoperative	P-value [a]	Follow-up
CE angle	–0.61 (9.4)°	< 0.001	35 (9.2)°	< 0.001	36 (8.6)°
range	–27–15°		10–60°		20–50°
AC angle	29 (7.0)°	< 0.001	2.2 (7.2)°	< 0.001	6.4 (9.1)°
range	12–43°		–15–22°		–10–28°
HLI	0.66 (0.10)	< 0.001	0.62 (0.11)	0.09	0.60 (0.10)
range	0.49–1.0		0.42–0.90		0.42–0.85

[a] Wilcoxon's signed-rank test

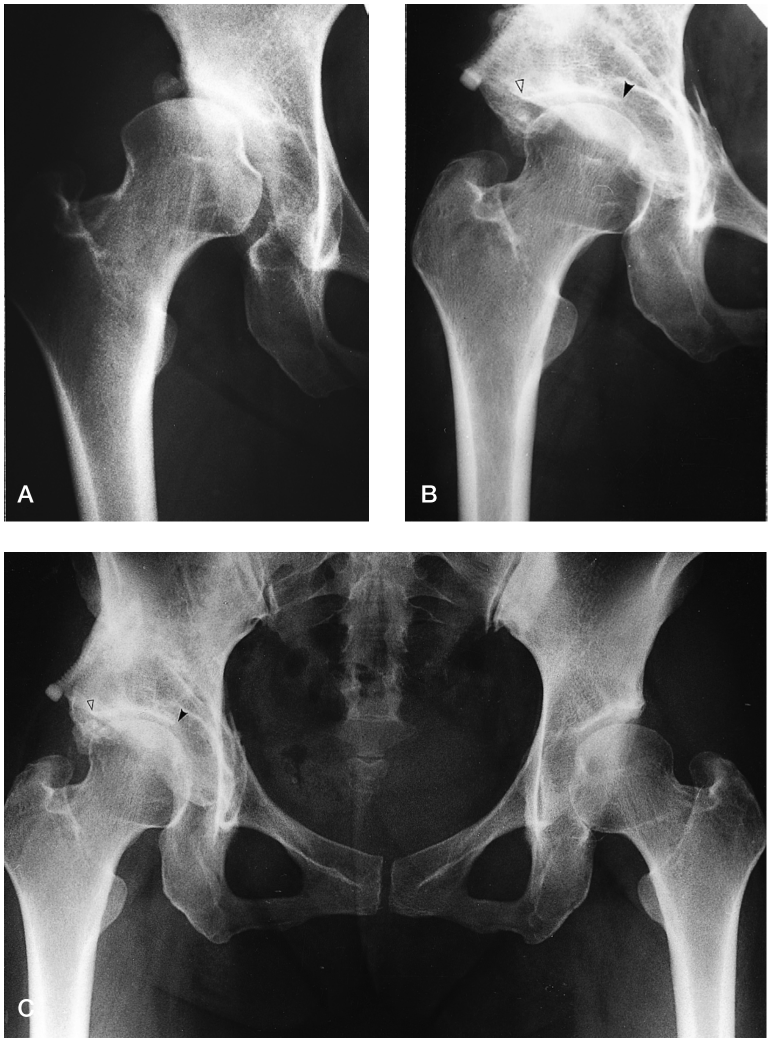


Figure 3. A. A 36-year-old woman at an early stage before RAO. Category B. Clinical score: 14 points (pain 3, mobility 6, walking 5). CE angle: - 5 degrees, AC angle: 31 degrees, HLI: 0.69.
B. After RAO. CE angle: 40 degrees, AC angle: 0 degrees, HLI: 0.54, joint congruency: good.
C. 12 years after RAO. Clinical score: 17 points (pain 6, mobility 6, walking 5). CE angle: 40 degrees, AC angle: 6 degrees, HLI: 0.54. No progression of arthrosis was found in both hip joints. Black arrow points to the medial margin of the subchondral bone in the acetabulum. White arrow indicates the lateral margin of the subchondral bone in the acetabulum.

Radiographic progression of osteoarthrosis was seen in 1 prearthrotic case and 5 early-stage cases without any difference in the rate of progression of osteoarthrosis between the two groups (log-rank test, $p = 0.85$). The rates of progression were similar in the Charnley groups A and B ($p = 0.3$). The postoperative CE angle (divided into < 35, $> = 35°$, $p = 0.18$), AC angle ($< 0°$, $> = 0°$, $p = 0.83$) and HLI (< 0.62, $> = 0.62$, $p = 0.5$) had no effect on the outcome. Presence or absence of joint remodeling likewise had no effect ($p = 0.6$), but age above 46 years ($p = 0.01$) and fair postoperative joint congruency (classified as excellent/good or fair, $p < 0.001$) indicated a poor prognosis (Figure 5).

Table 2. Nonparametric survivorship analysis was used to assess various risk factors that might play a role in progression of osteoarthritis

Variables	
Preoperative radiological stage (joints)	
Prearthritis	12 (1) [a]
Early stage	49 (5) [a]
Charnley's classification (joints)	
A	15 (1) [a]
B	46 (5) [a]
Age at operation (years)	35 (11) [b]
Postoperative CE angles (degrees)	35 (9.2) [b]
Postoperative AC angles (degrees)	2.2 (7.2) [b]
Postoperative HLI	0.62 (0.11) [b]
Postoperative congruency (joints)	
Excellent	21
Good	35 (2) [a]
Fair	5 (5) [a]
Poor	
Postoperative remodeling (joints)	
+	35 (3) [a]
–	26 (3) [a]

[a] Progression of osteoarthritis
[b] Mean, SD

Parametric survivorship analysis using the Cox proportional-hazards model, was employed to assess 8 variables with the log-rank tests. When each of these was screened separately, age at surgery and postoperative joint congruency were found to affect the radiographic progression of osteoarthritis. When these were analyzed together, postoperative joint congruency (hazard ratio 10, 95% CI 1.3–78, p = 0.03) was found to be a risk factor for radiographic progression of osteoarthrosis, but the age at surgery (hazard ratio 3.2, 95% CI 0.4–24, p = 0.3) was not.

Discussion

Kleuver et al. (1997) reported 48 joints subjected to triple osteotomy, after a mean follow-up of 10 years. The Merle d'Aubigné score exceeded 15 points in 29 (60%) cases, with progression of osteoarthrosis in 10 of them. Presence of preoperative osteoarthrosis was the reason for unfavorable results (Kleuver et al. 1997). Nakamura et al. studied, 145 joints subjected to RAO after a mean follow-up of 13 years. They found that 80% of cases with pre-and early stage osteoarthrosis had Merle d'Aubigné scores exceeding 15 points. However, only 27% of cases with advanced or end stage osteoarthrosis reached that level, which indicates the importance of preoperative absence or minimal radiographic arthrosis (Nakamura et al. 1998). After a mean follow-up of 17 years, Schramm et al. reported that, following Wagner's spherical acetabular osteotomy, the progression of arthrosis could be prevented in 24 of 38 cases. The cause of progression in 14 of these joints was secondary to poor correction (5 joints), deep infection (1 joint) and unknown in the remaining cases. These and other reports of mid-term results

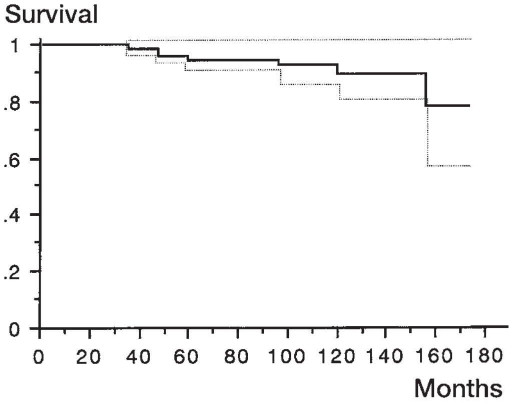


Figure 4. Cumulative probability of nonprogressive degenerative disease of the hip after RAO.

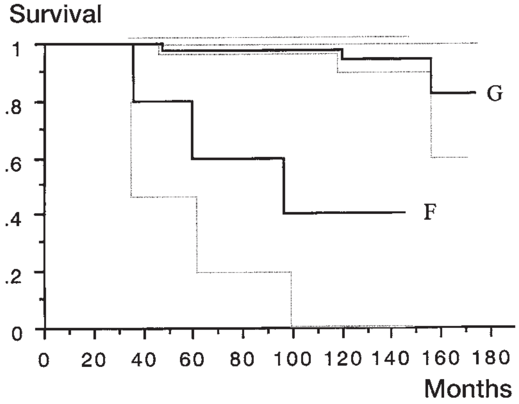


Figure 5. Comparison of radiographic survival between group with excellent or good postoperative joint congruency (G: 49 cases) and group with fair postoperative joint congruency (F: 5 cases)

(Ninomiya et al. 1984, Trousdale et al. 1995) have indicated that preoperative osteoarthrosis and unsatisfactory joint congruency after surgery result in postoperative progression of osteoarthritis.

Using multivariate survival analysis with the Cox proportional-hazards model, postoperative joint congruency alone was found to be a risk factor for postoperative progression of osteoarthrosis. Unlike the Chiari osteotomy, periacetabular osteotomies cause considerable changes in joint morphology and in mechanical load on the articular cartilage (Leitz and Reck 1979, Yasunaga et al. 1997). Unless postoperative joint congruency is satisfactory, the joint may be unable to cope with the mechanical changes and osteoarthrosis will progress soon after surgery (Millis 1984, Millis et al. 1995). Adaptation of articular cartilage is thought to decline with age (Yasunaga et al. 2003), which may affect the long-term results.

The long-term results of periacetabular osteotomy reported to date, including our present findings, are not adequate. To improve them, we believe that the indications for surgery should be based on findings of joint congruency during hip abduction on preoperative radiographs and the severity of the degenerative changes, using arthroscopy and/or magnetic resonance imaging (Yasunaga et al. 2001b).

No competing interests declared.

Charnley J. Numerical grading of clinical results. In: Low friction arthroplasty of the hip (ed. Charnley J). Springer, Berlin 1979: 20-4.

Eppright R H. Dial osteotomy of the acetabulum in the treatment of dysplasia of the hip. In: Proceedings of the American Orthopaedic Association. J Bone Joint Surg (Am) 1975; 57: 1172.

Ganz R, Klaue K, Vinh T S, et al. A new peri-acetabular osteotomy for the treatment of hip dysplasia: technique and preliminary results. Clin Orthop 1988; 232: 26-36.

Hsin J, Saluja R, Eilert R E. et al. Evaluation of the biomechanics of the hip following a triple osteotomy of the innominate bone. J Bone Joint Surg (Am) 1996; 78: 855-62.

Kleuver M, Kooijman M A P, Pavlov P W, et al. Triple osteotomy of the pelvis for acetabular dysplasia. J Bone Joint Surg (Br) 1997; 79: 225-9.

Leitz G, Reck R. Necessarily disappointing results after triple osteotomy in the dysplastic hip joint. Arch Orthop Trauma Surg 1979; 95: 271-3.

Massie W K, Howorth M B. Congenital dislocation of the hip: Part 1. Method of grading results. J Bone Joint Surg (Am) 1950; 32: 519-31.

Merle d'Aubigné R, Postel M. Functional results of hip arthroplasty with acrylic prosthesis. J Bone Joint Surg (Am) 1954; 36: 451-75.

Millis M B. Congenital hip dysplasia: treatment from infancy to skeletal maturity. In: Surgery of the hip joint (ed. Tronzo R G). Vol.1. 2nd ed, New York, Springer-Verlag 1984: 329-85.

Millis M B, Murphy S B, Poss R. Osteotomies about the hip for the prevention and treatment of osteoarthrosis. J Bone Joint Surg (Am) 1995; 77: 626-47.

Murphy S B, Kijewski P K, Millis M B, et al. Acetabular dysplasia in the adolescent and young adult. Clin Orthop 1990; 261: 214-23.

Nakamura S, Ninomiya S, Takatori Y, Morimoto S, Ueyama T. Long-term outcome of rotational acetabular osteotomy: 145 hips followed for 10-23 years. Acta Orthop Scand 1998; 69: 259-65.

Ninomiya S. Rotational acetabular osteotomy for the severely dysplastic hip in the adolescent and adult. Clin Orthop 1989; 247: 127-37.

Ninomiya S, Tagawa H. Rotational acetabular osteotomy for the dysplastic hip. J Bone Joint Surg (Am) 1984; 66: 430-6.

Schramm M, Pitto R P, Rohm E, et al. Long-term results of spherical acetabular osteotomy. J Bone Joint Surg (Br) 1999; 81: 60-6.

Steel H H. Triple osteotomy of the innominate bone. J Bone Joint Surg (Am) 1973; 55: 343-50.

Trousdale R T, Ekkernkamp A, Ganz R, et al. Periacetabular and intertrochanteric osteotomy for the treatment of osteoarthrosis in dysplastic hips. J Bone Joint Surg (Am) 1995; 77: 73-85.

Wagner H. Osteotomies for congenital hip dislocation. In: The hip. The C.V. Mosby Company, Saint Louis 1976: 45-66.

Wiberg G. Studies on dysplastic acetabula and congenital subluxation of the hip joint: with special reference to the complication of osteoarthritis. Acta Chir Scand (Suppl 58) 1939: 83.

Yasunaga Y, Ochi M, Ikuta Y, Shimogaki K, Dohi D. Rotational acetabular osteotomy: a rabbit model. Arch Orthop Trauma Surg 1997; 116: 74-6.

Yasunaga Y, Ikuta Y, Shigenobu T, Nakamura S, Yamamoto S, Nakashiro J. Rotational acetabular osteotomy for dysplastic hip dysplasia; medial enlargement of the acetabulum. Acta Orthop Scand 2001a; 72: 8-12.

Yasunaga Y, Kanazawa T, Ikuta Y, Takahashi K, Hisatime T. The state of articular cartilage at the time of surgery as an indication for rotational acetabular osteotomy. J Bone Joint Surg (Br) 2001b; 83: 1001-4.

Yasunaga Y, Takahashi K, Hisatome T, Ochi M, Ikuta Y, Nakashiro J, Yamamoto S. Rotational acetabular osteotomy in patients older than 46 years of age: Comparison with younger patients. J Bone Joint Surg (Am) 2003; 85: 266-72.