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Intermediate to Long-Term Results of Periacetabular Osteotomy in Patients Younger and Older Than Forty Years of Age

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Background: The treatment of middle-aged patients with periacetabular osteotomy remains controversial. The goal of the present retrospective study was to analyze the intermediate to long-term functional and radiographic results of periacetabular osteotomy in patients below and above the age of forty years.

Methods: Between February 1990 and December 2004, 166 periacetabular osteotomies were performed in 146 patients. We evaluated 158 hips in 139 patients who had a mean age of thirty-two years at the time of surgery. The mean duration of follow-up was eleven years (range, five to twenty years). We compared thirty-six patients (forty-one hips) who were forty years of age or older with 103 patients (117 hips) who were younger than forty years of age at the time of surgery.

Results: The average Harris hip score increased from 70 points preoperatively to 90 points postoperatively. The mean Harris hip scores at the time of the five-year follow-up were similar in the older and younger groups ($p = 0.57$), although the latest follow-up scores were significantly higher in the younger group than in the older group (91 compared with 88 points; $p = 0.02$). The average modified Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) function score (with 0 representing the worst score and 100 representing the best score) was higher for the younger group than for the older group (92 compared with 90 points; $p = 0.03$). Kaplan-Meier analysis with progression of the Tönnis grade of osteoarthritis as the end point showed a ten-year survival rate of 90.8% (95% confidence interval, 88.3% to 93.3%) and a fifteen-year survival rate of 83.0% (95% confidence interval, 78.5% to 87.5%); the ten-year survival rates in the younger and older groups were 94.4% and 81.3%, respectively, and the fifteen-year survival rates were 86.9% and 71.2%, respectively ($p = 0.025$).

Conclusions: Periacetabular osteotomy yielded similar results for the two groups at the time of the five-year follow-up, although the results for the older group deteriorated thereafter. Decrease in physical function due to aging and increased susceptibility to the progression of osteoarthritis may be responsible for the poorer results over time in the older group.

Level of Evidence: Therapeutic Level IV. See Instructions to Authors for a complete description of levels of evidence.

Patients with a dysplastic acetabulum often develop early secondary osteoarthritis[1]. Reducing articular cartilage contact stress with a pelvic osteotomy may delay the appearance or reduce the severity of osteoarthritis[2,3]. Various osteotomies to reposition the acetabulum have been described[4-8]. Satisfactory intermediate to long-term clinical results have been reported in association with these osteotomies[9-16]. Steppacher et al. reported that 60% of hips survived at an average of twenty years after Bernese periacetabular osteotomy[13]. Those authors identified several parameters associated with poor outcomes, which included older age at the time of surgery. Other studies have also identified older age as a predictor of failure[10,16]. However, good clinical results have been reported following periacetabular osteotomies in older patients[17-20].

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The results of those previous studies are conflicting, and the use of periacetabular osteotomy to treat middle-aged patients remains controversial. We found no previous studies comparing younger and older patients with more than ten years of follow-up. We hypothesized that a periacetabular osteotomy would yield similar results for young and old patients with short to intermediate-term follow-up, with the results in older patients deteriorating thereafter. We have performed periacetabular osteotomy through an Ollier lateral-U transtrochanteric approach since 1990 with consistent surgical indications and techniques[21]. The purpose of the present study was to compare the results in patients forty-years of age or older with those in patients less than forty years of age, with particular attention to differences between these two groups in terms of hip pain, hip function, and progression of osteoarthritis on radiographs.

Materials and Methods

Our institutional review board approved the present study. We retrospectively assessed all patients who had a periacetabular osteotomy between February 1990 and December 2004. During this period, 166 periacetabular osteotomies were performed for the treatment of acetabular dysplasia in 146 adolescent and adult patients, all of whom had moderate to severe hip pain. Surgical indications for the periacetabular osteotomy included a lateral center-edge angle[1] of <16° on anteroposterior radiographs, a congruent hip joint with hip abduction, pre-osteoarthritis or early-stage osteoarthritis (Tönnis grade 0, 1, or 2)[22], and an age of younger than sixty years. Joint congruency was classified as good if the curvature of the acetabulum and that of the femoral head were almost identical, with the joint-space width at the narrowest point being at least two-thirds of that at the widest point. Contraindications for the osteotomy were poor joint congruency showing partial narrowing or disappearance of the joint space with the hip in abduction, a severely deformed femoral head, advanced-stage (Tönnis grade-3) osteoarthritis[22], and an age of older than sixty years. Six patients (seven hips) were lost to follow-up. One patient (one hip) died of pulmonary embolism four days after surgery. We evaluated the remaining 139 patients (158 hips). Twenty-two patients were male, and 117 were female. Eighty-six hips were on the left side, and seventy-two hips were on the right side. Nineteen patients underwent bilateral surgery. The overall average age of the patients at the time of surgery was thirty-two years (range, twelve to fifty-six years).

Patients were classified into one of two groups: the first group included patients who were forty years of age or older at the time of surgery, and the second group included patients who were younger than forty years of age at the time of surgery. The older group included thirty-six patients (forty-one hips), and the younger group included 103 patients (117 hips). The average age was forty-seven years (range, forty to fifty-six years) in the older group and twenty-seven years (range, twelve to thirty-nine years) in the younger group. In two patients (two hips) in the younger group, periacetabular osteotomy was combined with an intertrochanteric valgus osteotomy. The femoral head of these two hips was distorted, and preoperative radiographs had shown worse joint congruity with the hip in an abducted position than in a neutral position. The mean duration of follow-up was eleven years (range, five to twenty years).

All osteotomies were performed by one of two surgeons. The operative techniques were described previously[21]. Briefly, the skin incision began at the anterosuperior iliac spine, curved downward and posteriorly 2 cm distal to the base of the greater trochanter, and then curved upward to the posterosuperior iliac spine. The greater trochanter was retracted proximally after the completion of an osteotomy at its base with an approximate thickness of 10 to 15 mm. The acetabular osteotomy was performed with use of a curved osteotome. The proximal osteotomy line, approximately 15 mm or more proximal to the acetabular joint, was confirmed with fluoroscopy. To eliminate the potential complication of osteonecrosis, a thick acetabular fragment was created. The osteotomy extended anteriorly and posteriorly around the circumference of the acetabulum. The posteroinferior osteotomy ended at the obturator foramen through the innominate groove of the ischium. The base of the superior pubic ramus was then exposed with use of paired iliopubic bone retractors, which were symmetrically twisted in shape and which were used to retract the iliopsoas tendon medially, providing wide exposure of the pubis[21]. The lateral portion of the protuberance of the iliopubic bone was osteotomized, and the circumferential periacetabular osteotomy was completed. The acetabular fragment was then rotated anteriorly and laterally for most patients with anterolateral acetabular deficiency. For some patients with acetabular retroversion, the posterior part of the fragment was rotated more laterally than the anterior part of the fragment. Adequate femoral head coverage, with a postoperative center-edge angle of approximately 35°, a more horizontal acetabular weight-bearing, and medialization of the hip center, was confirmed with fluoroscopy. For hips with severe anterior acetabular deficiency, anterior coverage was confirmed on oblique views. The hip was flexed and abducted to ensure that there was no anterior or lateral overcorrection, which could lead to femoroacetabular impingement. Hip motion of at least 120° of flexion and 30° of abduction was confirmed intraoperatively. If there was a gap between the osteotomy surfaces, small autologous bone chips from the iliac lateral edge or the pubic medial edge were grafted into this gap. We used no massive structural iliac bone graft. Three or four bioabsorbable cortical screws (Fixsorb or Super-Fixsorb; Takiron, Osaka, Japan) were used to transfix the redirected acetabular fragment. The screws were inserted from the lateral surface of the acetabular fragment to penetrate the medial cortex of the proximal part of the ilium. No intraoperative arthrotomy for labral debridement, labral repair, or osteochondroplasty was done. The greater trochanter was reduced and fixed with two or three 6.5-mm metallic or bioabsorbable cancellous screws. Preoperatively, the greater trochanter was considered to be high-riding if the proximal end of the greater trochanter was cephalad to the center of the femoral head. The high-riding greater trochanter was distally advanced by 10 to 25 mm to an anatomically normal position, with the proximal end of the greater trochanter being placed at the center of the femoral head.

Postoperative treatment and evaluations were the same for the older and younger groups. The patient was allowed to use a wheelchair, and postoperative active hip range of motion, quadriceps muscle strengthening, and straight leg-raising exercises were begun immediately. Non-weight-bearing walking was initially recommended for the first two weeks after surgery. Partial weight-bearing with two crutches began two to four weeks postoperatively. Full weight-bearing with one crutch began four to eight weeks postoperatively. Immediate postoperative full weight-bearing with two crutches was allowed after 2003. Full weight-bearing with one crutch began as tolerated, usually two to four weeks postoperatively. During the study period, use of one crutch for walking was recommended for three months postoperatively. Prophylaxis against deep-vein thrombosis was not routinely administered. Only high-risk patients with a previous history of thrombosis were managed with aspirin for two weeks postoperatively.

Clinical and radiographic evaluations were performed preoperatively; at one, two, four, six, and twelve months postoperatively; and annually thereafter for all patients. Pain and function at the time of the latest follow-up were measured with use of the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC)[23]. Two subscales of this self-administered questionnaire, specifically pain (five items) and physical function (seventeen items), were evaluated. Each WOMAC subscale score was transformed to a range of 0 (worst) to 100 (best). The Harris hip score[24] was also evaluated preoperatively and at the times of the follow-up visits. Preoperative and postoperative clinical data were collected from the charts of the patients.

Anteroposterior and lateral hip radiographs were performed for each evaluation. The radiographic severity of osteoarthritis was classified with use of the Tönnis system[22]. The center-edge angle of Wiberg[1], the acetabular head index, and the acetabular angle of Sharp[25] were measured. The acetabular head index is the same as the acetabulum-femoral head quotient described by Heyman and Herndon[26]. The head lateralization index was measured[16]. The presence of the cross-over sign of acetabular retroversion was recorded[27]. The male:female ratio, the duration of follow-up, the side of involvement, the severity of

osteoarthritis, the center-edge angle, the angle of Sharp, the acetabular head index, and the head lateralization index were comparable between the older and younger groups (Table I). Radiographic images were transferred to Image J software (National Institutes of Health, Bethesda, Maryland) on personal computers, and measurements were performed with an accuracy of ±0.01 mm and ±0.01°.

TABLE I Demographic Data, Clinical Outcomes, and Radiographic Findings in the Older and Younger Groups

Parameters	Older Group (≥40 Years Old) (N = 41)	Younger Group (<40 Years Old) (N = 117)	P Value
Age* *(yr)*	47.2 (40 to 56)	27.1 (12 to 39)	<0.01†
Male:female ratio *(no. of hips)*	7:34	17:100	0.80
Side (left:right) *(no. of hips)*	22:19	64:53	0.91
Duration of follow-up* *(yr)*	10.8 (5 to 18.5)	11.0 (5 to 20)	0.63
Harris hip score‡ *(points)*			
Overall			
Preop.	68.9 ± 7.3	70.1 ± 9.1	0.61
5-year follow-up	91.4 ± 8.4	92.0 ± 8.2	0.57
Latest follow-up	88.0 ± 11.7	91.4 ± 9.6	0.02†
Pain score at latest follow-up	39.4 ± 5.8	40.5 ± 5.6	0.11
Function score latest follow-up	41.7 ± 5.6	43.5 ± 4.3	0.02†
WOMAC at latest follow-up‡ *(points)*			
Pain	89.1 ± 11.3	92.3 ± 9.9	0.06
Function	89.7 ± 10.8	92.2 ± 10.8	0.03†
Radiographic evaluation			
Center-edge angle‡ *(deg)*			
Preop.	−1.3 ± 8.4 (−25 to 9)	−1.7 ± 9.7 (−28 to 15)	0.82
Postop.	36.4 ± 6.5 (21 to 50)	35.1 ± 6.2 (20 to 52)	0.19
Acetabular head index‡			
Preop.	52.7 ± 9.5 (23 to 68)	54.9 ± 8.6 (23 to 72)	0.67
Postop.	89.9 ± 8.4 (72 to 100)	87.9 ± 6.9 (72 to 100)	0.13
Sharp angle‡ *(deg)*			
Preop.	52.1 ± 2.5 (47 to 57)	51.8 ± 3.6 (45 to 58)	0.86
Postop.	39.6 ± 3.9 (31 to 48)	40.2 ± 4.1 (30 to 48)	0.23
Lateralization‡ *(mm)*			
Preop.	16.8 ± 4.6 (10 to 30)	15.8 ± 3.9 (9 to 30)	0.30
Postop.	9.9 ± 6.9 (−4 to 24)	11.4 ± 6.4 (−4 to 23)	0.12
Tönnis grade (preop./latest follow-up) *(no. of hips)*			0.91/0.40
0	10/9	30/30	
1	29/24	83/76	
2	2/5	4/7	
3	0/3	0/4	
Progression of osteoarthritis grade *(no. of hips)*	8 (20%)	9 (8%)	0.04†
Complications *(no. of hips)*			
Pulmonary embolism	1	0	0.26
Osteonecrosis of the rotated fragment	1	2	0.77
Displacement of the greater trochanter	1	3	0.97
Ischial fracture	2	3	0.47
Pubic nonunion	1	4	0.76
Heterotopic bone formation	0	2	0.40
Deep infection	0	1	0.55
Conversion to total hip arthroplasty *(no. of hips)*	3 (7%)	4 (3%)	0.38

*The values are given as the mean, with the range in parentheses. †Significant. ‡The values are given as the mean and the standard deviation, with or without the range in parentheses.

An orthopaedic instructor who specialized in hip surgery and imaging analyses of the hip joint performed all radiographic measurements. Preoperative and periodic postoperative radiographic analysis was performed in a blinded fashion for all patients. Intraobserver reliability studies for the severity of osteoarthritis were performed over a one-month interval. The intraclass correlation coefficients for the severity of osteoarthritis were 0.93 preoperatively and 0.92 postoperatively.

Univariate analyses included the chi-square test, the Mann-Whitney U test, and the Wilcoxon signed-rank test where appropriate. Preoperative and postoperative Harris hip scores were compared with use of the Wilcoxon

Fig. 1-A

Fig. 1-B

Figs. 1-A through 1-D Anteroposterior radiographs showing the hips and pelvis of a woman who was managed with periacetabular osteotomy for the treatment of acetabular dysplasia of the left hip at the age of fifty-three years. **Fig. 1-A** Preoperative radiograph. **Fig. 1-B** Anteroposterior pelvic radiograph made two weeks after periacetabular osteotomy. The greater trochanter was advanced distally by 10 mm to obtain appropriate tension of the hip abductor muscles.

signed-rank test. The chi-square test was used for analyses of the clinical factors, the preoperative and postoperative osteoarthritis grade, and progression of the osteoarthritis grade. The Wilcoxon signed-rank test was used for analyses of the preoperative and postoperative center-edge angle, acetabular head index, Sharp angle, and head lateralization index. The Mann-Whitney U test was used for analyses of the relationship between the progression of the Tönnis grade and the preoperative and postoperative center-edge angle, acetabular head index, Sharp angle, and head lateralization index. Kaplan-Meier survivorship analysis was performed with progression of the Tönnis grade as one end point and conversion to total hip arthroplasty as a second end point; patients awaiting

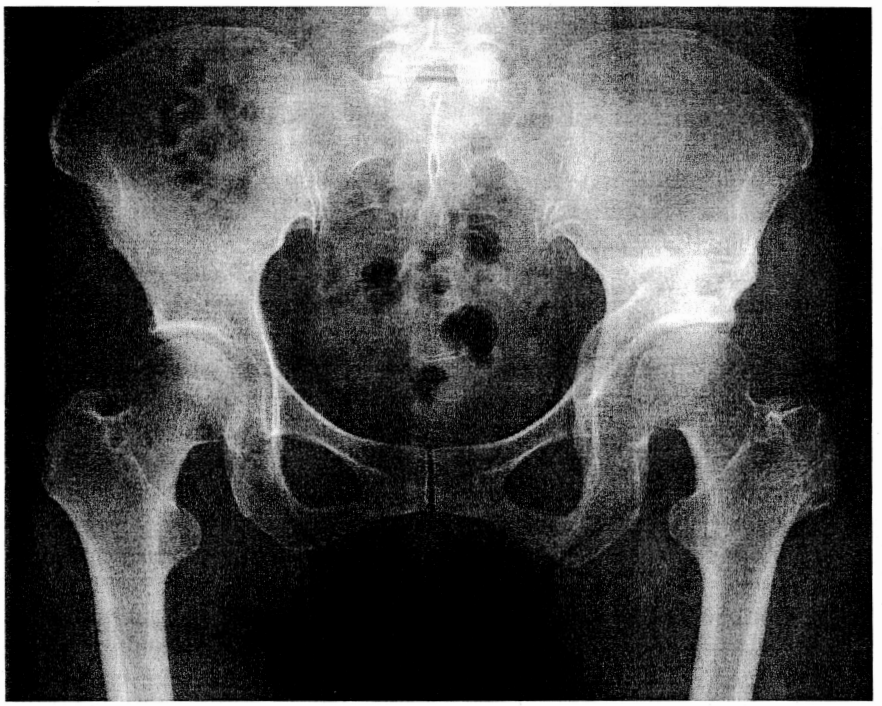

Fig. 1-C

Fig. 1-D

Fig. 1-C Anteroposterior pelvic radiograph made five years after osteotomy. Slight joint-space narrowing and subluxation of the femoral head were noted; however, the patient reported no hip pain. **Fig. 1-D** Anteroposterior pelvic radiograph made eleven years after osteotomy. The osteoarthritis progressed at ten years after surgery, at which time the patient reported left hip pain.

total hip arthroplasty were not considered in this analysis. Differences between the two groups in terms of the survival rate were determined with the log-rank test. A p value of <0.05 was considered significant. Statistical analyses were performed with use of SPSS software, version 17.0 (SPSS, Chicago, Illinois).

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There was no outside funding in support of this study.

Results

The average Harris hip score increased from 70 points (range, 52 to 95 points) preoperatively to 90 points (range, 44 to 100 points) at the time of the most recent follow-up ($p < 0.001$). The average pain score improved from 29 points (of 44 possible points) preoperatively to 40 points at the time of the most recent follow-up ($p < 0.001$). Overall, 143 hips (91%) had a Harris hip score of ≥80 points. The mean Harris hip scores preoperatively and at the five-year follow-up were similar in the older and younger groups, but the scores at the time of the latest follow-up were significantly higher in the younger group (Table I) (Figs. 1-A through 1-D). The WOMAC function scores at the time of the latest follow-up were significantly higher in the younger group. There were no significant differences between the patients who underwent unilateral and bilateral surgery in either the older ($p = 0.112$) or younger group ($p = 0.235$).

The overall mean center-edge angle increased from –2° ± 9° preoperatively to 36° ± 6° postoperatively ($p < 0.001$), the mean acetabular head index increased from 54 ± 9 to 88 ± 7 ($p < 0.001$), the mean Sharp angle decreased from 52° ± 3° to 40° ± 4° ($p < 0.001$), and lateralization decreased from 16 ± 4 mm to 11 ± 7 mm ($p < 0.001$). These improvements were similar in the older and younger groups (Table I). The cross-over sign was observed in fourteen hips (9%) preoperatively and in no hip postoperatively. Preoperatively, forty hips (25%) were classified as Tönnis grade 0, 112 (71%) were classified as grade 1, and six (4%) were classified as grade 2. At the time of the most recent follow-up or just before total hip arthroplasty, thirty-nine hips (25%) were classified as Tönnis grade 0, 100 (63%) were classified as grade 1, twelve (8%) were classified as grade 2, and seven (4%) were classified as grade 3. Seventeen hips (11%) had progression of Tönnis grade. There was a significant relationship between a higher preoperative Tönnis grade of osteoarthritis and osteoarthritic progression ($p = 0.041$). Osteoarthritic progression was found at a higher rate in the older group (Table I). Seven hips (4%) underwent total hip arthroplasty.

With progression of the Tönnis grade of osteoarthritis as the end point, the ten-year survival rate was 90.8% (95% confidence interval, 88.3% to 93.3%) and the fifteen-year survival rate was 83.0% (95% confidence interval, 78.5% to 87.5%); the ten-year survival rates for the younger and older groups were 94.4% and 81.3%, respectively, and the fifteen-year survival rates were 86.9% and 71.2%, respectively ($p = 0.025$) (Fig. 2). With conversion to total hip arthroplasty as the end point, the ten-year survival rate was 96.1% (95% confidence interval, 94.4% to 97.8%) and the fifteen-year survival rate was 91.9% (95% confidence interval, 88.4% to 95.4%); the ten-year survival rates for the younger and older groups were 97.9% and 91.3%, respectively, and the fifteen-year survival rates were 92.7% and 91.3%, respectively ($p = 0.281$).

Complications included pulmonary embolism (one hip), deep infection (one hip), osteonecrosis of the rotated acetabular fragment (three hips), proximal displacement of the greater trochanter because of breakage of the bioabsorbable screws (four hips), ischial fracture (five hips), asymptomatic pubic nonunion (five hips), and asymptomatic heterotopic bone formation (two hips). One postoperative deep infection extended

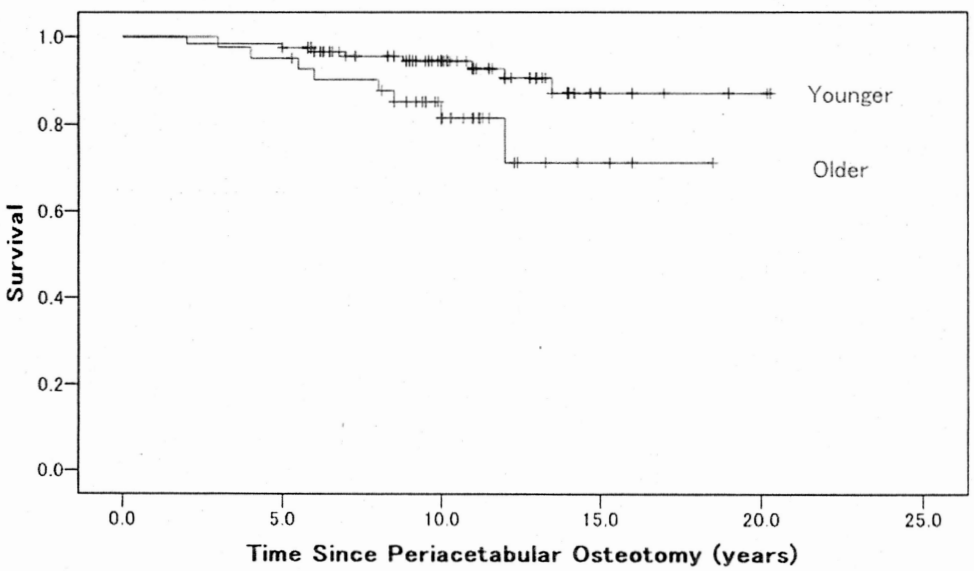

Fig. 2

Kaplan-Meier survivorship curves for the younger and older groups, demonstrating the numbers of hips without progression of the Tönnis osteoarthritis grade following periacetabular osteotomy. At the time of the latest follow-up, 92.3% of the patients in the younger group and 80.5% of the patients in the older group had no worsening of the Tönnis grade.

to septic arthritis, which healed after surgical debridement. Three of the four hips with displacement of the greater trochanter underwent revision surgery, and bone union was obtained. No patient had pain, tenderness, or focal reactions around the greater trochanter other than the four hips with displacement of the greater trochanter. No patient had an injury to the great vessels or major nerves. No patient had symptoms resulting from iatrogenic injury to the lateral femoral cutaneous nerves.

Discussion

Various rates of hip joint survival after periacetabular osteotomy have been reported. Yasunaga et al. reported that the ten-year survival rate after rotational acetabular osteotomy, with progression of osteoarthritis as the end point, was 70.0% in a group of twenty-six hips in twenty-four patients who were forty-six years old or more and 93.7% in a group of sixty-three hips in sixty patients who were less than forty-six years old[20]. Millis et al. performed Bernese periacetabular osteotomy for eighty-seven hips in seventy patients with a mean age of forty-four years at the time of surgery and evaluated the results after a mean duration of follow-up of five years[17]. The risk of total hip arthroplasty at five years was 12% for hips that had been classified as Tönnis grade 0 or 1 preoperatively and 27% for those that had been classified as Tönnis grade 2. Yamaguchi et al. reported that the rate of survival after eccentric rotational acetabular osteotomy, with conversion to total hip arthroplasty as the end point, was 96.5% and 88.9% at ten and fifteen years, respectively[19]. Schramm et al. performed Wagner spherical osteotomy for twenty-two hips in twenty-two patients with a mean age of twenty-four years and evaluated the results after a mean duration of follow-up of twenty-four years[12]. The survival rate at twenty-five years was 65.1% with total hip arthroplasty as the end point. We found a ten-year survival rate of 96.1% and a fifteen-year survival rate of 91.9% with conversion to total hip arthroplasty as the end point; thus, our overall survival rates were favorable. Strict surgical indications for hips with good preoperative joint congruency and our Japanese patients with short stature and low body-mass index may have contributed to the favorable results.

The Harris hip score decreases with age with or without hip disease[28-30]. The slight (3.4-point) difference between the older and younger groups in terms of the overall hip score (Table I) may not be of clinical importance, but the hip score in the older group is likely to decrease further during longer-term follow-up. The gradual decrease in the hip score in the older group seemed to be related to two major factors: (1) a decrease in physical function due to aging itself and (2) susceptibility to progression of osteoarthritis in the older group. The Harris and WOMAC pain scores were higher in the younger group but were not significantly different between the two groups, and the functional scores were significantly different. Because the aging process is slow, a gradual decrease in the hip scores in the older group seems reasonable. On the other hand, whether the higher rate of osteoarthritis progression in the older group was due to the long-term results of the osteotomy or to aging itself remains unclear. Because there was no significant difference between the hip scores at the five-year and latest follow-up evaluations in the younger group, a higher rate of osteoarthritis progression in the older group seems to be more closely related to aging issues rather than to the periacetabular osteotomy.

For symptomatic patients over the age of forty years who have a dysplastic hip, the operative indications for total hip arthroplasty or joint-preserving procedures are controversial[31-35]. Sharifi et al. reported that periacetabular osteotomy was more cost-effective than total hip arthroplasty for patients with Tönnis grade-0, 1, and 2 osteoarthritis[32]. Hsieh et al. evaluated thirty-one patients who were managed with periacetabular osteotomy for the treatment of Tönnis grade-0 to 2 osteoarthritis in one hip and total hip arthroplasty for the treatment of Tönnis grade-3 osteoarthritis in the other hip[33]. More patients preferred the periacetabular osteotomy to total hip arthroplasty (53% compared with 23%; $p = 0.029$) at a mean of six years after periacetabular osteotomy and seven years after total hip arthroplasty. Periacetabular osteotomy remains an important option for older patients who are not yet willing to undergo total hip arthroplasty.

It is important not to overcorrect the acetabular fragment laterally because this can lead to impingement and can bring the fovea into the weight-bearing surface[36]. In the present study, the average postoperative center-edge angle of 36° indicated that appropriate femoral head coverage could be achieved. To avoid femoroacetabular impingement, we measured the center-edge angle intraoperatively with use of fluoroscopy and confirmed that there was no overcoverage.

Our study had several limitations. We used five-year and most recent hip scores to assess clinical outcome, although only the most recent WOMAC pain and functional scores were available. Without the interval WOMAC scores, it is not clear how patients responded initially after surgery. Our study included a relatively small number of patients, which limited the statistical power. We did not compare the survival rate for our patients (all of whom were managed with periacetabular osteotomy) with that for patients who were not managed surgically or patients who were managed with total hip arthroplasty. Our results are representative only of Asian patients with short stature and low body-mass index. These results may not be applicable to white patients. Evaluation of preoperative labral tears with use of magnetic resonance imaging was not routinely performed during the study period.

We believe periacetabular osteotomy merits consideration for the treatment of hip dysplasia in patients who are forty years of age or older. However, surgeons should inform older patients that clinical results may deteriorate after five years postoperatively. ■

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References

1. Wiberg G. Studies on dysplastic acetabula and congenital subluxation of the hip joint with special reference to the complication of osteo-arthritis. Acta Chir Scand. 1939;83 Suppl 58:135.

2. Millis MB, Murphy SB, Poss R. Osteotomies about the hip for the prevention and treatment of osteoarthrosis. J Bone Joint Surg Am. 1995;77:626-47.

3. Poss R. The role of osteotomy in the treatment of osteoarthritis of the hip. J Bone Joint Surg Am. 1984;66:144-51.

4. Eppright RH. Dial osteotomy of the acetabulum in the treatment of dysplasia of the hip [abstract]. J Bone Joint Surg Am. 1975;57:1172.

5. Ganz R, Klaue K, Vinh TS, Mast JW. A new periacetabular osteotomy for the treatment of hip dysplasias. Technique and preliminary results. Clin Orthop Relat Res. 1988;232:26-36.

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

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

8. Wagner H. Experiences with spherical acetabular osteotomy for the correction of the dysplastic acetabulum. In: Weil UH, editor. Acetabular dysplasia: skeletal dysplasias in childhood. Progress in orthopaedic surgery. Vol 2. New York: Springer; 1978:131-45.

9. Miller NH, Krishnan SG, Kamaric E, Noble PC. Long-term results of the dial osteotomy in the treatment of high-grade acetabular dysplasia. Clin Orthop Relat Res. 2005;433:115-23.

10. Matheney T, Kim YJ, Zurakowski D, Matero C, Millis M. Intermediate to long-term results following the Bernese periacetabular osteotomy and predictors of clinical outcome. J Bone Joint Surg Am. 2009;91:2113-23.

11. Nozawa M, Shitoto K, Matsuda K, Maezawa K, Kurosawa H. Rotational acetabular osteotomy for acetabular dysplasia. A follow-up for more than ten years. J Bone Joint Surg Br. 2002;84:59-65.

12. Schramm M, Hohmann D, Radespiel-Troger M, Pitto RP. Treatment of the dysplastic acetabulum with Wagner spherical osteotomy. A study of patients followed for a minimum of twenty years. J Bone Joint Surg Am. 2003;85:808-14.

13. Steppacher SD, Tannast M, Ganz R, Siebenrock KA. Mean 20-year followup of Bernese periacetabular osteotomy. Clin Orthop Relat Res. 2008;466:1633-44.

14. Takatori Y, Ninomiya S, Nakamura S, Morimoto S, Moro T, Nagai I, Mabuchi A. Long-term results of rotational acetabular osteotomy in patients with slight narrowing of the joint space on preoperative radiographic findings. J Orthop Sci. 2001;6:137-40.

15. van Hellemondt GG, Sonneveld H, Schreuder MH, Kooijman MA, de Kleuver M. Triple osteotomy of the pelvis for acetabular dysplasia: results at a mean follow-up of 15 years. J Bone Joint Surg Br. 2005;87:911-5.

16. Yasunaga Y, Ochi M, Shimogaki K, Yamamoto S, Iwamori H. Rotational acetabular osteotomy for hip dysplasia: 61 hips followed for 8-15 years. Acta Orthop Scand. 2004;75:10-5.

17. Millis MB, Kain M, Sierra R, Trousdale R, Taunton MJ, Kim YJ, Rosenfeld SB, Kamath G, Schoenecker P, Clohisy JC. Periacetabular osteotomy for acetabular dysplasia in patients older than 40 years: a preliminary study. Clin Orthop Relat Res. 2009;467:2228-34.

18. Teratani T, Naito M, Kiyama T, Maeyama A. Periacetabular osteotomy in patients fifty years of age or older. J Bone Joint Surg Am. 2010;92:31-41.

19. Yamaguchi J, Hasegawa Y, Kanoh T, Seki T, Kawabe K. Similar survival of eccentric rotational acetabular osteotomy in patients younger and older than 50 years. Clin Orthop Relat Res. 2009;467:2630-7.

20. Yasunaga Y, Takahashi K, Ochi M, Ikuta Y, Hisatome T, Nakashiro J, Yamamoto S. Rotational acetabular osteotomy in patients forty-six years of age or older: comparison with younger patients. J Bone Joint Surg Am. 2003;85:266-72.

21. Ito H, Matsuno T, Minami A. Rotational acetabular osteotomy through an Ollier lateral U approach. Clin Orthop Relat Res. 2007;459:200-6.

22. Tönnis D, Legal H, Graf R. Congenital dysplasia and dislocation of the hip in children and adults. New York: Springer-Verlag; 1987. p167-71.

23. Bellamy N, Buchanan WW, Goldsmith CH, Campbell J, Stitt LW. Validation study of WOMAC: a health status instrument for measuring clinically important patient relevant outcomes to antirheumatic drug therapy in patients with osteoarthritis of the hip or knee. J Rheumatol. 1988;15:1833-40.

24. Harris WH. Traumatic arthritis of the hip after dislocation and acetabular fractures: treatment by mold arthroplasty. An end-result study using a new method of result evaluation. J Bone Joint Surg Am. 1969;51:737-55.

25. Sharp IK. Acetabular dysplasia: the acetabular angle. J Bone Joint Surg Br. 1961;43:268-72.

26. Heyman CH, Herndon CH. Legg-Perthes disease: a method for the measurement of the roentgenographic result. J Bone Joint Surg Am. 1950;32:767-78.

27. Reynolds D, Lucas J, Klaue K. Retroversion of the acetabulum. A cause of hip pain. J Bone Joint Surg Br. 1999;81:281-8.

28. Brinker MR, Lund PJ, Cox DD, Barrack RL. Demographic biases found in scoring instruments of total hip arthroplasty. J Arthroplasty. 1996;11:820-30.

29. Lieberman JR, Hawker G, Wright JG. Hip function in patients >55 years old: population reference values. J Arthroplasty. 2001;16:901-4.

30. Ritter MA, Thong AE, Davis KE, Berend ME, Meding JB, Faris PM. Long-term deterioration of joint evaluation scores. J Bone Joint Surg Br. 2004;86: 438-42.

31. van Bergayk AB, Garbuz DS. Quality of life and sports-specific outcomes after Bernese periacetabular osteotomy. J Bone Joint Surg Br. 2002;84:339-43.

32. Sharifi E, Sharifi H, Morshed S, Bozic K, Diab M. Cost-effectiveness analysis of periacetabular osteotomy. J Bone Joint Surg Am. 2008;90:1447-56.

33. Hsieh PH, Huang KC, Lee PC, Chang YH. Comparison of periacetabular osteotomy and total hip replacement in the same patient: a two- to ten-year follow-up study. J Bone Joint Surg Br. 2009;91:883-8.

34. Garbuz DS, Awwad MA, Duncan CP. Periacetabular osteotomy and total hip arthroplasty in patients older than 40 years. J Arthroplasty. 2008;23:960-3.

35. Parvizi J, Burmeister H, Ganz R. Previous Bernese periacetabular osteotomy does not compromise the results of total hip arthroplasty. Clin Orthop Relat Res. 2004;423:118-22.

36. Trousdale RT, Cabanela ME. Lessons learned after more than 250 periacetabular osteotomies. Acta Orthop Scand. 2003;74:119-26.