# Rotational acetabular osteotomy for hip dysplasia

## Spontaneous medial enlargement of the acetabulum

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**ABSTRACT – We followed 56 patients (63 joints) who had undergone rotational acetabular osteotomy (RAOs) between 1987 and 1993, mean 7 (5–12) years. The Merle d'Aubigné score increased by 15 points or more in 59 and decreased in 4 hips. The arthrosis progressed in 5 joints. In about 2/3 of the cases, we observed some medial and/or lateral expansion of the subchondral bone in the acetabulum 3 years postoperatively, suggesting enlargement of the load-bearing area.**

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Periacetabular osteotomy is theoretically better than pelvic osteotomy according to Chiari (1974), because it transfers the position of the acetabulum en bloc permitting coverage of the femoral head with cartilage (Steel 1973, Eppright 1975, Wagner 1976, Ninomiya and Tagawa 1984, Trousdale et al. 1995). These procedures have produced satisfactory long-term outcome in cases of early stage osteoarthrosis secondary to dysplasia of the hip (Trousdale et al. 1995, Kleuver et al. 1997). The joint morphology may remain unchanged postoperatively or remodel due to medial or lateral expansion of the subchondral acetabular bone. To our knowledge, there are no previous studies of this type of joint remodeling. We evaluated this phenomenon on conventional radiographs in 56 patients (63 joints) operated on with rotatiomnal acetabular osteotomy (RAO) (Ninomiya and Tagawa 1984) and with a minimal follow-up of 5 years.

## Patients and methods

49 women (55 joints) and 7 men (8 joints) who had undergone RAOs between 1987 and 1993 were included. During this period, we operated on 58 patients (65 joints). 2 patients (2 joints) were excluded, because they moved and could not be followed up. We divided osteoarthrosis of the hip into 4 stages, according to the radiographic appearance: 1) prearthrosis shows no osteoarthrotic change; 2) the early stage with slight narrowing of the joint space associated with sclerosis of the subchondral bone; 3) the advanced stage with narrowing of the joint space with cystic lucencies and small osteophytes; and 4) the end-stage with disappearance of the joint space with marked osteophyte formation. 14 patients (16 joints) were classified as prearthrosis stage and 42 (47 joints) as early stage. The mean age of the patients at the time of surgery was 34 (13–58) years. The mean follow-up was 7 (5–11) years. 10 had unilateral and 46 bilateral involvement (Charnley 1979). 39 of the patients with bilateral disease had undergone unilateral surgery. In these patients, the stage of the side that had not been operated on was classified as prearthrosis in 24 joints, early stage in 14 joints, 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. Cases showing an improvement in femoral head coverage and joint congruency in abduc-

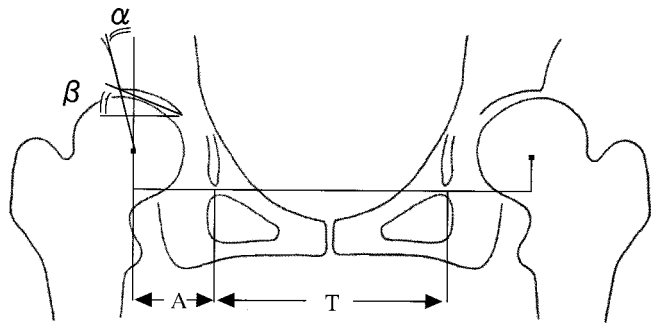


Figure 1. Radiographical indices of the hip.
α = center-edge angle (CE angle),
β = acetabular roof obliquity (AC angle),
Head lateralization index (HLI) = A /(1/2 T).

tion on the AP view of a plain radiograph and arthrograph were considered to be suitable for surgery.

RAOs were done according to Ninomiya and Tagawa, apart from fixation of the rotated acetabulum with 2 or 3 sapphire screws (Kyocera, Kyoto, Japan) instead of Kirschner wires. Resection of degenerative limbus or osteophytes was not done in any case. No postoperative cast was used, and active range of motion exercises of the hip were introduced on the 7th day after surgery. Partial weight bearing on two crutches was allowed in the 6th postoperative week, and full weight-bearing was began 5–6 months postoperatively, when Trendelenburg's sign had disappeared.

Clinical follow-up was done using the system of Merle d'Aubigné and Postels(1954). With this system, pain, mobility and walking ability are assessed with scores from 0 to 6. The CE angle, acetabular roof obliquity (AC angle) (Massie and Howorth 1950) and head lateralization index (HLI) (Hijikata et al. 1985) were measured on the anteroposterior view of the radiographs preoperatively, after 3 months, 3 years and at the last follow-up (Figures 1 and 3). 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. In measuring the AC angle at 3 years postoperatively or on follow-up, the acetabular lateral margin at 3 months postoperatively was used as the lateral base point in cases that showed lateral acetabular remodeling. To test the reproducibility of the radiographic measurement, 5 medical students measured the CE angle, AC angle and HLI in 3 randomly selected hips. Each observer measured each hip three times, with an interval of one week between each measurement. The data were analyzed for intraobserver and interobserver variances and the coefficient of variation was calculated. This was less than 5% and the reproducibility of measurements was considered reasonable.

## Results

The mean total preoperative scores increased from 14 (11–16) to 17 (11–18) ($p < 0.0001$, Wilcoxon sign rank test). This improvement was mainly an effect of reduced pain: the mean pain scores increased from 3.0 to 5.5 ($p < 0.0001$). In 4 cases (4 joints), the total scores decreased from mean 12.8 (12–13) to 12.0 (11–13) (Figure 2). So far, none of the patients have required further surgery.

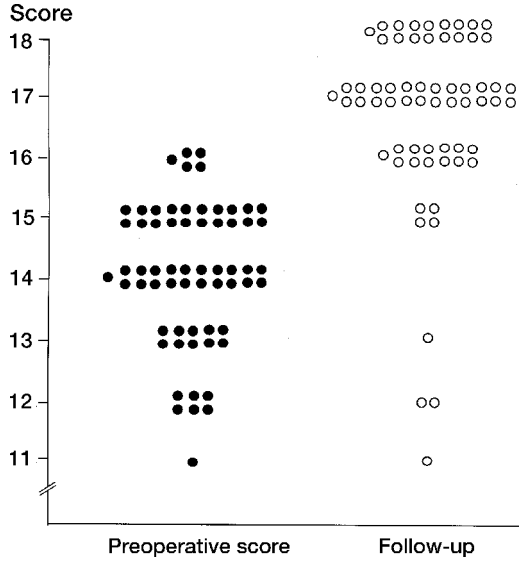


Figure 2. Clinical score.

**Radiographical evaluation in 58 joints. Mean *SD***

| | Preoperative | p-values | 3 months postoperative | p-values | 3 years postoperative | p-values | Follow-up |
|---|---|---|---|---|---|---|---|
| Center-edge angle (range) | –0.50 *9.8* (-27–15) | < 0.0001 | 35 *8.7* (10–50) | 0.4 | 35 *8.1* (10–55) | 0.06 | 35 *8.4* (20–55) |
| Acetabular roof obliquity (range) | 29 *7.5* (12–47) | < 0.0001 | 2.4 *7.9* (-20–30) | < 0.0001 | 8.8 *1.2* (-12–28) | 0.002 | 9.1 *1.2* (-12–28) |
| Head lateralization index (range) | 0.66 *0.11* (0.49–1.00) | 0.005 | 0.62 *0.12* (0.42–0.90) | 0.08 | 0.60 *0.11* (0.40–0.87) | 0.6 | 0.60 *0.12* (0.40–0.87) |

5 joints with progressive arthrosis excluded.
Wilcoxon sign rank test

As an effect of the surgical procedure, the mean preoperative CE angle increased from –0.5 to 35 degrees at 3 months (Table). Thereafter, there was no statistically significant change. At 3 months the AC angle had decreased from 29 to 2.4 degrees. On the following 2 follow-ups, we found a slight increase. The HLI showed a minimal reduction at 3 months and thereafter remained almost the same.

On the other hand, no change whatever was seen in the CE and AC angles during the postoperative course in 16 cases (19 joints), which maintained the postoperative joint morphology.

We assessed 12 factors to determine whether they contribute to the occurrence of postoperative joint remodeling, which means the presence of changes in the CE angle or AC angle during the postoperative course, using a multiple logistic regression analysis: 1) Charnley's category; 2) follow-up period; 3) age at surgery; 4) preoperative radiographic stage; 5) preoperative clinical score; 6) preoperative CE angle; 7) preoperative AC angle; 8) clinical score at follow-up; 9) 3-month postoperative CE angle; 10) 3-month postoperative AC angle; 11) level of improvement (3-month postoperative value minus preoperative value) of the CE angle; 12) level of improvement (3-month postoperative value minus preoperative value) of the AC angle. Using the backward elimination method, we selected 2 significant factors, age at surgery and level of improvement of AC angle. Postoperative joint remodeling was significantly related to the age at surgery (relative risk; 0.6, 95% confidence interval; 0.069–1.141, p = 0.03) and the level of improvement in AC angle (relative risk; 0.6, 95% confidence interval; 0.010–1.190, p = 0.02).

Progression of the radiographic stage was observed in 5 cases (5 joints). Narrowing of the lateral joint space occurred in 4 cases (4 joints) and slight narrowing in the entire joint space was seen in 1 case (1 joint). Poor postoperative joint congruency was probably the cause in these cases.

### *Surgical complications*

No major complications occurred, such as penetration of the chisel into articular cartilage, deep infection, damage to intrapelvic structures, nonunion and osteonecrosis of the acetabulum. However, a transient irritation of the lateral femoral cutaneous nerve was seen in 3 patients.

## Discussion

Satisfactory long-term clinical and radiographic results of periacetabular osteotomies such as RAOs have been reported in cases of prearthrosis and early stage osteoarthrosis secondary to dysplasia of the hip with the exception of cases of severe dysplasia and poor postoperative joint congruency (Ninomiya and Tagawa 1983, Trousdale et al. 1995, Kleuver et al. 1997). However, these radiographic results have been evaluated only immediately after the operation and occasionally at one follow-up. There have been no studies of joint remodeling during the postoperative course. The enlargement of the AC and CE angles that we found during the postoperative course indicates a medial and lateral extension of the subchondral

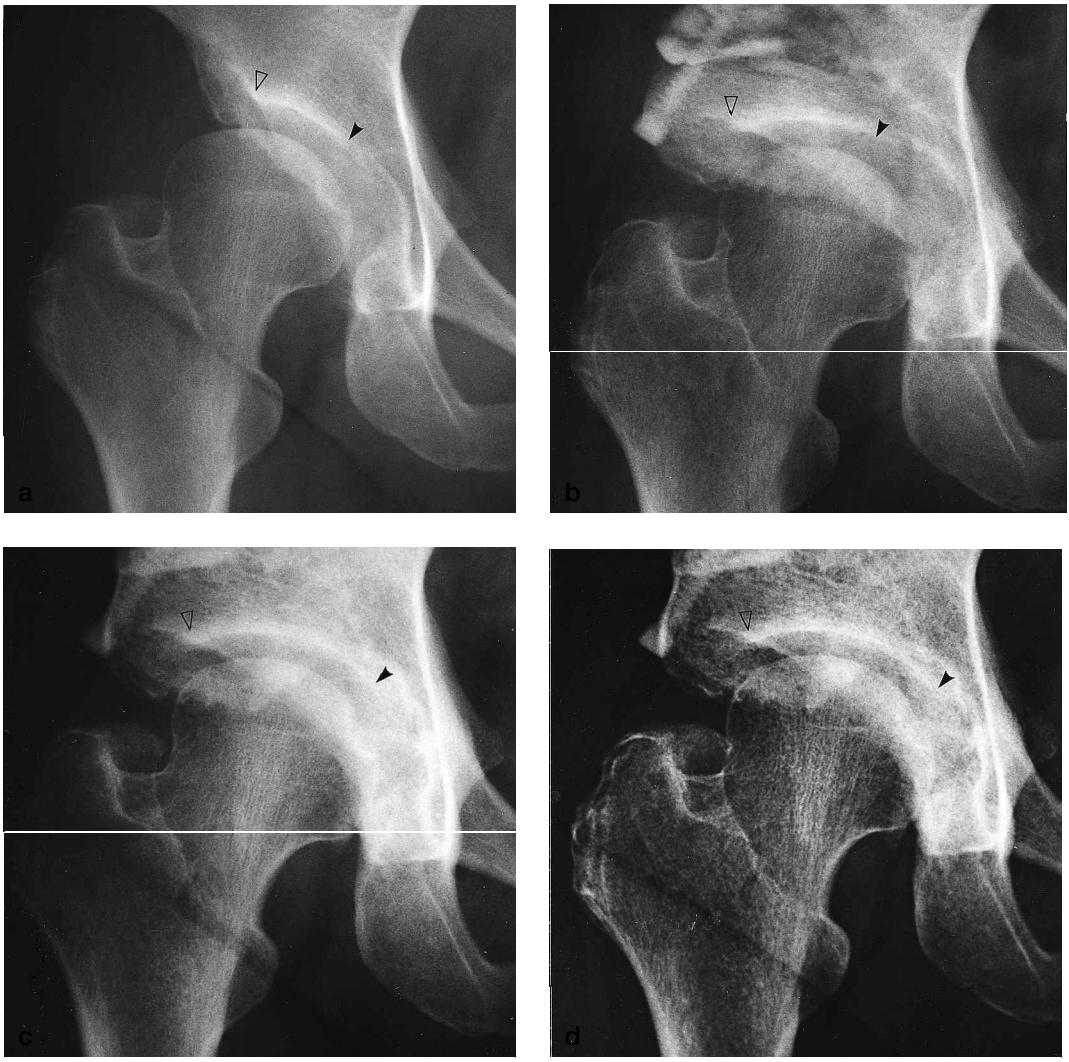


Figure 3. a. A 45-year-old woman before RAO. Clinical score: 13 points (pain 3, mobility 5, walking 5) CE angle: –3.0°, AC angle: 32°, HLI: 0.64.
b. 3 months after RAO. CE angle: 30°, AC angle: 3.0°, HLI 0.60.
c. 3 years after RAO. CE angle: 30°, AC angle: 17°, HLI: 0.59.
d. 7 years after RAO. Clinical score: 17 points (pain 6, mobility 5, walking 6), CE angle: 30°, AC angle: 17°, HLI: 0.58
Black arrow shows the medial margin of the subchondral bone of the acetabulum. White arrow shows the lateral margin of the subchondral bone of the acetabulum.

bone of the acetabulum and suggests an enlargement of the weight-bearing area (Dihlmann and Dihlmann 1994, Hsin et al. 1996). We consider this to be a useful joint remodeling, as it may prevent further progression of the arthrosis. The change in the HLI indicates absence of lateral migration of the femoral head and joint instability during the postoperative course. Thus, these joint remodelings which we noted differ from osteophyte formation accompanying progression of arthrosis.

We found significant joint remodeling on the medial side of the subchondral bone of the acetabulum. Our experimental study on rotational acetabular osteotomy indicated that activation of the articular cartilage develops in the early postoperative stage in response to load stress (Yasunaga et al. 1997). Synthetic clones of chondrocytes

(Mitchell et al. 1992) have been observed in the medial cartilage of the acetabulum which moved from a secondary load-site to the primary load-site, and these histological changes gradually stabilize. In the medial cartilage of the acetabulum and the acetabular fossa, cartilaginous metaplasia and cartilaginous ossification from fibro-fatty tissue of acetabulum can develop due to an increase in weight-bearing stress. These develop radiographically as an extension on the medial side of the subchondral bone of the acetabulum.

Periacetabular osteotomy such as RAO increases head coverage by articular cartilage and reduces the shear strength by horizontalization of the weight-bearing surface of the acetabulum (Hsin et al. 1996). In acetabular dysplasia, the articular cartilage area of the acetabulum is diminished, and this defect persists after the procedure. Our findings suggest that an enlargement of the articular cartilage area can be obtained by postoperative joint remodeling. However, in cases of a large reduction in the articular area, progression of the arthrosis following this procedure is very likely.

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