

Do young female dancers improve symptoms and return to dancing after periacetabular osteotomy for the treatment of symptomatic hip dysplasia?

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ABSTRACT

Although preservation of high activity level has been reported in active young patients after periacetabular osteotomy (PAO) for the treatment of symptomatic hip dysplasia, there is limited evidence whether a dancer may be able to resume dancing after PAO. We asked whether female dancers experience improvement in pain and sports-related activities and return to dance following PAO. Between 1997 and 2014 we performed a total of 44 PAOs in 33 female dancers with symptomatic hip dysplasia. The mean age was 20.3 years (SD 5.6 years) and the median follow-up was 2.7 years (IQR 1.7–5.9 years). The Hip Disability and Osteoarthritis Outcome Score (HOOS), the modified Harris hip score (MHHS) and hip motion were collected preoperatively and at most recent follow-up. Return to dance was recorded from self-reported questionnaires and medical record review. Female dancers reported an improvement in HOOS total scores of nearly 20 points ($P = 0.007$) and MHHS improved over 17 points ($P = 0.01$) from preoperative to most-recent follow-up. Out of the 30 patients for whom information about return to dance was available, 19 (63%; 95% CI = 43.9–79.5%) had returned to dance at an average of 8.8 months (± 3.6 months) after PAO. With the numbers available we did not identify any factors associated with returning to dance in this cohort. Improvement in hip pain, sports-related activities and hip function may be expected following PAO in young female dancers. Most female dancers can expect to return to dance during the first year after surgery.

INTRODUCTION

Modern dance and ballet require extreme movements with increased range of hip motion in flexion, extension and external rotation [1–3]. Extreme motion in female dancers is associated with shearing of the femoral head and may lead to labral and cartilage damage in the superior and postero-superior areas of the acetabulum [2, 4, 5].

Hip dysplasia is associated with insufficient coverage of the femoral head and micro-instability which may aggravate the shearing forces and subluxation associated with

extreme motion of the female dancer's hip. Although an association between hip dysplasia and dance has been recently postulated [6], the true incidence of hip dysplasia among dancers is still unknown [7, 8].

The Bernese periacetabular osteotomy (PAO) has become the mainstay in the treatment of symptomatic hip dysplasia [9–12]. Although the majority of patients undergoing PAO can improve or return to their preoperative activity level [13, 14], reduced motion and the demanding rehabilitation may impact the ability of dancers to

return to high level of dancing following PAO. However, there are limited data regarding outcomes after PAO among female dancers and whether undergoing PAO would preclude dancers from return to their activity after surgery.

We investigated a cohort of young female patients with symptomatic hip dysplasia who were dancers at the time of PAO surgery. We asked: (1) do female dancers experience improvement in pain, sports-related activities and hip function assessed by the Hip Disability and Osteoarthritis Outcome Score (HOOS) [15] and the modified Harris hip score (MHHS) [16] following PAO? (2) What is the proportion of female dancers that return to dance during the first year after PAO?

PATIENTS AND METHODS

After institutional review board approval, a query to our hospital's electronic medical record identified 1512 patients who underwent PAO between 1997 and 2014. Study inclusion criteria consisted of female patients with a minimum of 1-year follow-up after surgery and participation in dance which was confirmed by a preoperative questionnaire. Before surgery, patients were asked whether they had participated in sports/dance and to identify the type of sports/dance participation in the previous 12 months before surgery. A retrospective review of the medical records was performed to collect preoperative demographic data, intraoperative findings and postoperative complications.

Indications for surgery included a history of hip pain aggravated by dancing without resolution with nonsurgical treatment. Radiographic evidence of acetabular dysplasia was based on a lateral center-edge angle (LCEA) less than 20° [15] on an anteroposterior (AP) pelvic radiograph and/or anterior center-edge angle (ACEA) less than 20° on a false profile view [16]. Contra-indication for surgery included radiographic evidence of hip osteoarthritis with joint space narrowing and Tönnis [17] arthritis classification greater than grade 2.

The surgeries were performed by two surgeons according to a previously described technique [18] through an anterior modified Smith Petersen approach. Briefly, an incomplete osteotomy of the ischium was performed and followed by an osteotomy of the superior pubic ramus. Then, a supra-acetabular osteotomy was performed. The posterior column was split to allow repositioning of the acetabulum and improvement of femoral head coverage. The acetabular fragment was then fixed with 3.5 or 4.5 mm screws. Patients with suspected labral pathology on MRI or with less than 20° of internal rotation with the hip in 90° of flexion after PAO underwent an arthrotomy to evaluate for impingement. Arthrotomy was performed in a

total of 17 (37%) hips and osteochondroplasty of the femoral head neck junction was performed in 4 (9%) hips. Patients were instructed to use crutches with partial weight bearing for the first 6-8 weeks after surgery when radiographic healing was confirmed. Physical therapy was recommended after the 6- or 8-week visit, and gradual increase of functional training was allowed 3 months after surgery.

Improvement in pain, sports-related activities and hip function was assessed by self-reported questionnaires including the HOOS [19] and the MHHS [20] filled before surgery and at minimum 1-year follow-up. Pre- and postoperative radiographs were assessed by an independent professional research assistant not involved in the clinical care of patients for measurement of standard radiographic parameters of hip dysplasia including the LCEA [15], ACEA [16] and acetabular roof inclination of Tönnis [17]. Hip ranges of motion hip motion including hip flexion, internal and external rotation with the hip in 90° of flexion and in extension, adduction and abduction, were retrospectively collected from medical records before surgery and at minimum 2 years after PAO. Postoperative range of motion data were available for 30 hips in 22 (67%) patients. The treating orthopedic surgeon without the application of a goniometer visually assessed hip range of motion.

Return to dance after PAO was recorded from self-reported questionnaires completed by the patients before surgery and at the 6-, 12-month and most-recent follow-up visit. Information about return to dance was obtained from medical records when follow-up questionnaires were not available.

Statistical analysis

Continuous patient and hip characteristics were summarized by mean and standard deviation (SD) or median and interquartile range (IQR, 25th percentile–75th percentile) when data deviated from normality. Categorical characteristics were summarized by frequency and percent. Patient reported outcomes were summarized by patient and radiographic measurements were summarized by hip. Change in patient-reported outcomes including MHHS, HOOS total score and HOOS subdomains were compared between preoperative and most-recent follow-up using paired *t*-tests. The mean difference in each measurement was estimated along with a 95% CI. General estimating equations (GEE) approach was used with a linear outcome to analyse the change in radiographic measurements between time points by hip. The GEE approach controls for the repeated nature of the data taking into account potential bias introduced from bilateral subjects. The proportion of patients

who returned to dance within 1 year was estimated along with a 95% confidence interval (CI) based on the number of subjects who responded. Subgroup analysis was conducted across hips that returned to dance and those that did not return to dance. Preoperative characteristics were analysed using uni- and multivariable logistic regression to attempt to identify any characteristics that could predict return to dance. A comparison was conducted between subjects with 1-year follow-up data and those without. No differences between groups were detected with respect to any preoperative radiographic, patient-reported or range of motion measurement. Missing and incomplete data was assumed to be missing at random. All tests were two-sided and P -values less than 0.05 were considered significant. We hypothesized that pain and function would improve at most recent follow-up. Based on the HOOS pain and physical function subscales with SDs of 15, in order to detect at least a 1 SD, increase in pain score or in physical function score assuming a conservative estimate of measurement correlation of 0.1, we would require at least 17 paired measurements to achieve 80% power at the 5% significance level.

RESULTS

A total 33 female dancers (44 hips in) with a mean age of 20.3 years (SD 5.6 years; range 12.6–34.3 years) and mean body mass index (BMI) of 22.7 (SD 2.7) were included. The median follow-up after PAO was 2.7 years (IQR 1.7–5.9 years). Eighty-two percent (27 out of 33) of the patients had completed the HOOS and MHHS questionnaires while data on return to dance within 1 year was available for 91% (30/33) of the patients.

Female dancers reported over a 21-point improvement in HOOS pain score ($P = 0.003$) and an 18-point improvement in HOOS function and daily living ($P = 0.004$) from preoperative to most-recent follow-up. The HOOS total score improved nearly 20 points ($P = 0.007$) and MHHS improved over 17 points from preoperative to most recent follow-up ($P = 0.01$). The other HOOS subscales also improved between 17 and 26 points, on an average across all patients ($P = 0.007$ – 0.03) (Table I).

Accordingly, radiographic improvement was observed in the LCEA (mean preoperative LCEA $10.7^\circ \pm 7.5^\circ$ versus mean postoperative LCEA $28.8^\circ \pm 4.9^\circ$; mean difference 18.2° ; 95% CI: 15.9° – 20.5° , $P < 0.001$), the ACEA angle (mean preoperative ACEA $8.1^\circ \pm 9.8^\circ$ versus mean postoperative ACEA $29.6^\circ \pm 6.1^\circ$; mean difference 21.6° ; 95% CI: 18.7° – 24.5° , $P < 0.001$) and Tönnis angle (mean preoperative Tönnis angle $19.7^\circ \pm 6.8^\circ$ versus mean postoperative Tönnis angle $6.4^\circ \pm 5.1^\circ$; mean difference -13.3° ; 95% CI: -15° to -11.6° , $P < 0.001$). When

assessing hip motion before surgery and at most recent follow-up, hip flexion reduced an average of 10° (from 110° to 101.5° ; $P = 0.001$) and hip abduction reduced an average of 8° (from 44° to 36.4° ; $P = 0.001$) (Table II). At most recent follow-up we found no difference in hip motion between patients who returned to dance compared to those who did not return to dance (mean flexion $101.7^\circ \pm 9.7^\circ$ versus $104^\circ \pm 12.9^\circ$, $P = 0.72$; mean internal rotation in flexion $31.5^\circ \pm 13.3^\circ$ versus $27^\circ \pm 12.5^\circ$, $P = 0.50$; mean abduction $15.3^\circ \pm 1.2^\circ$ versus $18.8^\circ \pm 2.5^\circ$, $P = 0.07$).

Nineteen out of 30 (63%; 95% CI = 43.9–79.5%) female dancers reported that they had returned to dance within the first year at an average of 8.8 months (± 3.6 months) after PAO. There were no differences in any preoperative parameter including demographics, range of motion, radiographic degree of dysplasia and hip pain and function across patients who returned to dance when compared to patients that did not return to dance within 1 year after PAO (Table III). Similarly, with the numbers available, we did not find a difference in hip pain at most recent follow-up between patients who had returned to dance compared to those who did not return to dance (mean MHHS at most recent follow up 87.2 ± 14.3 versus 91.6 ± 8.8 ; $P = 0.51$ and mean HOOS score 83.8 ± 16.2 versus 90 ± 8.1 ; $P = 0.35$).

DISCUSSION

Female dancers with symptomatic hip dysplasia may desire to return to dancing without pain to perform at a high level. Although most young patients return to, or improve upon their preoperative activity levels following PAO [13, 14, 21], there is limited literature to help guide and set expectations about PAO surgery in dancers. In this retrospective study, we investigated a cohort of young female dancers to determine improvement in pain, sports-related function and return to dance at minimum 1-year after PAO.

In this cohort of young female dancers with hip dysplasia there was an overall improvement in pain, sports-related and daily activities and hip function assessed by the HOOS [19] and the MHHS [20] following a minimum 1-year after PAO. Our findings are in line with previous studies reporting improvement in hip functional, pain and activity scores following PAO in athletic patients [13, 14, 21, 22]. Van Bergayk *et al.* [21] reported improvement in Tegner activity scores from 1.9–4.4 at minimum of 2 years in 22 patients after PAO with one dancer included in their cohort. Bogunovic *et al.* [13] reported improvement on MHHS, hip dysfunction and osteoarthritis outcome score—quality of life and WOMAC index after PAO in a cohort of

Table I. Patient reported outcomes at preoperative and most-recent follow-up

Patient reported outcomes	Preoperative (28 patients)		Most-recent follow-up (22 patients)		Change from preoperative to most-recent follow-up (19 patients)		P-value
	Mean	± SD	Mean	± SD	Mean difference	(95% CI)	
MHHS	66.8	± 18.56	86.3	± 15.18	17.4	(4.5 to 30.4)	0.01
HOOS total score	67	± 19.59	84.4	± 14.7	18.7	(5.8 to 31.5)	0.007
Symptoms and stiffness	61.9	± 20.40	77.5	± 15.26	17.1	(5.3 to 28.8)	0.007
Pain	65.8	± 20.79	85.8	± 13.94	21.8	(8.4 to 35.1)	0.003
Function and daily living	74.4	± 20.08	89.8	± 13.81	18.0	(6.4 to 29.7)	0.004
Sports/recreational activities	54.3	± 25.97	77.3	± 21.35	22.1	(4.0 to 40.1)	0.02
Quality of life	46.4	± 26.17	70.2	± 27.41	26.1	(3.5 to 48.7)	0.03

Table II. Range of motion measurements for 22 patients (30 hips) before surgery and at most recent follow-up

Measurement	Preoperative		Most recent follow-up		Preoperative to most recent		P-value
	Mean	± SD	Mean	± SD	Difference	95% CI	
Flexion	110.0	± 10.29	101.5	± 9.93	-10	(-15.3 to -4.7)	0.001
IRF	37.4	± 16.05	30.2	± 15.03	-3.8	(-10.7 to 3.2)	0.27
ERF	38.8	± 14.13	39.1	± 14.85	-2.1	(-6.5 to 2.2)	0.31
Extension	0.0	± 0.00	0.2	± 0.91	0.3	(-0.3 to 0.9)	0.33
IRE	37.6	± 17.42	31.7	± 14.69	-6.0	(-13.5 to 1.5)	0.10
ERE	32.9	± 13.69	32.3	± 18.01	-2.5	(-7.6 to 2.6)	0.30
Abduction	44.0	± 9.92	36.4	± 8.48	7.8	(-12.9 to -2.8)	0.004
Adduction	16.6	± 2.63	16.2	± 2.18	-0.4	(-1.9 to 1.1)	0.58

IRF: internal rotation measured with the hip in flexion to 90°; ERF: external rotation measured with the hip in flexion to 90°; IRE: internal rotation measured with the hip in extension; ERE: external rotation measured with the hip in extension.

active patients without specifying the type of sports activity.

Sixty-three percent (19/30) of the young female dancers with hip dysplasia returned to dance at an average of 9 months following PAO. Although the proportion of patients returning to dance in our study is lower than the rate or returned to play after PAO reported by a previous study [22], in both studies patients resumed their activity at a mean of 9 months after PAO. In our study, we did find any difference of baseline demographic characteristics including age, hip motion, radiographic measurements and severity of symptoms assessed by the patient reported outcomes

across patients who did not return to dance compared with those who did. In a previous study, Novais *et al.* [14] showed that age and preoperative activity level were independent predictors of activity level at 1 year in a cohort of 51 patients undergoing PAO.

We found a reduced amplitude of hip flexion and abduction from preoperative to most recent follow-up after PAO in female dancers. This is in line with a study by Steppacher *et al.* [23] who used a computed tomography-based software to examine hip motion before and after PAO and found decreased flexion and abduction and increased adduction. Reduced hip motion after PAO in

Table III. Comparison of preoperative variables between patients that returned to dance within 1 year compared to those who did not return to dance by hip and by patient as appropriate

Variable	Returned to dance with 1 year (n = 25 hips)			Did not return to dance within 1 year (n = 15 hips)			P
	n	Freq.	(%)	n	Freq.	(%)	
Preoperative characteristics							
Age at surgery (years)	25	20.1	± 5.75	15	22	± 5.90	0.33
BMI	25	22.9	± 2.62	12	23.6	± 3.87	0.59
Duration of pain [months; median (IQR)]	25	8	(2–24)	15	6	(2–16)	0.82
ROM measures							
Flexion	25	111.8	± 10.69	15	106.7	± 9.00	0.11
Internal rotation in flexion	25	33.4	± 10.68	14	39.3	± 10.89	0.12
External rotation in flexion	24	40.2	± 13.39	14	40.4	± 10.82	0.97
Internal rotation in extension	19	33.4	± 12.59	10	38	± 7.15	0.22
External rotation in extension	19	33.4	± 10.94	10	37.5	± 16.37	0.49
Abduction	25	43.6	± 9.07	15	45	± 12.54	0.71
Adduction	22	16.6	± 2.38	14	16.1	± 2.89	0.58
Radiographic measures							
Lateral center-edge angle	25	10.6	± 7.62	15	10.7	± 8.19	0.97
Anterior center-edge angle	25	7.6	± 10.28	15	8.7	± 9.80	0.74
Tönnis angle	25	19.7	± 5.93	15	18.8	± 7.91	0.70
Patient reported outcomes							
	n	Mean	± SD	n	Mean	± SD	P
MHHS	17	68.7	± 19.19	9	59	± 14.55	0.17
HOOS total score	16	65.2	± 21.82	8	64.5	± 11.95	0.92
Symptoms and stiffness	16	58.4	± 19.72	8	60.6	± 17.41	0.79
Pain	16	63.3	± 23.75	8	64.7	± 11.14	0.85
Function and daily living	17	72.8	± 23.22	10	73.4	± 13.98	0.93
Sports and recreational activities	16	55.9	± 27.24	8	43	± 17.50	0.18
Quality of life	16	44.5	± 27.94	8	40.6	± 15.67	0.67

female dancers have two important implications. First, reduced motion could potentially compromise high-level dance performance as female dancers have been reported to have an increased range of hip motion [1, 2]. However, we found no difference in hip motion between patients who returned to dance and those who didn't dance after PAO. Further studies, will be necessary to clarify whether the reduced motion in flexion and abduction compromise long-term dancing after PAO. The second concern is development of femoroacetabular impingement (FAI); mainly if flexion and internal rotation amplitudes are reduced after PAO. This is specifically important in patients with hip dysplasia associated with a non-spherical femoral head and cam-type FAI morphology. In these patients, a hip arthroscopy can be performed at the same operative setting before the PAO which would allow for treatment of any associated cartilage and labral pathology. Another alternative is to perform the osteochondroplasty using an arthrotomy after PAO that has the advantage of evaluating the impingement after correction.

This study has several limitations. First, there is a risk of selection bias. During the study period, it is possible that we performed PAO in a selected group of dancers with more severe dysplasia while dancers with mild dysplasia may have been treated conservatively or may have refused to undergo PAO treatment. However, our indication for PAO was consistent throughout the study period and it was based on a widely accepted criterion for hip dysplasia (LCEA lower than or 20°) [15]. Therefore, we believe that our cohort is representative of young, active female dancers with well-defined hip dysplasia. Second, we did not collect return to dance prospectively during the entire study period and our data of return to dance was limited to the first year after surgery. However, it is expected that most active patients would return to their level of sports participation at 1 year after PAO [14]. Third, although we recommended a standard postoperative rehabilitation protocol, it is possible that differences in compliance with postoperative rehabilitation could have affected the ability to return to dance. Finally, we found a slight reduction in hip motion after PAO, which is in line with a previous study [23]. However, future studies will be necessary to assess whether the theoretical reduced motion in flexion and abduction is associated with return to dance after PAO.

In conclusion, young female dancers undergoing PAO for the treatment of symptomatic hip dysplasia showed improvement in hip pain, sports-related activities and hip function. The majority (63%) of the dancers were able to return to dancing during the first year following PAO at an average of 9 months. Although further studies will be necessary to determine factors associated with inability to

return to dance after PAO, our findings may help guidance of young, active, female dancers with hip pain secondary to acetabular dysplasia in regard to the expectation of pain improvement, and ability to return to dance after PAO.

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CONFLICT OF INTEREST STATEMENT

None declared.

REFERENCES

1. Drgęwska M, Gałuszka R, Śliwiński Z. Hip joint mobility in dancers: preliminary report. *Ortop Traumatol Rehabil* 2012; **14**: 1–52.
2. Kolo FC, Charbonnier C, Pfirrmann CWA *et al.* Extreme hip motion in professional ballet dancers: dynamic and morphological evaluation based on magnetic resonance imaging. *Skel Radiol* 2013; **42**: 689–98.
3. Reid DC, Burnham RS, Saboe LA, Kushner SF. Lower extremity flexibility patterns in classical ballet dancers and their correlation to lateral hip and knee injuries. *Am J Sports Med*. 1987; **15**: 347–52.
4. Charbonnier C, Kolo FC, Duthon VB *et al.* Assessment of congruence and impingement of the hip joint in professional ballet dancers. A motion capture study. *Am. J. Sports Med*. 2011; **39**: 557–66.
5. Duthon VB, Charbonnier C, Kolo FC. Correlation of clinical and magnetic resonance imaging findings in hips of elite female ballet dancers. *Arthroscopy* 2013; **29**: 411–9.
6. Turner R, O'Sullivan E, Edelstein J. Hip dysplasia and the performing arts: is there a correlation? *Curr Rev Musculoskel Med* 2012; **5**: 39–45.
7. Rietveld AB. Dance injuries in the older dancer: comparison with younger dancers. *J Dance Med Sci* 2000; **4**: 16–9.
8. van Dijk CN, Lim LS, Poortman A *et al.* Degenerative joint disease in female ballet dancers. *Am J Sports Med* 1995; **23**: 295–300.
9. Clohisy JC, Carlisle JC, Beaulé PE *et al.* A systematic approach to the plain radiographic evaluation of the young adult hip. *J Bone Joint Surg Am Vol* 2008; **90**: 47–66.
10. 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; 26–36.
11. Matheney T, Kim YJ, Zurakowski D *et al.* Intermediate to long-term results following the Bernese periacetabular osteotomy and predictors of clinical outcome. *J Bone Joint Surg Am Vol* 2009; **91**: 2113–23.
12. Steppacher SD, Tannast M, Ganz R, Siebenrock KA. Mean 20-year followup of Bernese periacetabular osteotomy. *Clin Orthop Relat Res* 2008; **466**: 1633–44.
13. Bogunovic L, Hunt D, Prather H *et al.* Activity tolerance after periacetabular osteotomy. *Am J Sports Med* 2014; **42**: 1791–5.

14. Novais EN, Heyworth B, Murray K *et al.* Physical activity level improves after periacetabular osteotomy for the treatment of symptomatic hip dysplasia. *Clin Orthop Relat Res* 2013; **471**: 981–8.
15. Wiberg G. Studies on dysplastic acetabula and congenital subluxation of the hip joint. With special reference to the complication of osteoarthritis. *Acta Chir Scand* 1939; **83**(Suppl. 58): 28–38.
16. Lequesne M, de S. False profile of the pelvis. A new radiographic incidence for the study of the hip. Its use in dysplasias and different coxopathies. *Rev Rhumat Malad Osteo-Articul* 1961; **28**: 643–52.
17. Tönnis D. General radiograph of the hip joint. In: Tönnis D (ed). *Congenital Dysplasia, Dislocation of the Hip*. New York: Springer, 1987, 100–42.
18. Matheney T, Kim YJ, Zurakowski D *et al.* Intermediate to long-term results following the bernese periacetabular osteotomy and predictors of clinical outcome: surgical technique. *J Bone Joint Surg Am Vol* 2010; **92**(Suppl. 1 Pt 2): 115–29.
19. Klassbo M, Larsson E, Mannevik E. Hip disability and osteoarthritis outcome score. An extension of the Western Ontario and McMaster Universities Osteoarthritis Index. *Scand J Rheumatol* 2003; **32**: 46–51.
20. 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 Vol* 1969; **51**: 737–55.
21. 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.
22. Heyworth BE, Novais EN, Murray K *et al.* Return to play after periacetabular osteotomy for treatment of acetabular dysplasia in adolescent and young adult athletes. *Am J Sports Med* 2016; **44**: 1573–81.
23. Steppacher SD, Zurmuhle CA, Puls M *et al.* Periacetabular osteotomy restores the typically excessive range of motion in dysplastic hips with a spherical head. *Clin Orthop Relat Res* 2015; **473**: 1404–16.