Long-term outcome of rotational acetabular osteotomy

145 hips followed for 10–23 years

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We report the long-term outcome of rotational acetabular osteotomy in 145 dysplastic hips of 131 patients after an average follow-up of 13 (10–23) years. The mean age at operation was 28 (11–52) years. The radiographic severity of osteoarthrosis before operation, according to the criteria of the Japanese Orthopaedic Association, was stage I (no degenerative change) in 63 hips, stage II (early degenerative stage) in 49, stage III (progressive stage) in 21 and stage IV (end stage) in 12.

The clinical outcome based on the Merle d'Aubigné and Postel score was excellent or good for 90 (80%) of the 112 hips which had stage I or II osteoarthrosis preoperatively, and was excellent or good for only 9 of the 33 hips which had stage III or IV osteoarthrosis ($p < 0.001$, chi-square test). The radiographic severity of osteoarthrosis at the most recent review was stage I or II for 79 (70%) of the 112 hips which had stage I or II osteoarthrosis preoperatively. The long-term outcome of rotational acetabular osteotomy was satisfactory for a dysplastic hip with little, if any, osteoarthrosis, but was unsatisfactory for a hip with more advanced osteoarthrosis.

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Many techniques are available for osteotomy of a dysplastic hip. Factors which affect the outcome after osteotomy include the age and activity of the patients, the severity of the anatomical deformity of the hip, and the severity of associated osteoarthrosis.

We have been performing rotational acetabular osteotomy—a type of periacetabular osteotomy—on dysplastic hips in adolescents and young adults. Several reports have now been published on the early outcome of rotational acetabular osteotomy (Ninomiya and Tagawa 1984, Azuma and Taneda 1989, Nakamura et al. 1993), but few on the long-term outcome with respect to the preoperative severity of osteoarthrosis.

Here we report the long-term outcome of rotational acetabular osteotomy, after a minimum follow-up of 10 years, and the correlation between the outcome and the preoperative severity of osteoarthrosis.

Patients and methods

Between April 1974 and November 1986, we performed a rotational acetabular osteotomy on 250 hips in 223 patients with no neurological disease at the University of Tokyo Hospital or the University of Tokyo Hospital Branch. The average age of the patients was 28 (11–52) years. The indications were (1) increasing hip pain, (2) a dysplastic hip, (3) anteroposterior radiographs showing improved congruity in abduction before operation.

The preoperative radiographic severity of the osteoarthrosis was assessed on an anteroposterior view, and staged from I to IV (Figure 1), according to the classification for osteoarthrosis of the hip joint advocated by the Japanese Orthopaedic Association (Ninomiya 1989, Shindo et al. 1996). Stage I showed no osteoarthrotic change, stage II (early degenerative stage) showed slight narrowing of the joint space, associated with sclerosis of the subchondral bone, stage III (progressive stage) showed marked narrowing of the joint space, with many cystic lucencies and small osteophytes in the femoral head and acetabulum, and stage IV (end stage) showed no joint space, but marked marginal osteophytes. The preoperative radiographic severity was stage I in 119 hips, stage II in 82 hips, stage III in 30 hips, stage IV in 18 hips and unknown in 1 hip.

Figure 1. Classification of osteoarthrosis in the hip joint.

Stage I (no degenerative change).

Stage II (early stage).

Stage III (progressive stage).

Stage IV (end stage).

Operative technique

The details of our surgical procedure have been described by Ninomiya and Tagawa (1984). The patient is placed in the lateral position. We use a combination of anterior iliofemoral and posterior approaches through a single anteriorly convex skin incision. After circumferential exposure, an osteotomy is performed using a special curved osteotome, starting just outside the capsule. When the acetabular fragment has been mobilized, its posterior ridge is thinned to move the femoral head medially. The acetabular fragment is rotated anterolaterally, and an autogenous bone graft from the iliac crest is placed in the gap. Finally, the acetabular fragment and the grafted bone are transfixed to the pelvis with two Kirschner wires. These Kirschner wires are removed through a small skin incision 5 or 6 weeks after surgery.

Review method

We could not trace 83 patients. Of the others, 2 had died and 6 did not come to our hospital for reasons unrelated to their hips. 132 patients returned for clinical and radiographic assessments. 1 patient was excluded since no preoperative radiograph was available, although the clinical outcome at 22 years after the operation was good. 7 hips, which had required and undergone a total hip arthroplasty during the follow-up period, and 138 hips, which had been followed for more than 10 years, were included in the follow-up study (145 hips, 131 patients). Thus, 104 hips were lost to the long-term follow-up.

Hips lost to long-term follow-up

The average follow-up period of the latter 104 hips was 4.1 years (0–9 years). 65 hips had been followed for more than 3 years (average 5.9 years), when last seen. The preoperative radiographic severity was stage I in 56 hips, stage II in 33 hips, stage III in 9 hips and stage IV in 6 hips. We performed a simultaneous intertrochanteric osteotomy in 7 hips and displaced the greater trochanter distally in 2 hips with a rotational acetabular osteotomy. During the follow-up period, 3 hips were subjected to an additional intertrochanteric femoral osteotomy, and 1 hip an additional displacement osteotomy of the greater trochanter, but no hip was given a total hip arthroplasty.

We sent questionnaires to the 6 patients who had not come to our hospital, and received answers from 5 patients (7 hips) 12–17 years after surgery. The preoperative radiographic severity in these 7 hips was stage I in 2 hips, stage II in 4 hips and stage IV in 1 hip. No patient had undergone a total hip arthroplasty. 2 patients had no limp, 2 had a mild limp and 1 used a cane. 4 hips caused no pain, 2 mild and occasional pain and 1 caused moderate pain.

Hips with 10-year minimum follow-up

The study included 145 hips in 131 patients (120 women). The average age at operation was 28 (11–52) years. 91 patients had been treated previously for congenital hip dislocation. 7 hips were subjected to a total hip arthroplasty 1–8 years after the osteotomy. The average follow-up of the other 138 hips was 12.9 (10–23) years. The preoperative radiographic severity was stage I in 63 hips, stage II in 49 hips, stage III in 21 hips and stage IV in 12 hips. Thus, 77% of the hips were in stages I and II, the corresponding figure for hips lost to long-term follow-up was 86%.

We performed a simultaneous intertrochanteric osteotomy, with a rotational acetabular osteotomy in 17 hips to achieve better congruity in the hip joint—a valgus osteotomy in 10 hips, a valgus-derotation osteotomy in 2, a varus-derotation osteotomy in 3 and a derotation osteotomy in 2 hips. In another 6 hips having a shortened femoral neck, with a relative overgrowth by the greater trochanter, we displaced the greater trochanter distally to increase the strength of the hip abductor muscles. 5 hips had undergone an additional intertrochanteric femoral osteotomy—a medial-rotation osteotomy in 1 hip and a valgus osteotomy in 4 hips—during the follow-up period, including 1 of those who eventually received a total hip arthroplasty.

Clinical assessment

For clinical assessment, we used the Merle d'Aubigné and Postel score (1954). This has a full score of 18 points: from 0 to 6 points for each of pain relief, mobility restoration and improvement in gait. 18 or 17 points were considered as excellent, 16 or 15 points as good, 14 or 13 points as fair, and 12 points or fewer as poor. For the hips that required and were given a total hip arthroplasty during the follow-up period, we assessed the score just before the total hip arthroplasty.

Radiographic assessment

The radiographic severity of acetabular dysplasia was evaluated by measuring the center-edge angle (Wiberg 1939) and the acetabular roof obliquity (Massie and Howorth 1950) on the anteroposterior radiograph before and after surgery.

Results

Complications

Of the 250 hips, 11 hips (10 patients) had complications. In 4 hips, the acetabular fragment showed osteosclerotic changes suggesting bone necrosis and delayed union due to an osteotomy close to the acetabulum. At the most recent review, the clinical result was poor in 2 (1 hip 4 years after surgery and another 16 years after surgery), good in another 16 years after surgery, and it was excellent in the other 17 years after surgery.

In both hips of 1 patient, a severe destruction of the acetabular fragment had occurred of unknown etiology, and the clinical outcome was poor in both hips 10 years after surgery. In 2 hips, the osteotome had penetrated the acetabular cartilage. The outcome was fair in 1 hip, 2 years after surgery, and was excellent in the other, 4 years after surgery. In 1 hip, the acetabular fragment displaced soon after surgery, and was reduced operatively 1 week after surgery. The outcome in this patient was good, 6 years after surgery. In 2 hips, a pelvic fracture occurred at the donor site of the bone graft in the ilium at surgery, and was transfixed immediately by Kirschner wires. The fractures healed without displacement. There was no nonunion, no deep infection and no injury to nerves or great vessels.

Clinical outcome in patients with long-term follow-up

The outcome was excellent in 62 hips, good in 37, fair in 27 and poor in 19. All 7 hips which had been subjected to a total hip arthroplasty showed severe osteoarthrosis before the arthroplasty. The mean pain score improved from 3.9 (2–5) to 5.2 (2–6) points, and the gait function score improved from 4.9 (2–6) to 5.3 (2–6), but the mobility score decreased from 5.4 (4–6) to 4.9 (2–6) points. The range of hip flexion was reduced from a preoperative mean of 118° (75°–145°) to a postoperative mean of 98° (10°–140°). The range of abduction was reduced from a preoperative mean of 27° (10°–60°) to a postoperative mean of 20° (-5°–50°).

The score at final review was related to the preoperative severity of osteoarthrosis (Table 1). The mean scores for pain, mobility and gait, were each above 5.0 for hips with stage I or II osteoarthrosis preoperatively. In contrast, the mean scores were not over 5.0—especially the mean mobility score was low, in hips with stage III or IV osteoarthrosis preoperatively.

The result was excellent or good for 90 (80%) of the 112 hips which had stage I or II osteoarthrosis preoperatively, and was excellent or good for only 9 (27%) of the 33 hips which had stage III or IV osteoarthrosis ($p < 0.001$, chi-square test) (Table 2).

Radiographic assessment

The average preoperative center-edge angle was -6° (-45°–20°), and the average acetabular roof obliquity was 34° (5°–55°). The average postoperative center-

Table 1. Merle d'Aubigné scores in 145 hips after rotational acetabular osteotomy, according to the preoperative severity of the osteoarthrosis

Preoperative stage of osteoarthrosis	n	Mean score at most recent review			
		Pain	Mobility	Gait	Total
I	63	5.5	5.1	5.5	16.1
II	49	5.2	5.1	5.4	15.7
III	21	4.7	4.1	4.8	13.6
IV	12	4.3	3.8	4.4	12.5

Table 2. Clinical results of rotational acetabular osteotomy in 145 hips, according to the preoperative severity of the osteoarthrosis (number of hips)

Preoperative stage of osteoarthrosis	n	Clinical result	
		Excellent or good	Fair or poor
I or II	112	90	22
III or IV	33	9	24

$p < 0.001$

edge angle was 32° (-20°–60°), and the average acetabular roof obliquity was 7° (-20°–35°). Of the 145 hips, 5 hips had a postoperative center-edge angle less than 10°.

The average preoperative center-edge angle and acetabular roof obliquity of the 99 hips with an excellent or good outcome was -5° and 34°, respectively, and was -6° and 34° of the 46 hips with a fair or poor outcome; no correlation was found between the clinical outcome and the preoperative severity of acetabular dysplasia.

The radiographic stage of osteoarthrosis at the most recent review (Figures 2 and 3) was stage I in 54 hips, stage II in 29, stage III in 24 and stage IV in 38. The radiographic stage at the most recent review was stage I or II for 79 (70%) of the 112 hips which had stage I or II osteoarthrosis preoperatively (Table 3).

Table 3. Radiographic severity of the osteoarthrosis before and after rotational acetabular osteotomy (number of hips)

Preoperative stage of osteoarthrosis	n	Postoperative stage of osteoarthrosis			
		I	II	III	IV
I	63	41	11	7	4
II	49	13	14	10	12
III	21	0	3	5	13
IV	12	0	1	2	9
Total	145	54	29	24	38

Discussion

There are various types of osteotomy for the operative treatment of the dysplastic hip in the adolescent and adult. The long-term outcome after an intertrochant-

Figure 2. A 33-year-old woman who had pain in both hips and walked with a limp. We performed a rotational acetabular osteotomy on both hips. 15 years after the left operation and 14 years after the right operation, she had no pain and no limp. The Merle d'Aubigné score improved from 14 to 18 points in the left hip, and from 15 to 17 in the right hip.

Preoperatively. Stage II osteoarthrosis in the left hip, stage I in the right hip.

15 years after the left operation and 14 years after the right operation, radiographic osteoarthrosis was stage I in both hips.

Figure 3. A 38-year-old woman who had mild pain in her right hip and who walked with a limp. We performed a rotational acetabular osteotomy on her right hip. At the most recent follow-up, 15 years after surgery, she has occasional mild pain with severe restriction in mobility of the right hip, and walks with a limp. The hip score has deteriorated from 14 to 12 points.

Preoperatively, radiographic osteoarthrosis stage III.

After 15 years, stage IV osteoarthrosis.

eric osteotomy, including varus osteotomy (Perlau et al. 1996) or valgus-extension osteotomy (Maistrelli et al. 1990) , is usually satisfactory for a hip with mild dysplasia, but is not satisfactory for a severely dysplastic hip, if the operation does not include pelvic osteotomy. Millis et al. (1995) have classified the various types of pelvic osteotomies as either salvage or reconstructive osteotomy. Salvage procedures include shelf osteotomy and Chiari osteotomy (Lack et al. 1991) and are indicated for a severely incongruous or unstable hip. Reconstructive osteotomy, which redirects the acetabulum, includes single innominate osteotomy (Salter 1961, McCarthy et al. 1996), double innominate osteotomy (Sutherland and Greenfield 1977), triple innominate osteotomy (Steel 1973) and the various types of periacetabular osteotomy, described by Wagner (1976), Eppright (1975), Ganz (Trousdale at al. 1995) and Ninomiya and Tagawa (1984).

Of the 2,000 consecutive cases diagnosed with osteoarthrosis of the hip joint at our clinic, 1,766 (88%) were due to congenital dislocation of the hip joint or acetabular dysplasia (Nakamura et al. 1989). Many patients, who have a dysplastic hip with early-moderate osteoarthrosis, complain of pain on exertion. Surgical intervention is indicated for those with increasing pain, and for those in whom there is progressive osteoarthrosis or a high risk of it. Our indications for total hip arthroplasty are: (1) age over 50 years, (2) osteoarthrosis stage IV (end stage), (3) severe pain, and poor walking ability. In patients younger than 50 years, we perform one of the following osteotomies: a rotational acetabular osteotomy, a varus osteotomy or a valgus osteotomy. A rotational acetabular osteotomy provides good lateral and anterior coverage of the femoral head by articular cartilage and is indicated as the first procedure for a moderately to severely dysplastic hip. Patients older than 50 years are poor candidates for rotational acetabular osteotomy, because the abductor muscles of the hip may not regain sufficient strength to prevent the development of a limp and a cane may be required for a long time. This osteotomy is not indicated in children whose triradiate cartilage has not closed, because the osteotomy may arrest its growth. The controversial point in indications is the radiographic severity of osteoarthrosis. We have previously reported a good short-term outcome of rotational acetabular osteotomy for the dysplastic hip with little, if any, early osteoarthrosis (Ninomiya and Tagawa 1984). This encouraged us to perform this osteotomy on hips with more advanced osteoarthrosis. Yano et al. (1990) reported a favorable short-term outcome after rotational acetabular osteotomy in 50 patients who had severe osteoarthrosis in the hip, after an average follow-up of 3 years, but their long-term outcomes are not available. The long-term outcomes in our present study suggest that rotational acetabular osteotomy is indicated only in the hip with little, if any, early osteoarthrosis. The outcomes after rotational acetabular osteotomy for a hip with little, if any, early osteoarthrosis have been reported as favorable, even when dysplasia was severe, with subluxation or a false acetabulum (Ninomiya 1989, Shindo et al. 1996).

The outcomes in the various types of periacetabular osteotomy have recently been published. Wagner reported the long-term outcomes after a spherical acetabular osteotomy in 107 cases, followed for 14–25

years, and stated that more than 90% of the cases showed an excellent or good result (Millis et al. 1995). However, no details of any long-term outcome are available with respect to the severity or stage of the preoperative osteoarthrosis. Trousdale et al. (1995) reported the short-term outcome after Ganz's periacetabular osteotomy in 42 cases of dysplastic hip with established preoperative osteoarthrosis, after an average follow-up of 4 (2–8) years. 32 of the 33 cases who had mild or moderate osteoarthrosis preoperatively had an excellent or good outcome, whereas 8 of the other 9 cases who had severe osteoarthrosis had a Harris hip score of less than 70 points at their most recent follow-up examination which is similar to our findings.

Since rotational acetabular osteotomy is technically complicated, the rate of complications is a matter of concern. Matsui et al. (1997) reported early deterioration in 10 of 25 hips after a modified rotational acetabular osteotomy through a transtrochanteric approach. They pointed out that chondrolysis and necrosis may have resulted from a trophic disturbance, due to an osteotomy that made the acetabular fragment very thin and to the transtrochanteric approach which might have impaired circulation around the acetabulum and hip. Among our patients who received a rotational acetabular osteotomy according to our original combined approach, only 6 (2%) of the 250 hips showed necrosis or destruction of the displaced acetabular fragment. We have not changed the operative procedure, except the internal fixation material; we have been using absorbable polylactide screws instead of Kirschner wires to transfix the acetabular fragment since 1990 (Nakamura et al. 1993). Complications of Ganz's periacetabular osteotomy in 42 cases (Trousdale et al. 1995) included no patients with necrosis of the acetabular fragment, but 2 cases of nonunion of the pubic osteotomy.

One of the aims of reconstructive periacetabular osteotomy is to prevent or delay the progression of osteoarthrosis. Several authors have described the natural course of a dysplastic hip. Wiberg (1939) reported that all of the 7 girls who had a severely dysplastic hip developed moderate or severe osteoarthrosis by the age of 42 years. Cooperman et al. (1983) studied the natural course of 20 patients, involving 32 dysplastic hips, which had met the following criteria: a center-edge angle of 20° or less, an intact Shenton line, no history of a serious disorder of the hip and no radiographic evidence of osteoarthrosis on the first examination. The initial average age of their 20 patients was 43 (27–57) years and, at the most recent follow-up examination, their age was 65 (36–79) years. 21 of the 32 hips showed severe osteoarthrosis after an average follow-up of 22 years. In our present study, 41 of the 63 dysplastic hips which had no degenerative change preoperatively showed no such change at the final review. However, the average age of the patients in this group was still under 40 years at the final review and we had no control group to compare with the study group. Further studies are required to evaluate the effects of rotational acetabular osteotomy on the onset or progression of osteoarthrosis.

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