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Bernese Periacetabular Osteotomy in Males

Is There an Increased Risk of Femoroacetabular Impingement (FAI) After Bernese Periacetabular Osteotomy?

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Abstract

Background The Bernese periacetabular osteotomy (PAO) is a popular option for treating symptomatic acetabular dysplasia. We noted symptomatic impingement after PAO in several male patients.

Questions/purposes We therefore determined (1) the incidence of clinical signs of FAI after PAO in the male population; and (2) whether any factors were associated with the positive impingement signs after PAO in males.

Patients and Methods We retrospectively reviewed 38 males who underwent 46 periacetabular osteotomies (PAO) between 2000 and 2007. Clinical and radiographic data were analyzed with the focus on pre- and postoperative incidence of femoroacetabular impingement. Minimum followup was 12 months (average, 43 months; range, 12–90 months).

Results We found a positive impingement sign in 19 of the 46 hips during the preoperative examination compared to 22 (47.8%) hips postoperatively. The ROM (flexion and internal rotation) decreased postoperatively compared to preoperatively. Radiographic parameters of coverage LCE-, ACE- and Tönnis angle improved into the normal range. Twenty hips had postoperative heterotopic ossification to varying degrees, mostly minor. WOMAC scores improved in the function and pain domains postoperatively.

Conclusions Despite normalization of coverage we found a high postoperative rate of clinical signs of FAI after PAO in males.

Level of Evidence Level IV, therapeutic study. See Guidelines for Authors for a complete description of levels of evidence.

Each author certifies that he or she has no commercial associations (eg, consultancies, stock ownership, equity interest, patent/licensing arrangements, etc) that might pose a conflict of interest in connection with the submitted article.
Each author certifies that his or her institution approved the human protocol for this investigation and that all investigations were conducted in conformity with ethical principles of research, and that informed consent for participation in the study was obtained.
This work was performed at Children's Hospital Boston.

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Introduction

Hip dysplasia, both treated and untreated, is one of the most common causes of osteoarthritis in the young adult population. Aronson [1] reported an incidence of 12% to 80% of DDH (developmental dysplasia of the hip) causing painful disability by the end of the fifth decade of life, depending upon complications of treatment and severity of dysplasia. These findings are similar to the investigations of Harris [12] and Tönnis and Heinecke [32]. The high incidence of good to excellent results (e.g. improvement of radiographic measurements and functional clinical scores, preservation of the hip) in 73% to 97% of patients who underwent PAO to treat symptomatic acetabular dysplasia has made it a feasible option for realigning the dysplastic hip [4, 6, 8, 21, 27, 33]. The goal of PAO is to preserve a native hip as long as possible [1, 18, 21, 27–29].

There has been a modest amount of literature on the mid- to long-term outcome of the PAO [14, 18–22], including 20 year results [29]. These studies showed an

improvement of the LCE-, ACE- and Tönnis angle. Siebenrock et al. [28] showed preservation of the hip in 82% of 71 patients after a followup of 11 years. Steppacher et al. [29] reported a further followup after 20 years with a preservation of the native hip in 60% of the cohort. Conversion to total hip arthroplasty was dependent on the grade of osteoarthritis and the function of the hip before operation.

Certain proximal femoral abnormalities like decreased head neck offset at the femoral head neck junction associated with hip impingement seem more common in the male dysplastic hip than in the female dysplastic hip [9]. Siebenrock et al. found 29% (17 of 58 hips) of a mixed group of males and females had symptomatic impingement after PAO [28]. Myers et al. [24] corroborated these findings in a case series of five patients. Given the frequency of certain anatomic abnormalities being higher in males with dysplastic hips, and given the possibility of symptomatic impingement after PAO, we asked if males might be particularly prone to impingement symptoms after PAO surgery.

We therefore determined (1) the incidence of clinical signs of FAI after PAO in the male population; and (2) whether any factors were associated with the positive impingement signs after PAO in males.

Patients and Methods

The methods section was organized and completed according to the STROBE guidelines. We retrospectively identified a cohort of 46 hips in 38 male patients who were treated between 2000 and 2007 out of a total PAO cohort at our institution of 475 patients (591 hips). All patients after PAO surgery were included in a registry that performed radiographic and historical review with functional score measurements. The primary diagnosis was dysplasia for all of the patients. Indications for PAO included pain, femoral head uncovering on the AP radiograph with lateral center edge (LCE) angle of less than 20°. Centering was confirmed preoperatively on a functional abduction internal rotation radiograph. Contraindications included osteoarthritis without obvious remaining cartilage that would be in a weightbearing position by proper reorientation of the articular surfaces and an open triradiate cartilage. We excluded from the study six patients who had prior surgery for their hip dysplasia ranging from previous open reduction to Steel osteotomy; the majority of these procedures were performed at outside institutions. We included all 38 male patients (46 hips). Nine of 38 patients (24%) had another diagnosis that may have contributed to the dysplasia (Table 1). There were 20 left and 26 right hips. Minimum followup was 12 months (Table 1). None of the 38 patients were lost to followup. We obtained prior Institutional Review Board approval.

Preoperatively we collected baseline demographic data, including age, primary and secondary diagnoses, and prior operations. We obtained WOMAC scores on each patient less than 1 month before surgery [2]. The WOMAC questionnaires were administered by a trained research assistant. All patients had preoperative AP pelvis, faux profile [16], and functional abduction and internal rotation views of the hips. MRI was performed as per a specific protocol that obtained standard two-dimensional reconstructions and delayed gadolinium-enhanced MRI of cartilage (dGEMRIC) [14] views. Plain radiograph measurements obtained included coccyx to symphysis distance, LCE angle [35], Tönnis angle [23], Tönnis grade [31], anterior center edge angle (ACE) [17], Shenton's line continuity [26], and restoration or maintenance of joint congruity following Von Rosen view. Heterotopic ossification was documented and classified according to the Brooker classification [3] postoperatively. The alpha angles [25] were measured on faux profile view.

All surgery was performed by two surgeons (MBM, YJK). The PAO was performed with the patient in the supine position, employing the abductor-sparing direct anterior approach [23]. The osteotomy cuts were made according to the technique of Ganz et al. [8], modified to include image intensifier control. Simultaneous anterior arthrotomy was frequent. After bony correction, freedom from impingement was confirmed by direct vision if arthrotomy was performed, by flexing the hip greater than

Table 1. Demographics

Variables (n = 46 hips)	Mean	Max.	Min.	Std. deviation	Median
Age at operation	23.5	47.6	13.5	10.1	18.7
Followup (years)	3.3	7.6	1	1.7	3
Concomitant procedure (number of patients)	Arthrotomies (23); intertrochanteric osteotomies (6); osteochondroplasties (3); trochanteric transfers (2); iliac osteoplasty (1)				
Second diagnosis (number of patients)	Charcot-Marie-Tooth (3); postseptic hip (1); M. Downs (2); M. Legg Calve-Perthes (1); postpoliomyelitis (1); arthrogryposis (1)				
Side	20 left; 26 right				

90° with adduction and internal rotation. If necessary, anterior head-neck osteoplasty was performed or correction reduced if believed excessive. If arthrotomy was not performed, then freedom from impingement was confirmed by direct palpation and image intensifier exam with the hip flexed adducted and internally rotated. The average duration of the operation was 165 minutes and the average estimated blood loss was 750 ml. Thirty-five of 46 (76%) patients had concomitant procedures (Table 1).

Postoperative pain was managed with intravenous and/or epidural analgesia, which was converted to oral medication before discharge. Patients were mobilized with partial weightbearing gait from the 3rd postoperative day (1/6 bodyweight on the affected leg for 6 weeks) and active assisted ROM exercises were taught to all patients before surgery. At postoperative outpatient visits, usually 1, 2, and 3 months after surgery, gentle nonresistive strengthening exercises were taught as weightbearing was increased. The postoperative mobilization and increasing of the weightbearing was supervised by our physiotherapists. Deep venous thrombosis prophylaxis routinely was with aspirin, with a few patients considered at higher risk given low-molecular-weight heparin for 1 month. Prophylaxis against heterotopic ossification was not used. Hospitalization averaged 5.4 days (range, 5–7 days). Implants routinely were removed 4 to 12 months after surgery on an outpatient basis.

Four weeks postoperative a first clinical visit was carried out with radiographic control in the AP and false profile projections. At the second visit 8 weeks postoperative, again radiographic documentation was performed with an AP pelvis and false profile radiograph. Consolidation of the osteotomies and the positioning of the implants were documented. Additionally, clinical data regarding range of motion and wound healing as well as adverse events were collected. We noted all subsequent operations. The WOMAC questionnaires were collected postoperatively from all patients at their 1 year followup visits and additionally at their latest followup. Shenton's line broken more than 5 mm was considered to be abnormal.

Three of the authors (JB, KZ, MBM), including one of the treating surgeons, independently evaluated all radiographs (all radiographs were read by at least two and some by three of us). We measured on the AP view the lateral center edge angle of Wiberg, the Tönnis angle and the Tönnis grade, Shenton's line as well as the heterotopic ossification according to Brooker et al., respectively [3, 17, 23, 26, 31]. The faux profile was used to measure the anterior center edge angle according to Lequesne and de Seze [17] and the alpha angle according to Notzli et al. [25]. Tannast et al. suggested a high inter- and intraobserver reliability could be expected in measuring AP pelvis radiographs by different individuals [30].

All pre- and postoperative WOMAC questionnaires, ROM data, and the presence or absence of an anterior impingement sign (discomfort in flexion adduction and internal rotation [10]), and radiographic measures were recorded on an Excel® spreadsheet (Microsoft Corp, Redmond, WA). Recorded operative data included operative time, estimated blood loss, and intraoperative complications (ie, breakage of instrumentation, intraarticular penetration). Late complications recorded included persisting nerve damage, and reoperation for any reason. No vascular damage or infections were noted. We defined failure as a WOMAC pain score of greater than 10, conversion to arthroplasty or arthrodesis, and any further joint reconstructive surgery. In addition to typical postoperative complications, we considered both a newly positive postoperative anterior impingement sign and heterotopic ossification of Brooker grade 2 or more as complications. If, however, new postoperative impingement signs and heterotopic ossification higher than grade 2 occurred in one patient, it was counted as one complication because in this situation we cannot exclude the possibility that the heterotopic ossification caused the impingement sign.

The incidence of positive impingement sign after PAO was assessed by descriptive statistics. Pre- and postoperative numerical outcome measures (LCE, ACE, Tönnis angle, Alpha angle, WOMAC scores, flexion, abduction, internal rotation, external rotation) were tested for normal distributions with one-sample Kolmogorov-Smirnov tests. Not all variables were normally distributed; therefore the differences between pre- and postoperative measures were tested with Wilcoxon signed rank tests. Radiographic signs (crossover sign, break in Shenton's line, posterior wall sign) were tested for differences with the chi square test in a cross-tabulation evaluation. Differences in numerical radiograph outcome measures (LCE, ACE, Tönnis angle, Alpha angle) were tested for with independent sample t-tests since normality was verified in one-sample Kolmogorov-Smirnov tests in all variables. The incidence of heterotopic ossification, crossover sign, posterior wall sign and break in Shenton's line in patients with and without impingement after PAO was tested with the chi square test in a cross-tabulation evaluation. We used SPSS® Version 17 software (SPSS Inc, Chicago, IL) to perform the statistical analyses and Excel® (Microsoft Corp) for descriptive statistics.

Results

A positive impingement sign was present in similar percentage ($p = 0.227$) of hips pre- and postoperatively: 19/46 (41%) hips preoperatively and 22/46 (47.8%) hips at last followup (Table 2). Postoperative radiographs confirmed

Table 2. Pre- and postoperative radiologic results

n = 46 hips	Yes	No	p Value
Impingement	**19**	**27**	p = 0.227
Impingement	22	24	
Crossover sign	**19**	**27**	p = 0.393
Crossover sign	23	23	
Posterior Wall sign	**2**	**44**	p = 0.062
Posterior Wall sign	7	39	
Break in Shenton's line	**31**	**15**	p = 0.0001
Break in Shenton's line	3	43	
HO Brooker Grade 1	7		
HO Brooker Grade 2	12		
HO Brooker Grade 3	1		

Preoperative data bold.

Table 3. Pre- and postoperative radiologic results

n = 46	Mean	Max.	Min.	Std. deviation	Median	p Value
LCE angle (°)	**−0.3**	**29**	**−30**	**12.7**	**0**	< 0.0001
LCE angle (°)	26.2	50	11	8.5	26.5	
ACE angle (°)	**−2.35**	**20**	**−37**	**15.2**	**2**	< 0.0001
ACE angle (°)	23.6	37	12	6.6	24	
Tönnis angle (°)	**29.6**	**45**	**16**	**6.7**	**30.5**	< 0.0001
Tönnis angle (°)	10.2	20	0	5.1	10.5	
Alpha angle (°)	**68.4**	**100**	**31**	**14.1**	**69.5**	< 0.006
Alpha angle (°)	60.7	86	37	12	59	

Preoperative data bold.

the orientation of the acetabulum had been substantially improved (Table 3). The incidence of a break in Shenton′s line was notably lower ($p < 0.001$) after surgery. In contrast, the incidence of crossover sign and posterior wall sign pre- and postoperatively did not differ (Table 2). The alpha angle was improved (Table 3). The WOMAC score for pain was also improved ($p < 0.001$) but WOMAC function and stiffness did not change ($p = 0.055$ and $p = 0.072$, respectively). The overall range of motion decreased after surgery (Table 4).

We observed no differences between cases with or without positive impingement sign in postoperative LCE ($p = 0.450$), ACE ($p = 0.327$), Tönnis angle ($p = 0.428$) and alpha angle ($p = 0.200$) measurements. The incidence of crossover and posterior wall sign as well as the occurrence of a break in Shenton's line did not differ between cases with and without positive impingement sign (Table 5). Heterotopic ossification occurred in 20 hips (one grade 3, twelve grade 2, seven grade 1); however, the incidence of heterotopic ossification was similar ($p = 0.184$) in patients with and without positive impingement sign (Table 5).

Table 4. Pre- and postoperative clinical results

n = 46	Mean	Max.	Min.	Std. deviation	Median	p Value
Flexion (°)	100.3	120	60	11.3	100	p = 0.027
Flexion (°)	94.9	115	50	9.9	95	
Abduction (°)	31.1	50	20	6.7	30	p = 0.010
Abduction (°)	28.4	45	10	6.1	30	
Internal rotation(°)	27.5	60	0	15.6	25	p = 0.082
Internal rotation(°)	22	50	0	13	20	

Preoperative data bold.

Table 5. Radiographic factors and clinical signs of impingement after PAO in males

Postoperative impingement	Yes	No	p Value
Crossover sign	n = 11	n = 12	p = 0.621
Posterior wall sign	n = 5	n = 34	p = 0.576
Break in Shenton's line	n = 2	n = 1	p = 0.639
HO Brooker (all grades)	n = 1	n = 9	p = 0.184

Overall complications occurred in 26 of 46 PAO (56%). Most of these were not major, such as Brooker grade two ossification (n = 12). Immediate complications were noted in two of 46 hips (4%) (two patients); one patient had a hematoma which required drainage, and a second patient had a sciatic neuropraxia with direct visualization of the nerve. The latter patient ultimately required an ankle foot orthosis after partial recovery of sciatic function. Late operative interventions were required in four additional patients (9%). One required arthroscopy because of progression of a previously débrided labral tear; one patient required bone grafting and repeat osteosynthesis of a delayed iliac union; a third patient required a repeat PAO because of undercorrection; and a fourth patient required THA at 18 months postoperatively because of progression of his preoperative Tönnis grade 2 osteoarthritis. He was considered a high-risk patient for failure both due to his advanced age at operation (47 years) and his advanced arthritis.

Discussion

Since its introduction in 1984, PAO has become a standard treatment for symptomatic acetabular dysplasia in the mature congruous nonarthritic hip. Numerous series with good long term followup have noted preservation of the native hip in 60% to 80% of cases [4, 15, 18, 20, 21, 27, 28]. Older patient age, osteoarthritis and poor joint

congruity have been identified as risk factors for poor outcome [7, 18, 29]. Consistent with the much higher incidence of DDH in the female population, patient cohorts of studies reporting results of PAOs are skewed in favor of female patients. After we noted clinical signs of FAI in several male patients after PAO we investigated the incidence of FAI symptoms in male patients after PAO surgery. We also wanted to look for factors associated with these clinical FAI signs.

Our study has certain limitations. First is the absence of a matched female patient group. Second is the relatively small number of patients. We are limited by the low incidence of dysplasia in the male population, so a much lower number of PAO's are performed in males. Third, we limited our analysis to male patients operated on after the year 2000; prior to that we did not collect WOMAC scores. Fourth, the minimum followup time is relatively short, and our conclusions must be considered preliminary. It is conceivable that impingement symptoms in some of the patients might resolve over time or might develop in others.

Our data suggest most outcome measures of PAO in our male patients are comparable to those in the PAO literature. The average ROM of these patients is comparable to the findings of other publications reporting the outcome of patients after PAO [4, 11, 18, 27]. The radiographic measures showed sufficient coverage of the femoral heads with substantial correction of the acetabular angles to normal ranges (Table 3). No signs of overcorrection in terms of increased LCE or ACE angles could be detected. However, we noted the high incidence of certain postoperative problems. Two patients had surgery in the immediate postoperative course because of postoperative hematoma and neuropraxia. Four other patients had further surgery during the followup period. Three out of the four because of pain symptoms and one due to undercorrection of the osteotomy. Thirteen patients who had negative impingement signs preoperatively had positive impingement tests at followup whereas with 10 patients the preoperative positive impingement sign disappeared at their followup examinations. The male patients appeared more likely to develop impingement signs after PAO surgery than the female population, although the total amount of hips with positive impingement signs did not substantially increase (19 hips preoperatively versus 22 hips postoperatively). Overcorrection of the acetabular fragment can be a possible reason for secondary impingement after pelvic osteotomy [5]. However, we noted no overcorrection of the acetabulum. Another conceivable reason for postoperative femoroacetabular impingement might be that the alpha angles in our group were in the high normal or low pathologic range postoperatively. However, 23 of 46 of the patients operated had an arthrotomy concomitant with the PAO, which verified more than 90° of flexion in internal rotation during surgery after the bony correction (Table 1). In three patients, a femoral head-neck osteochondroplasty was performed concomitantly because of evident femoroacetabular impingement after appropriate reorientation of the acetabular fragment (Table 1). All patients by our protocol had passive hip flexion of more than 90° in neutral rotation before wound closure.

Heterotopic ossification previously has been reported after PAO but compared to the literature the number in our study is very high [34] (Table 6). If we consider the patients with newly positive postoperative impingement signs and those patients with Brooker 2 heterotopic ossification as having complications, the overall complication rate in our cohort of patients is 56%. Theoretically, the high incidence of heterotopic ossification in this male patient cohort could cause painful flexion/internal rotation, but the statistical analysis, which failed to demonstrate a correlation, does not substantiate this hypothesis.

Compared to the recent review of 13 studies by Clohisy et al. [6] the average complication rate was 6% to 37% after PAO. The senior authors' average rate has been 15 % after PAO [13, 18, 21–23]; thus, the occurrence of adverse events in this solely male population was high. The high

Table 6. Reported problems in studies evaluating followup of PAO

Author	Year	Hips	Female:male	Followup (years)	Complications (%)	Impingement (%)	HO (%)
Siebenrock et al. [28]	1999	75	58:17	11	17	29	5.6
Steppacher et al. [29]	2008	58	35:23	19	n.i.	38	n.i.
Myers et al. [24]	1999	5	4:1	3.6	n.i.	all	n.i.
Trousdale et al. [34]	1995	42	30:8	4	33	n.i.	14
Matta et al. [19]	1999	66	42:16	4	41	n.i.	17
Mayo et al. [20]	1999	19	10:8	3.8	37	n.i.	16
Clohisy et al. [4]	2005	16	11:2	4.3	13	n.i.	n.i.
Ziebarth et al. [current study]	2010	46	0:46	3.5	56	47	43

n.i. = no information available.

rate of adverse events after PAO in males is clear. How to reduce the rate of their occurrence is under prospective study following our preliminary analysis.

According to Ganz and Leunig [9], the acetabular and femoral anatomy in the mature patient with developmental hip dysplasia is not uniform. We suggest there are anatomic and biologic differences in male patients compared to females, leading to the higher than expected number of postoperative problems we found. Identifying these gender differences might lead to changes in the operative or postoperative management of these male PAO patients, which could reduce the incidence of the frequently noted impingement signs and heterotopic ossification.

We found a high postoperative rate of anterior impingement signs in male patients after PAO. Further investigation is needed to improve outcomes in this high-risk population.

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