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What level of pain reduction can be expected up to two years after periacetabular osteotomy? A prospective cohort study of 146 patients

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ABSTRACT

Periacetabular osteotomy (PAO) corrects underlying anatomical anomalies, reduces pain and may postpone or even prevent osteoarthritis onset in patients with symptomatic acetabular dysplasia. Current evidence is based on immediate post-operative pain levels, but knowledge on pain levels in the period after PAO is scarce, and the association between pain score and acetabular angles at PAO is unknown. This study had two aims. First, we studied pain level and patient-reported outcome scores pre- and postoperatively; second, we analysed the association between acetabular angles and pain level. From our database, 426 patients operated from June 2012 to November 2015 were analysed; 127 were excluded. Patients were invited to complete standardized questionnaires preoperatively and postoperatively at 6 and 24 months. Pain was measured using visual analogue scale (VAS). Multiple regression analysis was used to investigate the association between change in centre edge (CE) and acetabular index (AI) angle and pre/postoperative pain levels. Mean (standard deviation, SD) VAS pain at rest before surgery and at the 6- and 24-month follow-up were 35 (24), 14 (20) and 14 (19), respectively. Mean (SD) VAS pain at activity were 69 (22), 41 (29) and 41 (30), respectively. Both VAS pain at rest and at activity fell from the preoperative level to 6 months post-surgery with no further change at 24 months. Patients reported significant improvement in outcomes after 6 months and no further change at the 24-month follow-up. There was no significant association between change in CE/AI angles and VAS pain, either during rest or activity.

INTRODUCTION

Radiologically verified acetabular dysplasia is present in 3–10% of the Danish population, and many of these cases of dysplasia become symptomatic [1]. Untreated, the disease eventually lead to secondary osteoarthritis due to overload and mechanical destruction of the labrum and articular cartilage [2–4]. While arthroscopic treatment addresses labral and chondral lesions, correction of the osseous abnormality is recommended to prevent further degradation. In 1988, Ganz *et al.* described the first periacetabular osteotomy (PAO) for treatment of symptomatic acetabular dysplasia [5]. The procedure aims to increase the coverage of the femoral head and reduce cartilage stress by reorienting the acetabulum. Studies show that the change in biomechanics resulting from reorienting the acetabulum may delay secondary osteoarthritis onset [6].

The open surgical technique is technically demanding and invasive. Radiological and clinical outcomes have been proven excellent [7–9], but only few studies have described patient-reported outcomes. Four studies have compared preoperative and postoperative values, and they all showed significant improvement in postoperative pain and activity levels [10–13]. To our knowledge, only a single study has mapped postoperative pain levels repeatedly over time, and this study reported significantly lower pain 1 year after surgery and an increased level of physical activity [14].

Hip dysplasia is defined as centre edge angle of Wiberg (CE) modified according to Ogata < 25 degrees measured by AP x-ray of the pelvis [15]. The perioperative reorientation of the acetabulum should be aimed at CE > 30 and below <40, but knowledge of how pain is influenced by these changes is scarce [9]. A previous study found no associations between acetabular angles measured postoperatively and quality of life [16].

The aim of this study was to examine pain and patient-reported outcome scores preoperatively and at 6 and 24 months after PAO. Furthermore, we investigated the association between degree of anatomical correction by acetabular angles and pre- and postoperative pain levels.

MATERIALS AND METHODS

Study design

Patient data was registered prospectively in an online database at the Department of Orthopaedics, Aarhus University Hospital, Denmark. A standardized questionnaire was mailed to patients who underwent surgery in the period starting June 2012 to November 2015. Patients received a questionnaire preoperatively and 6 and 24 months after the operation. Inclusion criteria were symptomatic acetabular dysplasia of the hip defined by persistent pain of the groin, CE angle < 25 degrees [17], a congruent hip joint, flexion of the hip > 110 and internal rotation > 15. Exclusion criteria were age > 45 years, Tönnis degree of osteoarthritis > 1 and body mass index (BMI) > 30. Patients with bilaterally performed PAO only entered once, and the first operated hip was included in this study, to avoid the same patient appearing twice. If both hips were operated at the same time, only the right hip was included in the study.

Study cohort

A total of 534 hips were operated in the 3-year period. Seventy-four patients had bilateral operation performed and were included only once. Thirty-four patients lived outside Denmark and were thus lost to follow-up. Out of 426 patients, 33 were above 45 years of age, and six were diagnosed with Calve Legg Perthes disease. Sixty-seven patients had answered only one or none of the questionnaires, one was re-operated and one had a previous femoral neck fracture, 10 chose not to participate due to personal reasons and nine had incomplete data. Thus, a total of 299 patients were included in the statistical analysis. Of these 146 was included for radiographic analysis. The inclusion and exclusion procedures are presented in Fig. 1.

Surgical procedure

All procedures were performed by a single surgeon (KS). A minimally invasive transsartorial approach was used involving a 7 cm incision followed by periosteal mobilization of soft tissue. The inguinal ligament was cut and the sartorius muscle was split using a periosteal elevator. The iliopsoas and medial part of sartorius was retracted and osteotomies were performed as described in details by Troelsen *et al.* [18]. During the operation, fluoroscopic evaluation was used. After reorientation of the acetabulum, the osteotomy was fixed with 2–3 cortical screws [19].

Outcome measures

We used three patient-reported questionnaires to obtain a range of demographic data; some of the questions were not validated. The Short Form 36 (SF-36) and the EuroQoL five dimension (EQ-5D) are general health assessment tools that can be applied to a variety of diseases, while the Hip Disability and Osteoarthritis Outcome Score (HOOS) is a hip-specific questionnaire. All of the questionnaires have shown high responsiveness and validity for patients undergoing THA [20–22].

Radiological measurements

We included only patients who had answered preoperative and 24-month questionnaires. Patients who had either insufficient or missing information were excluded. A total of six radiological parameters were measured: Wiberg CE angle modified according to Ogata, acetabular index (AI) angle, posterior wall sign, degree of osteoarthritis according to Tönnis' classification, ischial spine sign and crossover sign. All measurements were performed by one rater (SR) who had been under the supervision and training of an experienced orthopaedic PAO surgeon (KS).

Statistical analysis

VAS scores were analysed as combined scores and as separate groups of CE angle ≥ 20, CE angle < 20. The pain scores were presented as parametric and presented as mean and SD.

Radiographic data and data on pain were analysed using Spearman's rank correlation coefficient to test whether the data followed a monotonic function. When testing the association between change in acetabular angles and pain, a very large number of patients scored zero in postoperative pain. Therefore, a two-part model suggested by Duan *et al.* was used [23]; in the first part, a logistic regression allowing for the between-patient variance was used to model the odds of reporting zero scores. In the second part, given the probability of zeros, a mixed model was used on the log-scale of the positive data. All assumptions were met and normality was checked using histograms and QQ plots.

All analyses were made using STATA software v. 13.0 (StataCorp, College Station, TX, USA).

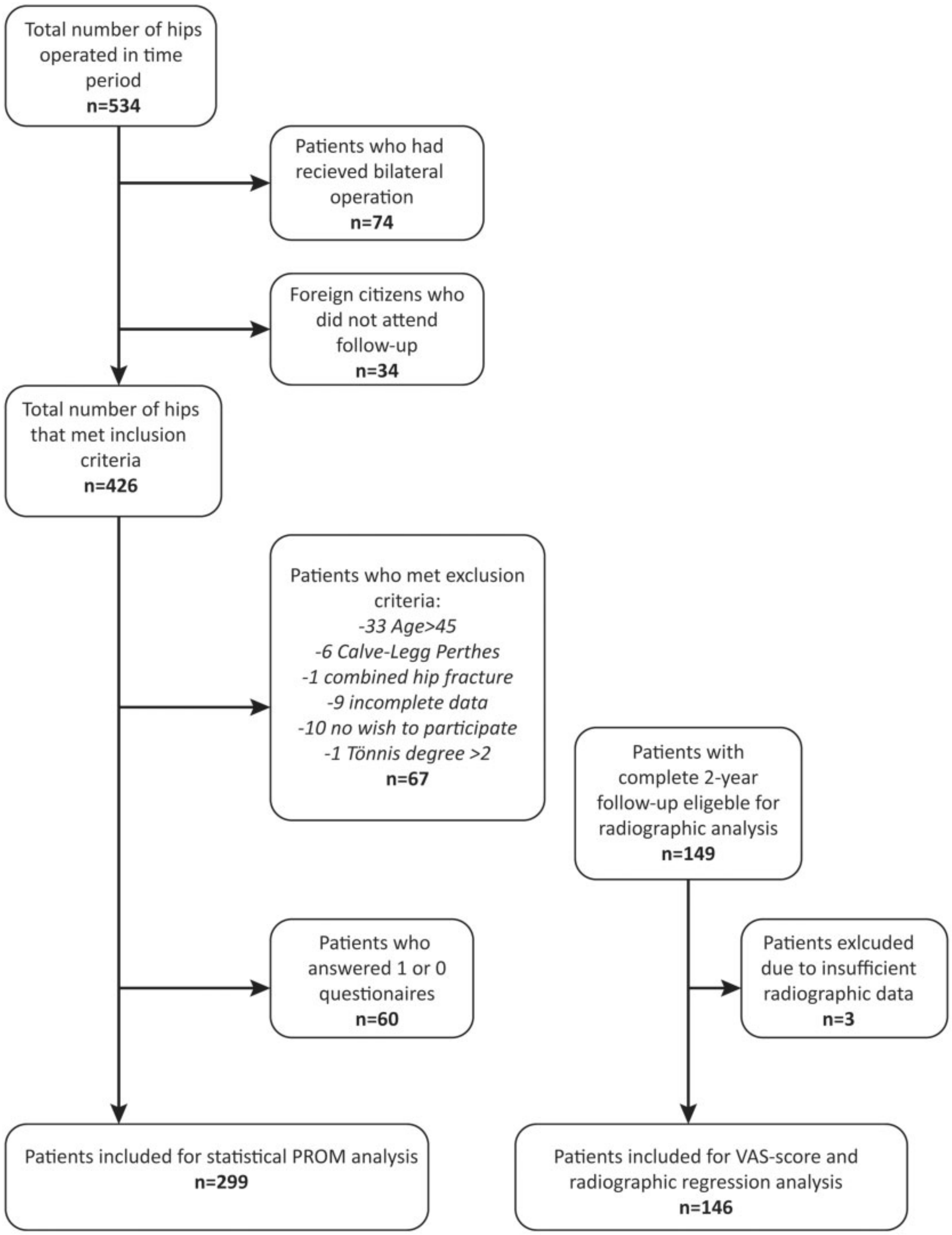

Fig. 1. Flow diagram of inclusion/exclusion criteria.

RESULTS

Demographic data

The patients' mean age at the time of operation was 29.6; the average follow-up was 2.3 years (Table I); 88% were females, 12% males. Median preoperative BMI was 22.9, and median educational level (International Standard Classification of Education 1997) was 4.

Table I. Demographic and radiographic data at pre- and postoperative levels

Parameter	*Preoperative value*	*Postoperative value*
Demographic data ($n = 299$):		
Male	38 (12)*	–
Female	261 (88)*	–
Age	31.9 (9.2)#	–
Age at operation	29.6 (9.2)#	–
Follow-up time	2.3 (1.0)#	–
BMI	22.9 (20.8–24.8)§	–
Bilateral operation	74 (24)*	–
Educational level (ISCED97)	4 (2–5)§	–
Radiographic data ($n = 147$):		
CE angle	18.6 (6.2)#	29.7 (5.8)#
AI angle	12.9 (5.6)#	2.5 (5.8)#
Change in AI angle	–	10.4 (5.4)#
Change in CE angle	–	11.5 (5.9)#
Ischial spine sign	0 (0)*	0 (0)*
Posterior wall sign	21 (14)*	20 (14)*
Positive crossover sign	8 (5)*	5 (3)*
Tönnis degree of osteoarthritis	0 (0–0)§	0 (0–0)§

Note: *, number (%); #, mean (SD), §, median (interquartile ranges).

VAS scores

A total of 131 patients had a complete follow-up for all three measuring points. The patients were divided into three groups: CE angle ≥20, CE < 20 and combined. Results are presented in Table II. Within all groups, VAS score at rest and during activity decreased when preoperative pain levels were compared with pain levels at 6 months, while no further change happened up to 24 months.

Patient-reported outcome measures

The patient-reported outcome scores presented in Table III all showed significant improvement from preoperative values to the 6-month follow-up ($P < 0.000$). Out of 16 sub-scores, two showed a significant change from 6 to 24 months of follow-up; SF-36, Physical Function ($P = 0.049$) and SF-36, Role Physical ($P = 0.017$).

Association between acetabular angles and pain

A total of 146 patients were included in the regression analysis. No significant associations were found between either preoperative or postoperative AI and CE angles and pain levels at rest and at activity (Table IV).

The two-part model was adjusted for sex, and no association was found between the change in AI and CE angles and the change in VAS scores at rest or at activity (Table IV).

DISCUSSION

The aim of this study was to examine pain levels and patient-reported outcome measures (HOOS, SF-36, EQ-5D) following PAO surgery. We also examined the association between the degree of anatomical correction measured by acetabular angles and self-assessed pain levels.

Patients reported a significant reduction in pain at rest (VAS 21) and during activity (VAS 29) and at both CE angle > 20 and CE angle < 20 already 6 months after surgery. No further pain reduction was found at 24 months after surgery.

Other patient-reported outcome scores followed the same pattern with HOOS, SF-36 and EQ5D reaching a steady state at 6 months ($P < 0.001$), with only a tendency toward additional improvement up to 24 months after surgery. Only two sub-scores within SF-36 showed slight improvement from 6 to 24 months*, but the difference is not of clinical importance.

To our knowledge, this is the largest prospective cohort study describing patient-reported functional outcome scores after PAO surgery, and the results are in line with those of previous studies, serving as a promising foundation for treatment of future patients with hip dysplasia.

It is important to note that the patient-reported questionnaires address patients' subjective experiences regarding pain and activity. HOOS was the only hip-specific questionnaire used. It was originally designed for patients with osteoarthritis undergoing total hip arthroplasty, but our patient group is younger and has a higher level of physical activity, which may result in ceiling effects. As for further limitations, this is a cohort study with no control group for comparison. We had no baseline data on hip pain levels in the Danish population and no knowledge of acetabular hip dysplasia patients who chose not to undergo operation. Finally, our results show merely short-term outcomes, and whether patients might experience increased

Table II. Mean pain level at rest preoperatively and at 6 and 24 months in groups CE ≥ 20, CE < 20 and combined

Pain level in groups at different time points:	*VAS at rest*			*VAS during activity*		
	Mean pain (SD)	N	*Min, Max*	*Mean pain (SD)*	N	*Min, Max*
CE ≥ 20:						
Preoperative	34.92 (25.13)	64	0; 94	70.72 (21.90)	64	14; 100
6 months	14.58 (19.20)	62	0; 87	40.97 (27.60)	62	2; 97
24 months	14.67 (18.94)	61	0; 93	40.05 (29.25)	61	0: 100
CE < 20:						
Preoperative	35.55 (23.11)	82	0; 94	68.83 (22.49)	82	6; 100
6 months	13.38 (19.12)	79	0; 84	40.67 (30.07)	79	0; 100
24 months	13.44 (19.12)	78	0; 85	41.10 (29.24)	78	0; 100
Combined:						
Preoperative	35.27 (23.94)	146	0; 94	69.66 (22.17)	146	6; 100
6 months	13.90 (19.03)	141	0; 87	40.80 (28.91)	141	0; 100
24 months	13.97 (19.02)	139	0; 93	40.64 (29.48)	139	0; 100

pain and decreased functional outcome level in longer term is a question for future studies.

VAS and outcome measures observed in the present study are comparable with those used in a previous study of acetabular dysplasia defined as CE angle <25 degrees and treated with hip arthroscopy [24]. This group also experienced an approximately 50% reduction in VAS pain. Other PAO studies have shown lasting hip survivorship following PAO surgery. The present study adds to these findings evidence of early pain relief.

The CE cut-off limit for determining radiologically verified hip dysplasia has been debated. We analysed pain levels in patients at CE angles ≥20 and <20. In both groups, we found a significant reduction in pain at rest and during activity already 6 months after surgery. No further reduction was found 24 months after surgery.

Two studies have investigated changes in patient-reported outcomes after PAO in a prospective setting. Novais *et al.* addressed 51 patients preoperatively and 1 year and 2 years after surgery, showing that a significant decrease in the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) pain subscore and an increase in the University of California, Los Angeles (UCLA) activity scale 1 year after operation were maintained for a minimum of 2 years [14]. Van BerGayk *et al.* included 22 patients, reporting significant improvement in pain and function 24 months after PAO within both the WOMAC and the SF-36 scores, although not in the SF-36 mental component score[12]. Several studies with a retrospective design all showed a significant drop in pain and an increase in the activity component of their patient-reported outcomes [10, 13].

We found no significant association between preoperative AI and CE angles and preoperative pain level, change in AI and CE angles and change in pain level, and between postoperative AI and CE angles and postoperative pain level. We show that the surgeon cannot expect patients with only a minor degree of hip dysplasia to have only a low level of pain. This is crucial information in the outpatient clinic when considering offering patients to undergo surgery. Our study shows that even a small degree of dysplasia can cause a high level of pain. Also, the change in the AI and CE angles was not related to the change in pain. This knowledge may inform the surgeon's decision concerning of magnitude of the correction required to still the patient's pain. Our findings support recent studies that the acetabular labrum plays a key role in the pain aetiology of the hip [4]. The lack of correlation between radiographic hip parameters and pain level is also observed with hip osteoarthritis where no association between the degree of hip osteoarthritis and degree of pain was found [25].

Table III. Outcome measure preoperatively and at 6 and 24 months of follow-up

Parameter	*Preoperative* (n = 285) *Mean (SD)*	*6-month follow-up* (n = 279) *Mean (SD)*	*24-month follow-up* (n = 142) *Mean (SD)*
HOOS			
Symptom	53 (20.2)*	73 (19.2)	73 (19.8)
Pain	55 (18.6)*	79 (17.0)	79 (17.3)
ADL	65 (19.9)*	85 (15.5)	86 (15.5)
SportRec	44 (24.1)*	69 (23.3)	71 (23.4)
QOL	34 (16.4)*	58 (22.8)	59 (22.4)
EQ-5D			
EQ-5D index	0.75 (0.06)*	0.82 (0.10)	0.84 (0.10)
SF36			
PF	60 (19.8)*	76 (19.2)**	78 (17.9)
RP	32(35.2)*	59 (40.3)**	66 (40.6)
BP	40 (19.8)*	64 (24.5)	66 (22.6)
GH	66 (20.7)*	74 (21.0)	73 (20.2)
VT	49 (22.4)*	64 (22.1)	65 (22.3)
SF	78 (25.0)*	88 (20.1)	90 (16.2)
RE	66 (40.6)*	83 (33.3)	87 (28.6)
MH	70 (18.8)*	80 (16.5)	81 (16.1)
Physical component	36 (8.7)*	44 (9.6)	45 (9.9)
Mental component	50 (11.5)*	55 (9.0)	55 (8.3)

Note: *Paired *t*-test: significant difference between preoperative and both 6- and 24-month follow-up.
**Significant difference between 6- and 24-month follow-up.

One study has previously compared postoperative SF-36 sub-scores on AI and CE angles with pain in a cross-sectional setting [16]. The results of this study showed no association in regards of physical functioning. Our study supports these findings. Two studies found that a postoperative CE angle <30 and >40 predicts conversion to total hip arthroplasty in long-term follow-up [9, 26], while another study showed that a postoperative AI angle outside the range of 0–10 predicted negative outcome [27]. Although our study shows no association between AI and CE angles and pain, it is still important to consider the angles to prevent a negative outcome. Our study had a mean follow-up of only 2.3 years, and none of our patients converted to total hip arthroplasty in this period.

CONCLUSION

This prospective study included 299 patients undergoing PAO for treatment of hip dysplasia. Patients can expect an approximately 50% reduction in pain level at rest (VAS 21) and at activity (VAS 29) 6 months after the operation. HOOS, EQ-5D and SF-36 all showed statistically significant improvements in terms of pain, QoL and activity 6 months after operation.

The association between the AI and CE angles and the pain level was investigated in 146 patients; no statistically significant associations were found. Our study suggests that patients with high levels of pain do not necessarily have a large anatomical deformity before surgery; moreover, the extent of the correction of the AI and CE angles

Table IV. Association between acetabular angles measured by CE angle of Wiberg and AI angle and pain levels measured by VAS (n = 146)

Parameter	VAS rest		VAS activity	
	Coefficient	*P-value*	*Coefficient*	*P-value*
Preoperative CE/AI compared with preoperative VAS score				
AI angle	rs = 0.04	$P = 0.60$	rs = −0.09	$P = 0.48$
CE angle	rs = 0.02	$P = 0.79$	rs = 0.15	$P = 0.07$
Postoperative CE/AI compared with postoperative VAS score				
AI angle	rs = 0.07	$P = 0.40$	rs = 0.01	$P = 0.86$
CE angle	rs = −0.07	$P = 0.41$	rs = 0.03	$P = 0.72$
Change in CE/AI compared with change in VAS score				
AI angle	$\beta = 1.02$	$P = 0.54$	$\beta =$ -0.92	$P = 0.26$
CE angle	$\beta = 1.03$	$P = 0.94$	$\beta = 0.90$	$P = 0.26$

Note: *rs, Spearman correlation coefficient; **β, two-part model; logistic regression coefficient.

during surgery does not correlate with the level to which pain is reduced.

This study offers crucial information for understanding pain associated with hip dysplasia and strengthens existing evidence that PAO is a valid treatment for reducing pain and increasing function in young patients. This information may be important to patients facing a large-scale operation at early age.

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CONFLICT OF INTEREST STATEMENT

None declared.

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