Rotational acetabular osteotomy for advanced osteoarthritis secondary to developmental dysplasia of the hip

K. Okano, H. Enomoto, M. Osaki, H. Shindo

From Nagasaki University, Nagasaki, Japan

We evaluated the results of rotational acetabular osteotomy in 44 hips (42 patients) with advanced osteoarthritis secondary to developmental dysplasia. The mean age of the patients at surgery was 43.4 years (30 to 59) and the mean follow-up was 12.1 years (8 to 19).

The mean Merle d’Aubigné clinical score improved from 10.8 points (8 to 15) preoperatively to 13.5 points (6 to 18) at follow-up. Radiologically, this procedure produced adequate improvement regarding cover of the femoral head. At follow-up, the osteoarthritic stage assessed using the Japanese Orthopaedic Association grading, was improved in 11 hips (25%), unchanged in 22 (50%) and had progressed in 11 (25%). The mean pre-operative roundness index of the femoral head was significantly different in the 33 hips which had improved or maintained their osteoarthritic stage compared with the 11 which had progressed (53.7% vs 63.7%; p < 0.001).

Osteoarthritis with a round femoral head is considered to be an indication for rotational acetabular osteotomy, even in advanced stages of the disease.

Developmental dysplasia of the hip (DDH) is the most common cause of secondary osteoarthritis (OA) in young adults. The triple osteotomy of Steel, the spherical acetabular osteotomy of Wagner, the rotational acetabular osteotomy developed by Ninomiya and Tagawa, and the peri-acetabular osteotomy of Ganz et al. all allow the femoral head to be covered with articular cartilage and have been used successfully in patients with DDH with no or early osteoarthritic involvement. However, there have been few mid- or long-term reports on patients with DDH and advanced-stage OA and those long-term results which are available have shown variable results.

Our aim was to assess whether rotational acetabular osteotomy was appropriate for patients with advanced-stage OA secondary to DDH.

Patients and Methods

Since 1985, we have performed the rotational acetabular osteotomy procedure developed by Ninomiya and Tagawa in 236 patients (257 hips) with DDH. Between 1985 and 1997, we performed this procedure without a concomitant femoral osteotomy or intra-articular procedure for advanced-stage OA in 51 patients with DDH (53 hips). Nine patients were lost to follow-up over more than eight years. We were able to contact three by telephone but they did not attend for review. We were unable to trace the other six patients. The mean age of these nine patients at the time of surgery was 41.3 years (30 to 51), and the mean follow-up was 3.1 years (1 to 6) during which time one patient had shown radiological evidence of the progression of OA.

The remaining 42 patients (44 hips) with follow-up for more than eight years had clinical and radiological assessments. Their mean follow-up was 12.1 years (8 to 19). There were 40 women and two men with a mean age at the time of surgery of 43.4 years (30 to 59). In this group, 11 patients had unilateral hip dysplasia and 31 bilateral dysplasia.

We classified OA of the hip into the following four stages according to the radiological staging system of the Japanese Orthopaedic Association: 1) pre-arthritis with no osteoarthritic change; 2) early, with slight narrowing of the joint space associated with sclerosis of the subchondral bone; 3) advanced, with narrowing of the joint space, cystic radiolucencies and small osteophytes; and 4) end-stage, with disappearance of the joint space and marked formation of osteophytes. The inclusion criterion for this study was advanced-stage OA of the hip. No patients with end-
stage OA were included. The indications for rotational acetabular osteotomy were acetabular dysplasia characterised by a centre-edge angle of $< 20^\circ$ on anteroposterior (AP) radiographs, progressive pain which interfered with daily activities and age $< 60$ years.

Post-operatively, partial weight-bearing aided by crutches was allowed in the sixth week after operation and full weight-bearing at four months.

The functional results were evaluated by the scoring system of Merle d’Aubigné and Postel, which assigns a maximum of six points for the three categories of pain, mobility and ability to walk. The activities-of-daily-living (ADL) score was also evaluated using the Japanese Orthopaedic Association scoring system. The highest possible score on the ADL was 20 points, based on a maximum of two points for each of the following categories: sitting on a chair, Japanese sitting, Japanese bowing, sitting down on the floor, standing up from the floor, putting on/taking off stockings, cutting toenails, standing on one leg, ascending and descending stairs. The pre-operative Merle d’Aubigné clinical and ADL scores were recorded routinely on the patients charts by an independent assessor (KO, HE, MO). All scores at follow-up were recorded by one author (KO).

In order to assess deformity of the femoral head the author (KO) measured the roundness index, which is calculated as the ratio of the distance from the medial border to the top of the femoral head (A) and that of the medial border to the lateral border of the femoral head (B). The acetabular head index is calculated as the ratio of the distance between the medial and lateral borders of the femoral head and that between the medial border of the femoral head and the lateral edge of the acetabular roof. The acetabular angle is the angle between a line joining the teardrop of the pelvis and a line between the teardrop and the lateral edge of the acetabular roof.

Statistical analysis. Differences between the pre- and post-operative measurements were tested using the Wilcoxon rank test. A $p$-value $< 0.05$ was considered to be significant. The cumulative probabilities of the radiological signs of progression of the OA were estimated using the Kaplan-Meier method. All analyses were performed using StatView Software (Abacus Concepts, Berkeley, California).

Results

The mean Merle d’Aubigné clinical score improved from 10.8 points (8 to 15) pre-operatively to 13.5 (6 to 18) at follow-up ($p < 0.001$), mainly because of increased scores for the reduction of pain. The mean pain score improved from 2.6 points (1 to 4) to 4.6 (2 to 6) ($p < 0.001$). The mean mobility score decreased from 5.3 points (4 to 6) to 4.5 (2 to 6) ($p = 0.004$) and the mean walking ability score improved from 3.0 points (1 to 4) to 4.4 (2 to 6) ($p = 0.0019$). The mean clinical score at follow-up was $\geq 15$ points for 28 hips, which included $\geq 17$ for 13 hips, but was $< 15$ points in 16 hips. Four patients under-
went total hip replacement (THR) during the period of follow-up. The mean ADL score improved from 12.0 points (7 to 18) pre-operatively to 16.4 (7 to 20) at follow-up (p < 0.001).

At follow-up, the radiological stage of OA was improved in 11 hips (25%), unchanged in 22 (50%) and had progressed in 11 (25%). We compared the 33 hips which had improved or maintained their OA stage (good group) with the 11 which had progressed (poor group) in terms of roundness index of the femoral head, centre-edge angle, acetabular head index and acetabular angle. The mean age at operation and the mean follow-up was 43.1 years (30 to 59) and 11.9 years (8 to 19), respectively in the good group and 43.8 (32 to 51) and 12.4 years (7 to 15), respectively, in the poor group. There were no significant differences in age at surgery and the period of follow-up between the two groups.

The mean pre-operative roundness index of the femoral head was significantly different in the groups: 53.7% (48.5% to 62.7%) in the good group and 63.7% (50.0% to 72.7%) in the poor group (p < 0.001). An example of a good result is shown in Figure 2.

The centre-edge angle, acetabular head index and acetabular angle were significantly improved after surgery (Wilcoxon rank sum test; centre-edge angle, p = 0.10, acetabular head index, p = 0.07, acetabular angle, p = 0.10) or follow-up (Wilcoxon rank sum test; centre-edge angle, p = 0.07, acetabular head index, p = 0.08, acetabular angle, p = 0.98) differences in these parameters in the groups (Table I).

In the good group, the mean Merle d’Aubigné clinical and ADL scores improved from 10.9 points (8 to 15) and 11.9 points (7 to 18) pre-operatively to 15.3 points (12 to 18) and 18.1 points (15 to 20), respectively at follow-up (p < 0.001). In the poor group, the mean Merle d’Aubigné clinical and ADL scores changed from 9.8 points (8 to 14) and 12.3 points (8 to 18), respectively to 8.5 points (6 to 13) and 11.5 points (7 to 15), respectively at follow-up. There were no significant differences between the pre-operative and follow-up scores in the poor group (Wilcoxon rank sum test; Merle d’Aubigné clinical score, p = 0.10, ADL score p = 0.17).

Kaplan-Meier survivorship analysis, with radiological signs of progression of OA as the endpoint, shows a survival rate of 75.0% (95% confidence interval 62.3 to 87.7) at ten years (Fig. 3).

Complications. No intra- or early post-operative complications including penetration of the joint, the osteotome, deep infection, post-operative migration of the rotated acetabulum, or delayed union of the site of the osteotomy, were observed in any patient.

Discussion
Several authors have reported various outcomes for rotational acetabular osteotomy for advanced or end-stage OA. Kanai et al. reported results of rotational acetabular osteotomy for 16 young active patients aged between 15 and 45 years, with end-stage arthritis, who were followed for a mean of eight years. In 11 patients, migration of the femoral head was observed in the first year after operation and in two, THR was performed. However, eight patients obtained relief from pain. Takatori et al. reported that rotational acetabular osteotomy effectively relieved pain and delayed the need for THR for more than ten years in 28 young patients aged between 19 and 40 years, with advanced- or end-stage OA. However, 10 of 21 patients with advanced-stage disease before surgery

Table I. Comparison of the logical parameters (mean, range) between the good (improved or maintained osteoarthritis stage) and poor (progressed osteoarthritis stage) groups

<table>
<thead>
<tr>
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<th>Good (n = 33)</th>
<th>Poor (n = 11)</th>
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<tbody>
<tr>
<td></td>
<td>Pre-operative</td>
<td>Post-operative</td>
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<tr>
<td>Centre-edge angle</td>
<td>0.97 (-20 to +18)</td>
<td>42.9 (22 to 73)</td>
</tr>
<tr>
<td>Acetabular head index</td>
<td>50.5 (37 to 74)</td>
<td>97.0 (80 to 120)</td>
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<tr>
<td>Acetabular angle</td>
<td>50.1 (40 to 60)</td>
<td>38.1 (28 to 44)</td>
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* p < 0.01 post-operative vs pre-operative (within-group comparison)
had progressed to end-stage disease at the time of follow-up. Yasunaga et al reported that 10 of 43 patients with advanced-stage OA who underwent rotational acetabular osteotomy progressed to end-stage disease at a mean follow-up of 8.5 years and two underwent THR. Some cartilaginous remodelling following rotational acetabular osteotomy has recently been reported in animal studies. Trousdale et al reported the results of the Bernese periacetabular osteotomy which is similar to a rotational acetabular osteotomy. Using the criteria of Tönnis to grade the pre-operative OA they found that three of 18 patients with pre-operative grade-2 disease required revision which included one THR and two subsequent femoral osteotomies. In our series 11 of 44 hips (25%) with advanced-stage OA progressed to end-stage disease and four patients (9%) underwent THR during a mean follow-up period of 12.1 years. The results of rotational acetabular osteotomy for patients with advanced OA are unreliable compared with those with early-stage disease. Yasunaga et al reported that the most important factor influencing the outcome in these patients was post-operative joint congruency and the pre- and post-operative joint space.

In our study, if the pre-operative roundness index of the femoral head was higher (less spherical), progression of OA could not be prevented in the long term by rotational acetabular osteotomy in patients with advanced OA. Instead, another osteotomy, such as a Chiari, acetabular osteotomy in patients with advanced OA.

Yanagimoto et al reported that the outcome of a Chiari osteotomy for advanced OA is determined by the roundness index. A flat femoral head, defined as a roundness index of more than 65%, predicts a good surgical outcome, but patients with a spherical femoral head may still experience early progression to OA.

In our study, if the pre-operative roundness index of the femoral head was higher (less spherical), progression of OA could not be prevented in the long term by rotational acetabular osteotomy in patients with advanced OA. Instead, another osteotomy, such as a Chiari, should be selected.

Our study had limitations. The roundness index of the femoral head which we proposed addressed only a two-dimensional assessment of a three-dimensional structure. However, AP radiographs were generally used to decide the indications for pelvic osteotomy. We believe that the degree of deformity of the femoral head can be used to determine whether rotational acetabular osteotomy will be successful in patients in advanced-stage OA.

In conclusion, OA in DDH with a round femoral head is considered to be an indication for rotational acetabular osteotomy, even in advanced stages of disease. However, patients who have a deformed femoral head in association with advanced OA may experience progression to end-stage disease with this procedure.

No benefits in any form have been received or will be received from a commercial party related directly to the subject of this article.

References