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Acetabular dysplasia: a comparison of periacetabular osteotomy results of patients older and younger than 35 years

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Abstract. – OBJECTIVE: Patient age has been reported to be an important determinant of treatment success in developmental dysplasia of the hip (DDH). This study aimed to determine the efficacy of periacetabular osteotomy (PAO) in DDH patients aged ≥ 35 years and to compare patient-reported and radiological outcomes with a control cohort of younger patients.

PATIENTS AND METHODS: This retrospective analysis included 43 patients (23 aged < 35 years; 20 aged ≥ 35 years) who underwent unilateral Bernese PAO for symptomatic DDH, between May 2001 and August 2015. Patients with a history of ipsilateral pelvic osteotomy or other pelvic pathologies were excluded. To evaluate the morphology of the dysplastic hip joints, 11 conventional radiographic measures were taken. Preoperative and postoperative Harris Hip Scores, postoperative visual analogue scale scores, Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) scores, and hip range of motion measurements were used for clinical evaluation.

RESULTS: Of the 43 patients, 31 (72.1%) were women and 14 (27.9%) were men. The average age was 32 (range: 19-45) years. Regarding sex, surgery site, mean body mass index and mean follow-up time, there were no significant differences between the groups. Both groups showed significant differences in radiographic parameters before and after the PAO. There were no significant differences in preoperative or postoperative clinical outcomes between the groups, except for the WOMAC score.

CONCLUSIONS: PAO can be performed safely to treat acetabular dysplasia in patients aged ≥ 35 years, before the onset of femoroacetabular osteoarthritis, with satisfactory clinical and functional outcomes.

Key Words:
Acetabular dysplasia, Femoroacetabular osteoarthritis, Periacetabular osteotomy, Total hip arthroplasty.

Introduction

Developmental dysplasia of the hip (DDH) is a leading cause of hip osteoarthritis[1,2]. Corrective osteotomies, commonly known as hip-preserving surgeries, are preferentially performed to prevent the development of secondary osteoarthritis[3]. Although total hip arthroplasty (THA) is a well-established surgical treatment for patients with secondary osteoarthritis, corrective osteotomies for DDH prior to the development of secondary osteoarthritis have been practiced more commonly over the last 40 years[4].

Several periacetabular osteotomy (PAO) techniques have been described for the treatment of DDH[5,6]. Among these, the first technique to be described was Bernese's PAO, developed in 1983. It is one of the most performed hip-preserving surgeries for DDH[7]. Various studies in the literature have reported long-term pain relief, improvement in hip function, and long-term survivability without THA after PAO[3,8-11].

Patient age is an important determinant of the success of DDH treatment. Older age at the time of surgery and high preoperative osteoarthritis grade have been associated with poor outcomes or failure of the PAO techniques (commonly performed in adolescents and young adults)[3,9]. According to Matheney et al[9], age > 35 years is an independent predictor of PAO failure. However, Beaulé et al[12] found that age was not associated with worse patient-reported outcomes after PAO. Moreover, Yasunaga et al[13] demonstrated that PAO in elderly patients can prevent the progression of osteoarthritis; they reported 70% hip survivorship 10 years after the procedure. Furthermore, in selected patients, PAO is worth considering, at least as a temporizing operation[14].

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Although age is an important parameter for the success of PAO in the treatment of DDH, its effect on clinical and radiological results is unknown, and the use of periacetabular osteotomy in the treatment of middle-aged patients is controversial. This study aimed to determine the effectiveness of PAO in DDH patients ≥35 years and to compare patient-reported outcomes and radiological findings with the outcomes in a control cohort of younger patients (< 35 years). We hypothesized that the results would be more satisfactory in the group of patients aged < 35 years.

Materials and Methods

Study Design

This retrospective study was conducted in accordance with the ethical standards of the SBU Haseki Training and Research Hospital Clinical Research Ethics Committee and the 1975 Declaration of Helsinki revised in 2013. Ethics Committee Approval was obtained (Decision No. 2020-217). This was a single-center retrospective comparative study involving 43 patients who underwent unilateral Bernese PAO for symptomatic hip dysplasia, between May 2001 and August 2015. The main indication for the PAO was symptomatic hip dysplasia with severe hip pain (affecting daily activities) and dysfunction of hip joint motion in all patients. The inclusion criteria were as follows: (1) age between 18 and 45 years at the time of surgery; (2) radiologically diagnosed hip dysplasia (i.e., center-edge angle < 25°); (3) osteoarthritis degree ≤ 2 according to the Tönnis grading system; and (4) the availability of complete follow-up data for a follow-up time of at least 6 years. Patients with a history of ipsilateral pelvic osteotomy, Legg-Calvé-Perthes disease, slipped capital femoral epiphysis, and acetabular retroversion that affected the femoroacetabular alignment were excluded from the study. The patients were classified into the following two groups according to their age at the time of surgery: Group 1 included patients who were < 35 years, and Group 2 included patients who were ≥ 35 years (Figure 1).

Surgical Technique

First-generation cephalosporins were used for antibiotic prophylaxis in all the patients. All the surgical procedures were performed under general anesthesia, in the supine position, on

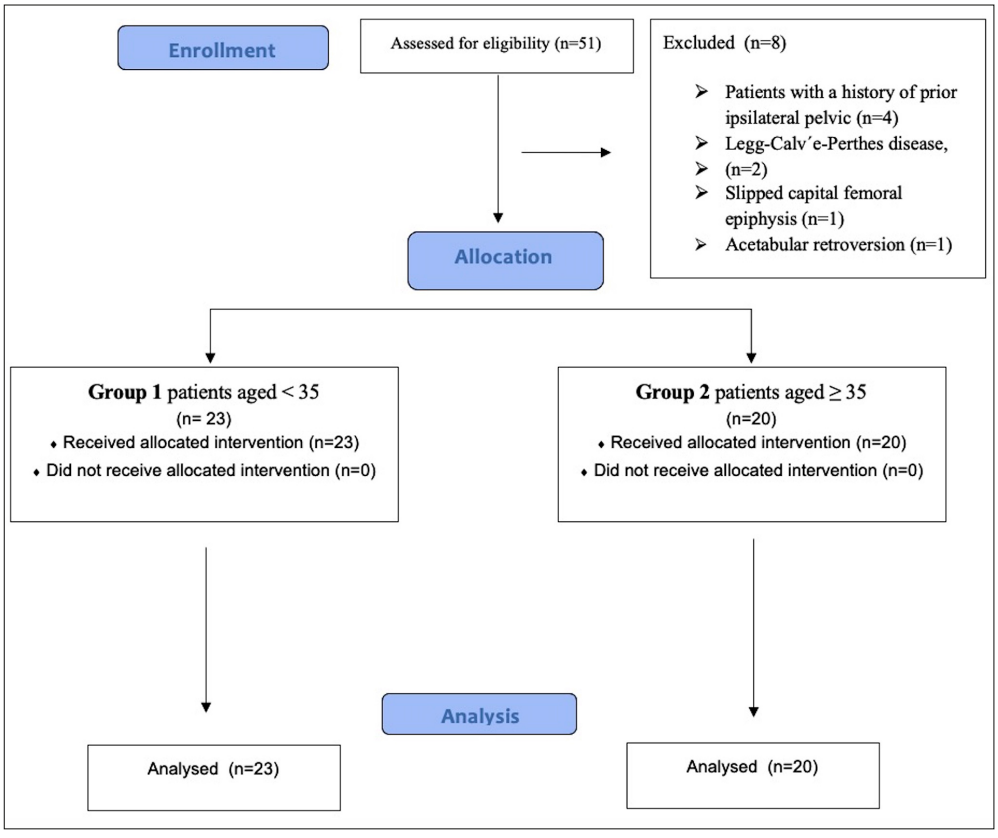

Figure 1. Flowchart of the study populations.

a radiolucent table by a senior surgeon using a modified Smith-Petersen surgical approach. Four periacetabular osteotomies including pubic bone osteotomy, ischial bone osteotomy, posterior iliac bone osteotomy, and osteotomy of the posterior column of the acetabulum were performed under fluoroscopic control, as described by Ganz et al[7]. After the osteotomy, the acetabular fragment was repositioned in a satisfactory position, and the osteotomy block was clamped with forceps and fixed with two or three 4.5mm cortical screws under fluoroscopic control. A single-suction drain was inserted in all the patients and removed on the second postoperative day. Transfusion was performed and recorded in patients with low hemoglobin levels (≤ 9 g/dL) or with clinical symptoms of decompensated anemia or acute blood loss (as evidenced by tachycardia, hypotension, profuse sweating, etc.). All the patients were administered low-molecular-weight heparin at a dose of 4000 IU (0.4 mL)/day subcutaneously, for a period of 4 weeks postoperatively (starting 12 hours after the operation), for the prevention of venous thromboembolic events. The rehabilitation recovery protocol was the same for all the patients. The patients were mobilized 24 hours postoperatively, and partial weight bearing with the use of two crutches was permitted. The weight-bearing capacity was gradually increased after eight weeks. Within 3 months postoperatively, full body weight-bearing was allowed. Control clinical and radiographic examinations were performed after 4 weeks, 8 weeks, and 6 months postoperatively, and annually.

Radiological Evaluation

Routine radiographic evaluations, both preoperatively and at the latest follow-up appointment, were performed by independent observers on standard anterior-posterior (AP) pelvic radiographs and computed tomography of the pelvis. To describe the morphological features of the dysplastic hip joint, 11 standard radiographic parameters were measured. These parameters included the lateral center-edge angle (LCEA), Tönnis angle, Sharp angle, extrusion index, Tönnis osteoarthritis grade, Shenton line, crossover sign, posterior wall sign, anterior femoral head coverage, posterior femoral head coverage, and craniocaudal femoral head coverage (Figure 2). The last follow-op post-

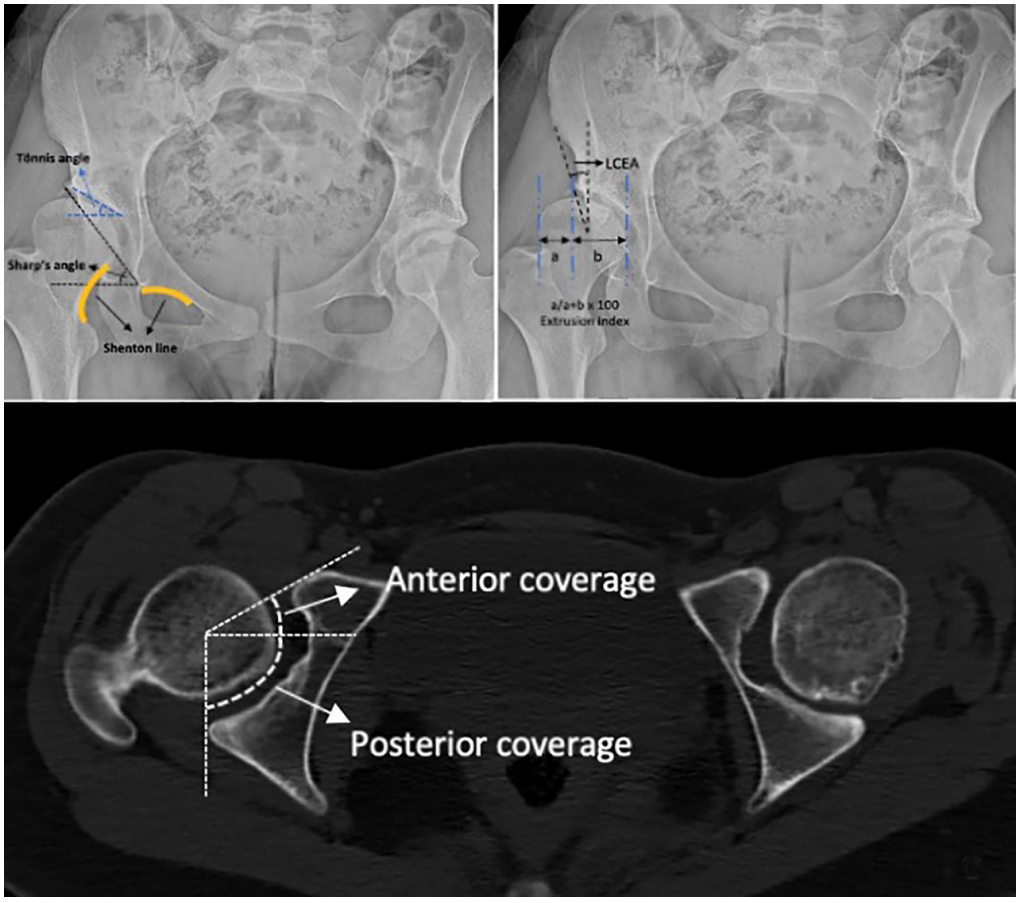

Figure 2. Demonstration of the radiological measurement methods on the AP radiographic view and on computed tomography view of the pelvis.

operative values of these parameters were compared with the preoperative values.

Clinical Evaluation

The preoperative Harris Hip Score (HHS) and visual analogue scale (VAS) scores were collected from patient files. Hip range of motion (including flexion, extension, internal and external rotation, and adduction and abduction), postoperative HHS, postoperative VAS score, and postoperative Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) scores were measured by an independent observer during the patients' last clinical visits. In addition, all postoperative complications were documented.

Statistical Analysis

Statistical analyses were performed using the software Statistical Packages for the Social Sciences (SPSS version 20.0; IBM Corp., Armonk, NY, USA). Descriptive statistics are expressed as means, medians, standard deviations, ranges, and percentages. Data were tested for normality using the Kolmogorov-Smirnov test. Comparisons between groups were performed using an independent sample *t*-test for quantitative variables. A paired *t*-test was performed to compare the preoperative and postoperative quantitative variables that followed a normal distribution. Categorical variables were expressed as percentages (%), and Pearson's Chi-square test was used for preoperative and postoperative comparisons. A two-sided p-value < 0.05 was considered significant.

Results

We included 23 patients aged < 35 years and 20 patients aged ≥ 35 years. Among the 43 patients, 31 (72.1%) were women and 14 (27.9%) were men. The patients' mean age was 32.19 ± 8.4 (range: 19-45) years. PAO was performed on the right hip in 25 patients (58.1 %) and the left hip in 18 patients (41.9 %). The mean BMI of the patients was 25.97 ± 2.63 (range: 18.9-29.4) and the mean follow-up time was 7.53 ± 3.14 (6-15) years. There were no significant differences between the groups in terms of sex, surgical side, mean BMI, and mean follow-up time (Table I).

The radiographic parameters significantly changed before and after the PAO in both groups. In Group 1, the mean LCEA increased from 11.72° to 32.83° ($p < 0.001$), and in Group 2, it increased from 11.25° to 31.8° ($p < 0.001$). In Group 1, the mean Tönnis angle decreased from 22.39º to 8.7º ($p < 0.001$), the mean extrusion index decreased from 35.44% to 11.35% ($p < 0.001$), and the mean Sharp angle decreased from 47.78º to 34.52° ($p < 0.001$). In Group 2, the mean Tönnis angle decreased from 24.35° to 7.6° ($p < 0.001$), the mean extrusion index decreased from 42.38% to 10.52% ($p < 0.001$), and the mean Sharp angle decreased from 47.7° to 35.15° ($p < 0.001$). In Group 1, the Shenton line was broken in 15 (65.2%) hips preoperatively and 8 hips (34.8%) postoperatively ($p = 0.011$). In Group 2, the Shenton line was broken in 13 (65%) hips preoperatively and 7 hips (35%) postoperatively ($p = 0.032$).

In Group 1, compared to the preoperative osteoarthritis degree according to the Tönnis grading system, there was no progression of arthritis on radiographs taken at the latest clinical visit ($p = 0.071$). A similar finding was found in Group 2 ($p = 0.23$). In comparison to the preoperative radiographic values in both groups, we observed a decrease in the postoperative positive crossover sign and posterior wall sign ($p < 0.001$ for both values). In comparison with the preoperative radiographic values, we observed an increase in the

Table I. Comparison of demographic and clinical characteristics of the groups.

Variables	Group 1 (n = 23)	Group 2 (n = 20)	*p*-value
Mean age (years)	25.5 ± 5.12 (19-33)	39.9 ± 2.97 (35-45)	< **0.001***
Sex			0.281**
Female (%)	15 (65.2%)	16 (80%)	
Male (%)	8 (34.8%)	4 (20%)	
Side			0.395**
Left	11 (47.8%)	7 (35%)	
Right	12 (52.2%)	13 (65%)	
BMI (kg/m²)	25.8 ± 2.69 (19.3-29.4)	26.2 ± 2.59 (18.9-29.1)	0.598*
Mean follow-up (years)	9.30 ± 3.67 (6-15)	10.20 ± 3.30 (6-15)	0.352*

*Independent samples *t*-test, **Pearson's Chi-Square test, Bold values indicate significance.

postoperative anterior, posterior, and craniocaudal coverage of the femoral head ($p < 0.001$ for all values).

There were no significant differences between the two groups regarding the preoperative and postoperative radiographic findings (Tables II and III), and the preoperative clinical outcomes (Table IV), except for the postoperative WOMAC physical function scores (Table V).

Discussion

After the PAO, both groups had the same HHS, VAS scores, WOMAC pain scores, and hip range of motion. The postoperative WOMAC physical function scores were significantly different between the two groups. When we evaluated the results of the study in light of the literature, the results were in concordance with the findings in the literature[13-16]. For example, our radiological results showed that the surgical technique was applied correctly, and adequate coverage of the femoral head was achieved in both patient groups[14-16].

The long-term functional and clinical outcomes of PAO have previously been investigated, and PAO has been shown to be a reliable procedure that helps in preventing secondary osteoarthritis[17]. Numerous studies have assessed the outcomes of PAO in middle-aged and older patients[13-16,18,19]. Franken et al[19] evaluated the results of PAO according to age groups and reported age as an important parameter to be considered when determining the indication of PAO; however, even in patients > 40 years, PAO achieves good functional results and patient satisfaction. They stated that the functional results depend on the morphological features of the hip joint and the degree of osteoarthritis. Conversely, Ito et al[16] evaluated periacetabular osteotomy results in two groups of patients (patients > and < 40 years) and found that PAO gave satisfactory results in Tönnis grade 0 and 1 hips; however, the results in the elderly group deteriorated after 5 years. They attributed this to a decrease in physical function due to ageing and an increase in susceptibility to osteoarthritis progression. In this study, PAO results were compared between a group of patients < 35 years and ≥ 35 years. Although there are similar studies in the literature, as Ito et al[16] stated, it is necessary to analyze the results in different ethnic groups to better understand the outcomes of PAO. In addition, as Trousdale et al[20] stated, the present study and similar studies evaluating the clinical outcomes of PAO are im-

Table II. Comparison of preoperative radiographic findings of the groups.

Variables	Group 1 (n = 23)	Group 2 (n = 20)	*p*-value
LCEA (º)	11.72º ± 8.7 (-6 to 25º)	11.25º ± 5.6 (-4 to 20º)	0.838*
Tönnis angle (º)	22.39º ± 5.06 (13 to 36º)	24.35º ± 7.22 (-5 to 15º)	0.304*
Extrusion index (%)	35.44 ± 11.62 (12.8-58.7)	42.38 ± 11.39 (25.4-65)	0.506*
Sharp Angle (º)	47.78º ± 3.63 (42-55)	47.7º ± 3.83 (42-54)	0.942*
Shenton line			0.988**
Continuous (%)	8 (34.8%)	7 (35%)	
Discontinuous (%)	15 (65.2%)	13 (65%)	
Tönnis Grade			0.817**
Grade 0	13 (56.5%)	10 (50%)	
Grade 1	6 (26.1%)	7 (35%)	
Grade 2	4 (17.4%)	3 (15%)	
Grade 3	-	-	
Crossover sign			0.053**
Negative	17 (73.9%)	9 (45%)	
Positive	6 (26.1%)	11 (55%)	
Posterior wall sign			0.889**
Negative	5 (21.7%)	4 (20%)	
Positive	18 (78.3%)	16 (80%)	
Anterior coverage (%)	15.65 ± 4.58 (8-27)	14.1 ± 6.9 (5-30)	0.385*
Posterior coverage (%)	35.39 ± 11.3 (12-65)	31.55 ± 11.94 (10-56)	0.285*
Craniocaudal coverage (%)	61.87 ± 10.7 (45-80)	58.75 ± 13.66 (35-85)	0.406*

Table III. Comparison of postoperative radiolographic findings of the groups.

Variables	Group 1 (n = 23)	Group 2 (n = 20)	*p*-value
LCEA (º)	32.83º ± 7.21 (15 to 46º)	31.8º ± 4.87 (25 to 46º)	0.593*
Tönnis angle (º)	8.7º ± 3.93 (-5 to 15º)	7.6º ± 5.34 (-5 to 15º)	0.434*
Extrusion index (%)	11.35 ± 5.5 (2.5-24.5)	10.52 ± 2.45 (6.4-16.8)	0.536*
Sharp Angle (º)	34.52º ± 1.83 (32-38)	35.15º ± 2.25 (31-39)	0.319*
Shenton line			0.739**
Continuous (%)	15 (65.2%)	14 (70%)	
Discontinuous (%)	8 (34.8%)	6 (30%)	
Tönnis Grade			
Grade 0	16 (69.6%)	10 (50%)	0.128**
Grade 1	3 (13%)	7 (35%)	
Grade 2	3 (13%)	2 (10%)	
Grade 3	1 (4.3%)	1 (5%)	
Crossover sign			0.541**
Negative	19 (82.6%)	15 (75%)	
Positive	4 (17.4%)	5 (25%)	
Posterior wall sign			0.954**
Negative	9 (39.1%)	8 (40%)	
Positive	14 (60.9%)	12 (60%)	
Anterior coverage (%)	19.26 ± 8.43 (12-48)	16.9 ± 5.96 (9-31)	0.302*
Posterior coverage (%)	43.26 ± 14.48 (20-75)	37.55 ± 8.42 (23-50)	0.129*
Craniocaudal coverage (%)	80.22 ± 7.15 (70-100)	76.25 ± 7.41 (60-90)	0.082*

*Independent samples *t*-test, **Pearson's Chi-Square test.

portant (to better the understanding of the results of PAO) since the learning curve of PAO is long, and good results depend on surgical experience.

THA is described as "the operation of the 20th century" because of its excellent functional and clinical results and high long-term survival rate[21]. THA is frequently preferred for the treatment of hip osteoarthritis in young patients. Many studies have compared the results of THA and PAO[22-24]. The incidence of postoperative complications and revision surgery did not differ between THA and PAO patients in a sys-

Table IV. Comparison of preoperative clinical outcomes of the groups.

Variables	Group 1 (n = 23)	Group 2 (n = 20)	*p*-value
VAS score	6.48 ± 0.99 (5-8)	6.85 ± 1.14 (5-9)	0.259*
HHS (points)	59.48 ± 11 (46-80)	64.4 ± 10 (46-74)	0.136*
Grade of HHS			0.052**
Poor (< 70 points)	16 (69.6%)	8 (60%)	
Fair (70-79 points)	7 (21.7%)	12 (40%)	
Good (80-89 points)	-	-	
Excellent (90-100 points)	-	-	
Range of motion			
Flexion	116.1 ± 11.8 (90-140)	115.8 ± 9.9 (95-130)	0.92*
Extension	3.04 ± 10.74 (-10-20)	4 ± 10.71 (-20-20)	0.772*
Abduction	37.4 ± 9.87 (20-55)	35 ± 9.03 (20-60)	0.415*
Adduction	24.57 ± 8.51 (10-40)	28.5 ± 7.63 (15-40)	0.12*
Internal rotation	37.4 ± 8.38 (20-55)	33 ± 10.9 (10-50)	0.144*
External rotation	38.26 ± 13.53 (5-60)	38.5 ± 13.38 (5-60)	0.954*

*Independent samples *t* test, **Pearson's Chi-Square test.

Table V. Comparison of preoperative clinical outcomes of the groups.

Variables	Group 1 (n = 23)	Group 2 (n = 20)	*p*-value
VAS score	1.52 ± 0.79 (0-3)	1.35 ± 1.08 (0-4)	0.554*
HHS (points)	85.96 ± 7.71 (70-96)	82.05 ± 5.85 (70-93)	0.072*
WOMAC functional score	91.09 ± 3.68 (85-95)	87.5 ± 5 (80-95)	0.01*
WOMAC pain score	89.57 ± 3.66 (85-95)	87.75 ± 2.55 (85-90)	0.071*
Grade of HHS			0.296**
Poor (< 70 points)	1 (4.3%)	1 (5%)	
Fair (70-79 points)	4 (17.4%)	5 (25%)	
Good (80-89 points)	10 (43.5%)	12 (60%)	
Excellent (90-100 points)	8 (34.8%)	2 (10%)	
Range of motion			
Flexion	102.8 ± 11.4 (80-125)	105.8 ± 12.6 (80-130)	0.428*
Extension	3.48 ± 4.1 (0-15)	2.75 ± 3.43 (0-10)	0.535*
Abduction	32.39 ± 8.77 (20-50)	32.5 ± 9.8 (20-60)	0.97*
Adduction	24.78 ± 7.15 (10-40)	26.25 ± 6.46 (15-40)	0.487*
Internal rotation	33.7 ± 7.26 (20-50)	30.5 ± 11.46 (5-45)	0.275*
External rotation	36.3 ± 10.4 (15-60)	37.3 ± 12.9 (10-65)	0.791*

*Independent samples *t* test, **Pearson's Chi-Square test, Bold values indicate significance.

tematic review by Kim et al[25]. In the follow-ups, however, THA patients had less postoperative discomfort and PAO patients had a higher activity score. Although THA and PAO are not alternatives to each other, satisfactory results can be obtained in suitable patients for both surgical treatments. Moreover, although the results of this study support the literature, it has been shown that PAO applied before the development of osteoarthritis provides good functional and clinical results in patients with acetabular dysplasia (without necessarily performing THA).

Limitations

The most important limitations of our study were the small sample size and its retrospective nature. In addition, the lack of preoperative WOMAC scores and MRI evaluations of the labrum were other limitations of the study. The long follow-up period and the fact that both groups had similar demographic and clinical features (apart from age) were the most important strengths of our study.

Conclusions

PAO can be safely applied for the treatment of acetabular dysplasia, before the development of femoroacetabular osteoarthritis in patients aged ≥ 35 years, with satisfactory clinical and functional results.

Conflict of Interest

None of the authors received any type of financial support that could be considered potential conflict of interest regarding the manuscript or its submission.

Ethics Approval

This retrospective study was conducted in accordance with the ethical standards of the SBU Haseki Training and Research Hospital Clinical Research Ethics Committee and the 1975 Declaration of Helsinki revised in 2013. Ethics Committee Approval was obtained (Decision No. 2020-217).

Informed Consent

All patients included in this study signed an informed consent form.

Authors' Contribution

M. Yilmaz: Conception and designing, drafting the article. M. Aydin: Data collection, analysis, and interpretation of data. S. Capkin: Preparing the article; critically reviewing the article for important intellectual content.

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