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Research article

Complications associated with combined surgical hip dislocation and periacetabular osteotomy for complex hip deformities

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ABSTRACT

Surgical hip dislocation (SD) and periacetabular osteotomy (PAO) are well-described treatments for femoroacetabular impingement (FAI) and acetabular dysplasia, respectively. Occasionally, complex deformities require a combined SD/PAO; the morbidity of performing both procedures in a single stage has not been fully investigated. We performed a retrospective review of a consecutive group of patients undergoing combined SD/PAO to investigate the incidence and character of perioperative complications. Forty-five patients (46 hips) were identified. Perioperative complications were graded by the modified Clindo-Davien complication scheme. Mean follow-up was 36 months (range 12–128), and no patients were lost to follow-up. Six complications occurred in six hips (13%). Four (8.7%) complications were minor (Grades I or II): one Brooker Grade III heterotopic ossification requiring no treatment, one superior pubic ramus nonunion requiring no treatment and two superficial wound infections requiring antibiotics. Two (4.3%) complications were major (Grades III or IV): one coxa saltans interna and labral tear requiring hip arthroscopy with labral repair and iliopsoas lengthening, and one deep surgical site infection requiring irrigation and debridement followed by development of arthritis requiring conversion to arthroplasty. The average Harris hip score improved from 62 ± 13 preoperatively to 80 ± 19 at final follow-up. Except for the single joint replacement, there were no long-term disabilities. There were no major neurovascular injuries, osteonecrosis, fractures or trochanteric nonunions. Combined SD/PAO for the treatment of complex, concomitant deformities of the proximal femur and acetabulum is associated with an acceptable risk of complications. The vast majority of complications that occurred were managed without permanent disability.

Level of Evidence: IV

INTRODUCTION

Advances in the understanding of hip pathomechanics and improved surgical techniques have allowed for successful surgical management of symptomatic, pre-arthritic hip deformities. Hip deformities can be conceptualized as an aberrancy of constraint of the ball-and-socket joint with potential abnormalities arising from both the femoral and acetabular anatomy [1, 2]. Femoroacetabular impingement (FAI) indicates excessive constraint secondary to acetabular overcoverage (pincer deformity), femoral head–neck offset deficiency (cam deformity) or both [3]. Acetabular dysplasia indicates deficient constraint of the joint from a shallow acetabulum and results in hip instability [4]. Patients with symptomatic FAI or acetabular dysplasia may be candidates for treatment with surgical hip dislocation (SD) or periacetabular osteotomy (PAO), respectively [5, 6].

Residual Perthes-like deformity is a complex hip deformity that often includes characteristics of both complex FAI and acetabular dysplasia [7–9]. Femoral deformities include a large aspherical femoral head, coxa vara, coxa breva, variable femoral version and a high-riding greater trochanter [7, 10, 11]. These femoral abnormalities commonly put the hip at risk for both intra-articular (aspheric femoral head) and extra-articular (coxa breva and high-riding trochanter) impingement. Abnormalities in acetabular morphology affecting version, inclination and size of the sourcil may also be present [9, 12–14]. Commonly, secondary acetabular dysplasia puts the hip at risk for structural instability and static overload of the acetabular rim. Perthes-like deformity is associated with the development of pain and secondary arthritis [15, 16]. When complex deformities involving both the femur and acetabulum exist, surgical correction including both SD and PAO may be required to create a stable, impingement-free hip joint [17–19]. Prior reports have documented good short-term outcomes with this combined approach [8, 19, 20]. However, while the complication burden associated with each procedure in isolation has been well-described, the complication profile associated with the combined procedure remains to be fully elucidated [21, 22].

In this study, we sought to use a standardized complication grading scheme [23, 24] to define the incidence and character of complications associated with combined SD/PAO for the treatment of complex (Perthes-like) deformities with concurrent FAI and instability. These data will inform treating surgeons regarding the perioperative risk of this surgical strategy for managing the complex combination of structural abnormalities encountered in residual Perthes deformities. This will facilitate surgeon decision-making and patient counseling when contemplating this treatment option.

MATERIALS AND METHODS

Patient selection

Following Institutional Review Board approval, we performed a retrospective review of all cases of combined SD/PAO performed by the senior author from 2007 to 2016. These cases were part of a prospectively maintained institutional hip preservation repository (1630 cases total during this time period). All included patients had a diagnosis of complex (Perthes-like) deformity with instability and complex FAI, and had symptoms attributable to their hip pathology that did not respond to a trial of nonoperative treatment (≥3 months of activity modification, anti-inflammatory medication and corticosteroid injections). Perthes-like deformity with instability was defined as femoral morphological abnormalities consistent with a history of Perthes disease (femoral head asphericity, coxa magna, coxa vara, coxa breva, high greater trochanter) as well as secondary acetabular dysplasia as previously described [25] with intraoperative confirmation of hip instability [8]. All had radiographic findings demonstrating Perthes-like deformity and acetabular dysplasia in the absence of advanced arthritis (Tönnis grade ≤ 2) or severe hip joint incongruity. All patients had minimum follow-up of 1 year, and no patients were lost to follow-up.

The final study group included 46 hips in 45 patients, with 28 (62.2%) females and mean age 19.6 years (range 12–36) (Table I). The mean body mass index was 24.2 kg/m^2 (range 14.7–32.4). Common comorbidities included back pain (20%), obesity (11.1%) and asthma (11.1%). The preoperative diagnosis was Perthes-like hip deformity with structural instability in 100% of patients. In 42 of 45 patients (93.3%), the hip deformity was attributed to a history of Perthes disease. One patient had a remote history of Developmental dysplasia of the hip (DDH) and had prior femoral and acetabular osteotomies (at an outside institution) for treatment. The patient presented to our clinic with residual acetabular dysplasia as well as complex iatrogenic FAI related to the prior femoral osteotomy. One additional patient had undergone casting and bracing as a child for DDH (with no history of Perthes diagnosis), and presented to our clinic with residual dysplasia and complex FAI with Perthes-like femoral deformity presumably due to osteonecrosis and head remodeling from DDH treatment. One patient's hip deformity was attributed to a diagnosis of metaphyseal chondrodysplasia. The mean estimated blood loss was 882 ml (range 150–2600). Mean follow-up was 35.9 months (range 12–128). All patients were followed until union of the trochanter and PAO was confirmed radiographically.

Surgical procedure

Surgical dislocation was performed as described by Ganz *et al.* [5] and intra-articular pathology, proximal femoral deformity and any sources of impingement were addressed. This included femoral head–neck osteochondroplasty, relative femoral neck lengthening, ligamentum teres debridement and trochanteric advancement in the majority of cases. Other procedures performed in selected cases included labral debridement or refixation, trochanteric osteoplasty, acetabular rim osteoplasty, acetabular chondroplasty, acetabular microfracture, proximal femoral osteotomy and psoas lengthening (Table II). PAO was then performed [6] following intraoperative examination [18] demonstrating (i) adequate hip range of motion to accommodate a PAO (flexion > 90°, abduction > 20°), (ii) dynamic hip instability with ranging of the hip joint

Table I. Patient demographic and comorbidity data

Patient demographics	*n* =
Number of patients	45
Number of hips	46
Sex	*n* (%)
Women	28 (62.2)
Men	17 (37.8)
Age at surgery (years) (mean [range])	19.6 (12–36)
BMI kg/m^2 (mean [range])	24.2 (14.7–32.4)
Overweight	12
Obese	5
Patient reported comorbidities	*n* (%)
Heart disease	2 (4.4)
Asthma	5 (11.1)
Back pain	9 (20)
Tobacco use	2 (4.4)
Drug use (in past)	1 (2.2)

BMI, body mass index.

Table II. Perioperative details and concurrent procedures performed

Perioperative details for *N*=46 hips	mean	range
OR time (min)	337	(172–480)
Estimated blood loss (cc)	882	(150–2600)
Concurrent procedures performed	*n*=	%
Head and/or neck osteochondroplasty	43	93%
Femoral neck lengthening	40	87%
Trochanteric advancement	40	87%
Ligamentum teres debridement	35	76%
Labral repair/debridement	21	46%
Labral resection	10	22%
Chondroplasty	9	20%
Trochanteric osteoplasty	6	13%
Microfracture	4	9%
Femoral intertrochanteric osteotomy	2	4%
Femoral head central resection	2	4%
Acetabular rim osteoplasty	1	2%
Psoas lengthening	1	2%

OR, operating room.

through functional positions and (iii) adequate joint congruency as determined by intraoperative fluoroscopic examination. The acetabulum was reoriented and its position assessed fluoroscopically followed by placement of screws from the iliac crest into the acetabular fragment. The post-operative protocol included 24 h of antibiotic prophylaxis, flat-foot weight bearing with hip abductor precautions, aspirin for venous thromboembolism prophylaxis, naproxen for heterotopic ossification prophylaxis and utilization of a continuous passive motion machine in addition to post-operative day-0 mobilization with physical therapy.

Data collection

Chart review was completed for patient demographic and comorbidity data as well as for the occurrence of any perioperative complications throughout a minimum 1-year follow-up period. This case review was performed independent of the treating surgeon. No patients were lost to follow-up. Complications were defined as any abnormal intraoperative or post-operative events leading to a deviation from expected treatment, recovery or radiographic follow-up, whether or not specific intervention was required. Complications were graded according to Clavien and Dindo [24], utilizing a modified grading scheme wherein complications are rated by the intervention required and the impact on long-term function and health. This scheme has been validated in hip preservation surgery and has been used previously to study complications of both PAO and SD procedures [21–23]. Complications were graded as follows: Grade I, the complication is associated with no deviation from routine post-operative recovery and requires no intervention; Grade II, the complication is a deviation from routine recovery and requires pharmacologic treatment or close outpatient monitoring; Grade III, the complication is a deviation from routine recovery and requires surgical intervention with or without an unplanned hospital admission; Grade IV, the complication has potential for permanent disability and is not treatable; Grade V, death. Minor, asymptomatic heterotopic ossification (Brooker Grades I–II) was not considered a complication as this is a common, trivial finding after these procedures and does not impact clinical outcomes. Major heterotopic ossification (Grades III and IV)

Table III. Complications organized by Clavien–Dindo grade

Grade I			*Grade II*			*Grade III*			*Grade IV*		
Complication	*n* =	*(%)*	*Complication*	*n*=	*(%)*	*Complication*	*n*=	*(%)*	*Complication*	*n*=	*(%)*
Brooker Grade III heterotrophic ossification	1	2.2	Superficial wound infection (treated with antibiotics)	2	4.3	Symptomatic snapping psoas/labral tear	1	2.2	Deep surgical site infection leading to THA	1	2.2%
Superior pubic ramus nonunion	1	2.2									
Total *n*=(% hips)	2	4.3	Total *n*=(% hips)	2	4.3	Total *n*=(% hips)	1	2.2	Total *n*=(% hips)	1	2.2

THA, total hip arthroplasty.

was considered a complication. Similarly, we did not include decreased sensation in the distribution of the lateral femoral cutaneous nerve (LFCN) as a complication because this is an expected sequela of the operative approach for the PAO [22]. Conversely, dysesthesia in the LFCN distribution leading to ongoing pain was considered a complication. Due to the multifactorial nature of post-operative pain, we did not include the occurrence of pain in the post-operative period as a complication. We also did not include elective hardware remove as a complication. Screening for complications also included review of post-operative standing anteroposterior pelvis radiographs at all time points. Heterotopic ossification, if present, was classified according to Brooker *et al.* [26].

Statistical analysis

Descriptive statistics were performed for patient demographics, comorbidities and for the occurrence and grade of complications.

RESULTS

There were six total complications for an overall complication rate of 13% (Table III). Of these, 4 (8.7%) complications were Grades I or II, and 2 (4.3%) complications were Grades III or IV and required reoperation. There were no Grade V complications.

Two Grade I complications occurred in 4.3% of hips and were identified via review of post-operative radiographs. There was one Brooker Grade III heterotopic ossification and one superior pubic ramus nonunion identified on post-operative radiographs. Both of these complications were asymptomatic, resulted in no functional deficits and required no additional interventions beyond routine post-operative care.

There were two Grade II complications (4.3% of hips). Both were superficial wound infections that were treated with oral antibiotics. Each of these infections resolved completely with only pharmacologic treatment and clinical observation. Neither resulted in long-term disability.

One Grade III complication occurred (2.2%). This patient developed a post-operative symptomatic coxa saltans interna as well as a labral tear. Symptoms were initially managed with physical therapy, anti-inflammatories and psoas injections. Due to failure of nonoperative modalities, the patient was taken back to the operating room 23 months following the index procedure for hip arthroscopy with lysis of adhesions, revision labral repair and iliopsoas lengthening. The patient required no additional intervention following the arthroscopy and at 25 months after arthroscopy had a Harris hip score of 100.

There was one (2.2%) Grade IV complication consisting of a deep infection following the combined SD/PAO that was managed with operative irrigation and debridement, but subsequently went on develop degenerative joint changes that were attributed to the infection. The patient was treated with a total hip arthroplasty 40 months post-operatively.

There were no Grade V complications. The average Harris hip score improved from 63 ± 13 preoperatively to 80 ± 19 at most recent follow-up.

DISCUSSION

Residual Perthes-like hip deformities most commonly involve both femoral and acetabular abnormalities that can cause intra-articular and/or extra-articular impingement, hip instability, abductor dysfunction or combinations of these pathomechanics. This combination of complex deformities poses a major challenge for surgical decision-making and reconstructive techniques. In treating patients with symptomatic Perthes-like deformity, the goal of the hip preservation surgery is to reduce symptoms by creating a stable, impingement-free hip joint and to theoretically delay the progression of secondary osteoarthritis. For some

patients, achieving these goals requires a surgical dislocation to address intra-articular pathology and proximal femoral deformity, in addition to a PAO to address hip instability. While promising early outcomes have been reported with this combined surgical strategy, it is critical to analyze the safety of the procedure as the benefit of any joint preservation surgery must be weighed against the potential risks of the intervention. Therefore, we sought to investigate the complication profile of combined SD/PAO for the treatment of symptomatic Perthes-like hip deformities. To our knowledge, this is the largest series to date reporting on the safety of this procedure. Our results demonstrate an acceptable complication rate with a 13% overall complication rate, <5% occurrence of complications leading to reoperation and a 2.2% rate of complications leading to conversion to total hip arthroplasty.

The complication profiles related to surgical dislocation and PAO in isolation have been well-described. In describing the technique for SD, Ganz *et al.* reported on 213 cases with minimum 2-year follow-up [5]. There were no cases of avascular necrosis or infection. Complications included 2 transient sciatic neuropraxias, 3 trochanteric fixation failures and 79 cases of heterotopic ossification, of which only two were Brooker Grade III and underwent excision. In a multicenter retrospective study, Sink *et al.* reported on 334 hips that underwent surgical dislocation with an overall complication rate of 9% [21]. Excluding Brooker Grades I or II heterotopic ossification, the complication rate fell to 4.8%. Other complications included 6 trochanteric nonunions, 2 deep venous thromboses, 1 deep and 2 superficial infections and 2 sciatic nerve palsies (1 transient, 1 with partial resolution). Similar to Ganz's report, Sink *et al.* had no cases of avascular necrosis.

Complications related to PAO have also been well-documented. Reports have found complication rates as high as 46%, particularly in series from surgeons in the 'learning curve' of performing the procedure, although many of these complications have been radiographic findings of heterotopic ossification that were not clinically relevant [27–30]. In their description of the first 75 Bernese PAOs, Ganz *et al.* found that all clinically significant complications occurred in the first 18 cases [6]. Complications included 2 intra-articular osteotomies, 1 excessive lateralization of the hip center, 2 recurrent hip subluxations, 2 delayed unions, 1 pubic nonunion and symptomatic heterotopic ossification in four patients. In a prospective, multicenter study of 205 PAOs performed by experienced PAO surgeons, Zaltz *et al.* found an overall complication rate of 34.6% [22]. Of these, 28.8% was Grades I or II complications (of which 91.6% was heterotopic ossification), and only 5.9% was Grades III or IV complications. The Grade III complications all required return to the operating room and included 1 acetabular fragment migration, 2 deep infections and 1 peroneal nerve palsy. The Grade IV complications were all venous thromboemboli that were managed medically without long-term sequelae.

Reports of the complication burden related to combined SD/PAO are limited. Albers *et al.* reported on 53 patients that underwent surgical treatment of complex Perthes-like deformity, of whom four had combined SD/PAO, with minimum 5.1-year follow-up [19]. They had no cases of osteonecrosis. Of the entire cohort, there were three reoperations for joint instability and one reoperation for heterotopic ossification; however, the authors did not specify if these reoperations occurred in the patients that had the combined SD/PAO. Anderson *et al.* reported on five cases of staged SD and PAO and noted no complications at mean follow-up of 38.8 months [20]. Shore *et al.* described 29 patients that underwent SD for residual Perthes deformity, including one patient that additionally underwent a staged PAO [31]. This patient had 1 year of follow-up, with no osteonecrosis, deep infection, nonunion or reoperations. There were two superficial infections in the cohort, but it was not reported if this complication occurred in the patient that had the staged SD/PAO. In a report of the initial experience with treatment of Perthes-like deformity with combined SD/PAO from our institution, 3 complications in 16 cases were reported including 1 superficial infection, 1 coxa saltans interna and 1 deep infection that subsequently required a total hip arthroplasty [8]. These complications are also included in this report. We now present updated results on a larger sample of patients undergoing combined SD/PAO with systematic grading of all complications. To our knowledge, this is the largest series of this procedure that has been reported. These data provide more comprehensive analysis in a larger patient group thus providing more meaningful data for hip preservation surgeons. We find the complication profile to be acceptable, with only two (4.3%) complications requiring reoperation and only one (2.2%) complication leading to loss of the joint and conversion to an arthroplasty. These complication rates fall within the ranges of complication rates for isolated SD or PAO [21, 22], and the rate of conversion to arthroplasty falls within the range reported with isolated PAO [32]. Notably, there were no occurrences of avascular necrosis, fracture, nonunion requiring reoperation or nerve injury.

This study should be considered in the context of its limitations. First, the cases in this report were all completed by one surgeon with significant experience performing open hip preservation surgery and the documented complication profile may not be generalizable to other

centers or surgeons, particularly during the so-called 'learning curve' of the surgeon's hip preservation practice. Second, although patients were prospectively entered into the senior author's hip preservation institutional repository, comprehensive data on complications were collected retrospectively. Third, many patients in this study group traveled from out of state to the authors' institution to undergo surgery, and the possibility that some complications were identified and treated at outside facilities, and hence not captured here, cannot be excluded. However, all patients in the study had at minimum 1-year follow-up and all had radiographic union of the trochanter and PAO at final follow-up. Thus, additional undocumented surgical complications would be unlikely.

In conclusion, for patients with complex Perthes-like hip deformity with concurrent complex FAI and structural hip instability, combined SD with PAO can be performed safely by experienced surgeons. This procedure is associated with an acceptable risk of complications, similar to that associated with each procedure in isolation. Further study is needed to determine if these results are generalizable and to provide longer term data on the clinical outcomes of this surgical procedure.

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CONFLICT OF INTEREST STATEMENT

None declared.

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