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ORIGINAL PAPER

Complications and patient satisfaction after periacetabular pelvic osteotomy

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Abstract Periacetabular osteotomy (PAO) is a well established method to treat hip dysplasia in the adult. There is, however, a lack of information on the subjective outcome of patients with complications after PAO. The purpose of this study was therefore to assess the influence of complications on the patients' post-operative wellbeing and function: 60 PAOs on 50 patients were investigated retrospectively after a mean follow-up of 7.4 years. The patients' self-reported assessment of health and function was evaluated by the Medical Outcomes Short Form-36 (SF-36) and the Western Ontario and McMaster Universities (WOMAC) questionnaires at last follow-up. Forty healthy persons served as a control group. Of the 60 interventions 13 had no complications. Minor complications occurred in 25 (41%) and in 22 (37%) at least one major complication occurred. SF-36 summary measure was 76.4 for PAO patients and 90.3 for the control group. Mean WOMAC score was 25.1. Patients with major complications had a similar subjective outcome as patients with minor or without complications, but persistent dysaesthesia due to lateral femoral cutaneous nerve dysfunction led to a worse subjective function. Lesions of the lateral femoral cutaneous nerve have much greater influence on patients' self-assessed functional outcome after PAO than previously reported and greater attention has to be given to this supposedly minor complication.

Résumé L'ostéotomie péri acétabulaire (PAO) est aujourd'hui une méthode de traitement de la dysplasie de la hanche chez l'adulte néanmoins un certain nombre d'études montre qu'il existe des complications post-opératoires. Le but de ce travail est d'évaluer ces complications et la fonction des patients. 60 PAO chez 50 patients ont été ainsi analysées de façon rétrospectives après un recul moyen de 7.4 ans. Une dernière évaluation clinique et fonctionnelle a été réalisée selon les questionnaires SF-36 et WOMAC, 40 personnes non opérées servant de groupe contrôle. Sur 60 interventions, 13 n'ont pas entraînée de complication. Des complications mineures sont survenues chez 25 patients (41%) et au moins une complication majeure chez 22 patients (37%). Le score de WOMAC a été mesuré en moyenne à 25.1. Les patients ayant présenté des complications majeures et ceux ayant présenté des complications mineures ont le même résultat subjectif et la même analyse de leur intervention avec une fonction qu'ils considèrent objectivement comme mauvaise, les lésions du nerf fémoro-cutanées ont donc une grande influence sur le devenir fonctionnel de ces patients, il est nécessaire de faire très attention à sa préservation pour éviter ce type de complications lors de l'ostéotomie péri acétabulaire.

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Introduction

Hip dysplasia in the adult is reportedly associated with a high rate of early osteoarthritis [13]. Hip arthroplasty provides excellent midterm results for patients with degenerative joint disease but, as a nonbiological solution, the results will deteriorate over time which for the younger patient, is a significant consideration [12]. The Bernese

periacetabular osteotomy (PAO) is presented as a joint-preserving procedure, facilitating an extensive acetabular reorientation leaving the posterior column intact, thus allowing minimal internal fixation and early mobilisation [4]. Literature therefore portrays the PAO as a favourable method for acetabular reorientation despite technical complexities and a significant surgical learning curve [6, 12, 15]. It has even been characterised as a "physiological" form of treatment for dysplastic hips [10]. There are however a number of severe and frequent minor complications that occur along with deterioration in the grade of osteoarthritis with time that influence the longer term result after PAO [4, 6, 8, 12, 18, 24]. In particular the lateral cutaneous nerve is prone to injury reportedly in up to one third of patients [6, 8, 15], but regarded as a minor problem and given only little attention by the surgeon.

Generic outcome measures offer the opportunity to determine treatment efficacy and compare different treatment options [7]. A significant improvement of self-assessed pain and function after PAO has been shown in a previous study [2]. But there is a lack of data on the subjective outcome of patients with complications after PAO and not a single study has investigated the influence of lateral cutaneous nerve dysfunction. The purpose of this study was therefore to assess the influence of complications and the relationship of the radiological outcome on the patients' post-operative wellbeing and function.

Patients and methods

All consecutive patients who had PAO performed at the first author's institution between October 1988 and March 1998 and a minimum follow-up of 2 years were viewed. The operation was performed by six different surgeons. There were 60 PAOs on 50 patients, 35 on the right and 25 on the left side; 36 patients were female and 14 were male. The mean age of the patients at the time of surgery was 27.3 years (12–44). Seventeen patients underwent concomitant intertrochanteric varus osteotomy. Mean follow-up was 7.4 years (2.1–12.5). All operations were via the classic Smith-Petersen approach. The indications and technique for the periacetabular osteotomy have been described previously [6].

The centre-edge (CE) angle according to Wiberg [25] and the inclination of the weight-bearing surface of the hip joint (WBS) or sourcil angle were measured on an anteroposterior (AP) radiograph of the pelvis preoperatively and on the most recent radiograph. Mean radiological follow-up was 5 years. The severity of hip osteoarthritis was graded according to the classification of Tönnis from grade 0 to 3 [23].

Complications were classified as minor or major. Minor complications included haematoma, delayed wound closure, dysaesthesia of lateral femoral cutaneous nerve, heterotopic ossifications (Brooker I and II), urinary tract infections and post-operative fever. Major complications included avascular necrosis of the femoral head or acetabulum, sciatic or femoral nerve palsy, major bleeding (administration of more than 5 blood units intra- and post-operatively), peroneal neurapraxia, fracture of posterior column, delayed or nonunion of pubic, ischial or iliac bone and heterotopic ossifications (Brooker III and IV). Radiographic evaluation and analysis of complications was performed by an independent observer who was not involved in surgery (GA).

The patients' self-reported assessment of health and function was evaluated by the Medical Outcomes Short Form-36 (SF-36) [3, 22] and the Western Ontario and McMaster Universities (WOMAC) [1] questionnaires. The WOMAC evaluates three dimensions: pain, stiffness and physical function and is typically used for osteoarthritis patients. It was scored using a visual analogue scale and the results transformed to a scale between 0 and 100 points, with a lower number indicating less severity. The SF-36 is a general health assessment tool validated for measuring the global functional outcome. It consists of 36 items in 8 dimensions which are summarised in the two summary measures of physical and mental health. For each dimension, item scores are coded, summed and transformed to a scale from 0 (worst health) to 100 (best health). The SF-36 was also sent to 40 healthy persons who served as a control group, matched for age (mean age: 27 years) with a male to female ratio of 1:1.

In addition to these questionnaires, patients after PAO were asked three questions about actual dysaesthesias, subjective improvement after the intervention and if they would undergo the same procedure again. Self-reported assessment of patients without or with only minor complications (group 1) was compared with patients with at least one major complication (group 2). In a second step, patients with frequent complications such as peroneal apraxia, lateral femoral cutaneous nerve dysfunction, ectopic bone formation or delayed wound closure were grouped according to the type of complication, and these subgroups were each compared with the outcome measures of patients in group 1.

Statistical analysis was performed with the SPSS 10.0 statistical software package (SPSS Inc., Chicago, IL, USA). Gaussian distribution was tested with the Kolmogorov-Smirnov test. Quantitative variables are described by mean and standard deviation (mean±SD). Mean values of the subgroups were compared with Student's *t*-test, the non-parametric Mann-Whitney test or Kruskal-Wallis test, respectively. Nonparametric tests were used to compare mean values of the WOMAC and SF-36 questionnaires as suggested in the literature [1]. Correlations were calculated with Spearman's correlation coefficient. A 0.05 level of significance was used for all analyses.

Results

The centre-edge angle improved from a mean of 8.7° (±5.5) preoperatively to 31.5° (±9.4) post-operatively (*t*-test: $p<0.01$). WBS values decreased from a mean lateral opening of 8.7° (±6.3) preoperatively to 4.2° (±9.7) post-operatively ($p<0.01$). The degree of osteoarthritis improved in 1 case, was unchanged in 20 and deteriorated in 17 (Table 1). Higher post-operative CE angles showed a trend towards osteoarthritic changes over time, but this trend did not reach statistical significance. There was a significant, but low correlation between the post-operative degree of osteoarthritis and the general health perception as measured with the SF-36 (Spearman's correlation: $r=0.45$, $p<0.05$), and the post-operative increase of the CE angle ($r=0.37$, $p<0.05$).

Of the 60 interventions 13 had no complications. There were minor complications in 25 interventions (41%) and in 22 (37%) at least one major complication occurred. The most frequent complication was dysaesthesia of the lateral femoral cutaneous nerve with an incidence of 30%. Of the severe complications delayed or nonunion of the osteotomy was the most frequent; peroneal nerve dysfunction, major intra-operative blood loss and high-grade ectopic bone formation occurred at slightly lower rates.

Forty-two patients (84%) completed the questionnaires. Six patients moved to an unknown address and two patients did not reply. Mean total score of the SF-36 questionnaire was 76.4 for PAO patients and 90.3 for the control group, respectively (Kruskal-Wallis test: $p<0.01$). Summary measures for physical and mental health showed significantly better values for the control group than the PAO group (see Table 2). But both groups had a comparable general health perception and mental health. WOMAC score for all PAO patients was 24.1±20 for pain, 30.4±23.3 for stiffness and 24.7±18.5 for function, respectively. Mean total WOMAC score was 25.1±18.3. There was a significant negative correlation between the summary scores of both questionnaires (Spearman's correlation: $r=-0.66$, $p<0.01$). The total number of all complications as well as type of complications did not correlate with the patient's wellbeing and function. Summary measures as well as all the dimensions of both the SF-36 and WOMAC did not show significant differences between patients with minor or no complications (group 1) and patients with major complications (group 2). General health perception and mental health of all PAO patients and social functioning of PAO group 2 did not differ from the control group. All other items as well as the summary measures differed significantly between PAO patients and the controls (see Table 2). Over 75% of patients felt a good ($n=27$) or slight improvement ($n=10$) after the operation up to the latest follow-up. One felt the situation unchanged and eight complained about a subjective deterioration (slight: $n=6$, severe: $n=2$); 65% of patients would repeat the intervention, 24% would not and 11% did not answer this question.

Twenty-four patients complained of dysaesthesias in the leg at last follow-up. Of these 24, 14 had a documented lesion of the lateral femoral cutaneous nerve post-operatively. Comparison of subjective outcome of these patients with other patients with minor or no complications did not reveal statistically significant differences between their SF-36 measures. This contrasted dramatically with that seen on the WOMAC scores where for each level (pain, stiffness, function) there was a significant difference between the patients with dysaesthesia and those who were unaffected (see Table 2 and Fig. 1).

The subjective outcome of patients with other frequent complications such as peroneal neurapraxia, ectopic bone formation or secondary wound closure was each compared with the subjective outcome of group 1. None of these complications were found to significantly worsen the subjective result, as assessed with the SF-36 or WOMAC measures.

Discussion

PAO is extremely effective in the correction of hip dysplasia (see Table 1). In this series, the CE angle improved 23°, which is comparable to previous reports [4, 12, 13]. Achieving proper acetabular orientation is technically challenging with the PAO [4, 6]. The difference between insufficient, normal and overcoverage is rather small and influenced by a multitude of factors [20]. PAO was shown to be effective for reorientation of a retroverted acetabulum [19], but may produce excessive lateral and anterior correction leading to acetabulofemoral impingement [20]. Crockarell et al. [4] observed a decrease of ROM in all planes after PAO and overcorrection was regarded as an explanation for a decrease in hip flexion. Ganz et al. [6] reported only secondary overcorrection but no primary overcorrection in their first series ($n=75$), neither of which were accompanied by clinical symptoms. But in a later study on 58 patients of this first series in whom the hip joint was preserved until follow-up examination, the impingement test was positive in 29% and was considered to compromise the result in future [20], as it was thought to place the patient at a higher risk of having degenerative changes in the hip develop. Patients with pre-existing pathology such as labral tears and osteoarthritic changes had a significantly worse outcome than those patients whose joints had not deteriorated [10, 18, 20]. Similarly, other authors reported on a positive correlation of progression of radiographic signs and initial grade of osteoarthritis [12, 13, 24]. As would be expected excellent clinical results were mainly achieved for younger patients with minimal or no degenerative changes

Table 1 Complications after PAO as published in previous studies and our study

Study ID	Present	Ganz [6]	Siebenrock [20]	Hussell [8]	Matta [12]	Siebenrock [18]	Cockarell [4]	Trumble [24]	Murphy [15]	Murphy [14]	Kralj [9]	Pogliacomi [16]
Years of investigation	1988–1998	1984–1987	1984–1988	1984–1999	1987–1996	1993–1997	1992–1995	1988–1998	1992–1996		1987–1995	1994–2001
Number of PAOs	60	75	71	508	66	70	21	123	94	95	26	36
Varisation osteotomies	17	16			10		4	33				
CE angle improvement	22.8°	31°	34°		28.4°		22°			~27°	~22°	~21°
Follow-up (years)	7.4		11.3		4		3.2	4.3		5.4	12	4.1
Degree of osteoarthritis												
Improvement	2%		7%		14%		14%	–			–	
Unchanged	42%		67%		53%		76%	95%			<46%	
Deterioration	17%		26%		33%		10%	5%			>54%	
Conversion to arthroplasty or arthrodesis (failures)	–		13		5		1		2	6	4	3
Major complications												
Femoral head necrosis	1		1									
Acetabular necrosis	2		3	–				–			–	
Femoral nerve dysfunction	–	1	4	–				2	–	–	–	
Sciatic nerve dysfunction	1		5	–	1				–	–	1	
Peroneal nerve dysfunction	5				3	2		4	1	–	–	
Major blood loss	5				2							
Post. column discontinuity	4		6		1							
Intra-articular osteotomy or fracture	(1)	2	11			2				1		
Ischial fracture	–				3	3						
Delayed union or nonunion	8	2	7	11	10	3	1	9	4		1	
Reflex sympathetic dystrophy	–				2							
Deep vein thrombosis and/or embolism	–				1		2		–	1	–	
Arterial thrombosis	–						3		–		–	
Overcorrection		2	7								(5)	
Undercorrection			4									
Resubluxation	–	2	5									
Acetabular fragment migration or displacement	–	1	4		1						1	
Ectopic bone formation Brooker III-IV or excision	4	4	6	5	–		1			1		
Minor complications												
Dysaesthesia of lateral femoral cutaneous nerve	20	Frequent	~30%	1	15				Most		18	
Ectopic bone formation Brooker I-II	9			9	3							
Haematoma	3				2		5			1		
Symptomatic hardware removal	–	13		7	1		31		2	9	1	
Secondary wound closure or wound infection	9				2		2			–		
Urinary tract infection	8				1							
Fever post-operatively	11											
Avulsion of iliac crest	–						5					

Table 2 Results of SF-36 and WOMAC measures (mean ± SD) of all patients after PAO in our study (PAO total), patients without or with only minor complications (PAO group 1), patients with major complications (PAO group 2) and the control group in comparison to published results in the literature (numbers in parentheses = normal values not mentioned; values transformed to a scale between 1 and 100*)

SF–36

	PAO group 1—no/minor complications	PAO group 2—major complications	Level of significance	PAO total	Control group	Level of significance	Random population (25–34 years) [3]	PAO [2]	THR [21]	THR [17]	THR [7]	THR revisions [7]
Physical functioning	78.8±15.4	72.4±14.8	0.134	75.8±15.3	98.9±1.9	<0.01	95			72.7	64.3	53.8
Social functioning	88.7±20.1	92.6±14.5	0.596	90.5±17.7	97.5±6.7	0.011	89			92.1	83.6	77.7
Role-physical	79.5±21.8	75.8±22.2	0.739	77.8±21.8	97.5±6.4	<0.01	90			67.1	63.6	57.1
Role-emotional	86.9±17.3	73.7±27.4	0.095	80.9±23.1	94.9±10.1	<0.01	84			85.9	78.6	81.5
Functional status	83.5±15.6	78.6±15.5	0.266	81.3±15.5	97.2±4.7	<0.01		(49.2)				
Mental health	74.1±14.4	79.2±13.5	0.053	76.4±14.1	80.9±8.9	0.225	73			84.6	77.8	78.6
Vitality	68.5±13.3	65.6±11.7	0.371	67.2±12.5	75±9.3	<0.01	63			66.1	63.2	60.1
Bodily pain	66.1±21.4	62.3±23.7	0.339	64.4±22.3	93.8±11.1	<0.01	84			72,2	68.6	66.2
Wellbeing	69.6±13.9	69 ±12.8	0.658	69.3±13.3	83.2±7.1	<0.01		(54.7)				
General health	80.8±13.9	75.8±22.5	0.694	78.5±18.2	84.3±10.6	0.226	77			76.8	70.9	65.1
SF-36 total	77.9±12.9	74.7±13.3	0.426	76.4±13	90.3±4.6	<0.01						
Health change	56.5±18.7	63.2±20.3	0.121	59.5±19.5	62±13.4	0.615					60.8	58.9
WOMAC												
				Patients without dysaesthesia	Patients with actual dysaesthesia		Random population (58–64 years) [11]					
Pain	23.2±20.9	25.3±19.3	0.308	15.4±7.6	30±24.2	0.014	4.9*	29.6*	44*			
Stiffness	28±21.4	33.2±25.8	0.639	18.6±14.9	38.5±25	<0.01	5.4*	37*	46*			
Function	21.5±17.2	28.8±19.6	0.293	18.9±12.7	29.4±20.9	0.015	2.9*	28.2*	47*			
WOMAC total	22.4±17.1	28.4±19.7	0.511	18.1±11.5	30.3±20.8	<0.01	3.5		46*			

THR total hip replacement
Level of significance was determined with the Kruskal-Wallis test

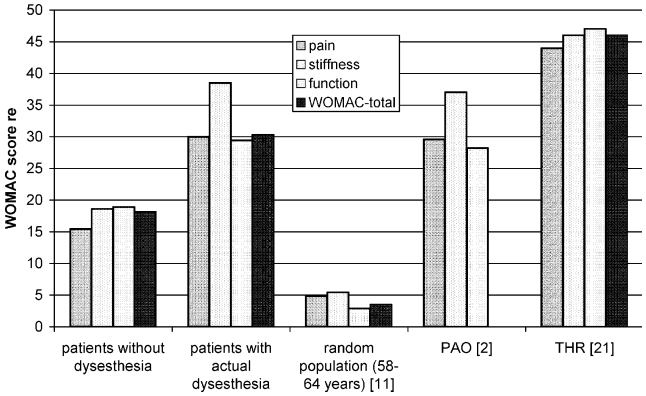

Fig. 1 Results of WOMAC measures of PAO patients with dysaesthesia due to dysfunction of the lateral cutaneous nerve, PAO patients without dysaesthesia in comparison to WOMAC measures of a random population, patients after PAO and THR in other centres as published in the literature

preoperatively [6, 12, 18, 20, 24]. Based on these findings, PAO was not recommended for patients with advanced degenerative changes [15]. Most series, however, report small numbers of patients whose joint space does improve after PAO but the majority of patients in these reports demonstrate deterioration over time [4, 12, 20]. Kralj et al. [9] stated that longer follow-up would probably show further deterioration even in their initially successful hips. A review of the literature suggests that the rate of failure is 1% per year and the probability of deterioration increases by 3% annually after the intervention (see Fig. 2). In our study, a relationship between high post-operative CE angles and deterioration was seen, indicating overcorrection inducing pincer impingement as the main cause for deterioration.

The PAO is a technically demanding procedure [5, 6, 16, 20] with a relatively high complication rate [8]. A significant and long learning curve has been reported in previous studies [5, 16] and therefore it is recommended that surgeons practice on models and cadavers before undertaking this procedure [6]. After appropriate training and multiple cadaver operations, the operation of PAO was introduced to our institution in 1988. Since 2000, all PAOs in our institution are performed via the modified Smith-Petersen approach [8], but in this study the classic Smith-Petersen approach was used for all patients. The different surgical approaches (ilioinguinal, classic and the modified Smith-Petersen approach) all possess potential for morbidity. The modified Smith-Petersen approach is likely to lead to division, especially of the first branch of the lateral cutaneous nerve [8]. Murphy and Deshmukh [14] found dysaesthesias in the majority of their patients using this approach. But dysaesthesias of the lateral femoral cutaneous nerve were also observed frequently for the classic Smith-Petersen approach [6, 8] and in nearly all patients for the direct anterior approach [15]. This complication is regarded as minor in the literature and given little attention as an outcome parameter despite its frequent occurrence. In this study the significance of dysaesthesia of the lateral cutaneous nerve of the thigh was reflected in the poorer WOMAC scores of the affected patients (Fig. 1) but not in the SF-36 self-assessment questionnaire. This complication has been given scant regard in the literature but deserves the surgeon's attention as the presence of dysaesthesia appears to be related to the poorer outcome for the patient in the long term.

The WOMAC and Medical Outcomes Short Form-36 have both been identified as reliable and valid generic measures of functional status and general health perception, respectively [1, 3, 22]. Because of its generic nature, the SF-36 can be used to compare the relative value of a diverse variety of medical surgical interventions [7]. In a previous study with 21 patients completing the questionnaire, physical health but not mental health summary measures in the SF-36 were shown to improve significantly 2 years after PAO [2]. Similarly, THR was reported to enhance quality of life dramatically [7]. In our study, age-matched controls had significantly higher values within all SF-36 dimensions except for mental health 7 years after surgery. The severity of complications had no significant influence on the self-assessed health and function in our study, supposedly due to the low number of patients with major complications. But persistent dysaesthesias deteriorated the subjective functional status. Subjective midterm outcome as determined with the SF-36 more than 7 years after PAO in our study was similar or better than outcome of older patients 6 months after THR reported in previous

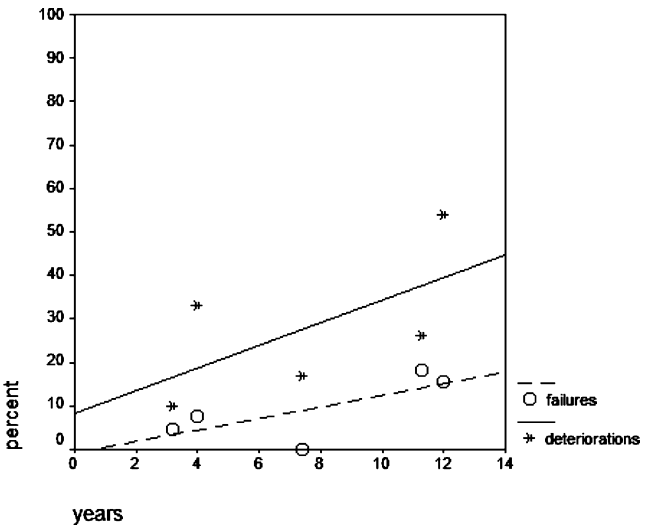

Fig. 2 Failures (conversion to arthroplasty or arthrodesis—*small circles* and *interrupted line*) and radiological deteriorations in the present study and in the literature as cited in Table 1 (*asterisks* and *continuous line*). The number of failures is presented as a percentage of the initial group of patients. The number of deteriorations is presented as a percentage of the patients with radiological deteriorations and without failure at the time of follow-up. Linear regression is shown for failures (*dotted line*) and for deteriorations (*continuous line*)

studies [17]. A comparison of WOMAC measures indicates less pain, considerably lower stiffness and better function for patients after PAO in our study than after THR in previous publications [2, 21], but does not take into account age differences of the two groups. Both outcome measures were significantly worse after PAO than for a control group or historical groups of a random healthy population [3, 11] (see Fig. 1). Although it has been suggested that PAO is deemed successful if it gives the patient a useful hip for 10 years before additional treatment is required, this premise is yet to be proved [12].

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