Low Early Failure Rates Using a Surgical Dislocation Approach in Healed Legg-Calvé-Perthes Disease

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Abstract

Background Hip deformity secondary to Legg-Calvé Perthes disease (LCPD) may result in femoroacetabular impingement (FAI) and ultimately osteoarthritis. Observations made with the surgical hip dislocation approach have improved our understanding of the pathologic mechanics of FAI. However, owing to concerns about complications related to the vascularity, the role of surgical hip dislocation in the treatment of healed LCPD remains controversial.

Questions/purposes We present an algorithm to treat deformities associated with healed LCPD and asked (1) whether femoral head-neck osteochondroplasty and other procedures performed with the surgical hip dislocation approach provide short-term clinical improvement; and (2) is the complication rate low enough to be acceptable.

Methods We retrospectively reviewed 29 patients (19 males, 10 females; mean age, 17 years; range, 9–35 years) with symptomatic LCPD between 2001 and

2009. All patients underwent a surgical hip dislocation approach and femoral head-neck osteochondroplasty and 26 patients had 37 additional procedures performed. Clinical improvement was assessed using the WOMAC index. The minimum followup was 12 months (mean, 3 years; range, 12–70 months).

Results WOMAC scores improved at final followup (8 to 4 for pain, 21 to 13 for function, and 4 to 2 for the stiffness subscales). No patients had osteonecrosis, implant failure, deep infection, or nonunion. Three patients underwent THA at 1, 3, and 6 years after their index procedure.

Conclusions Using the surgical hip dislocation approach as a tool to dynamically inspect the hip for causes of FAI, we were able to perform a variety of procedures to treat the complex deformities of healed LCPD. In the short term, we found improvement in WOMAC scores with a low complication rate.

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

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Each author certifies that his or her institution approved the human protocol for this investigation, that all investigations were conducted in conformity with ethical principles of research, and that informed consent for participation in the study was obtained.

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Introduction

Legg-Calvé-Perthes disease (LCPD) is a childhood disease associated with idiopathic necrosis of the proximal femoral epiphysis [6, 23, 36]. The resultant proximal femoral growth disturbance and deformity manifest as a spectrum of severity often associated with but not limited to coxa magna, trochanteric overgrowth, and femoroacetabular impingement (FAI) [23, 32, 33]. FAI is defined as abnormal contact between the anterior head-neck junction and the anterior aspect of the acetabular rim [12]. FAI in LCPD may result from the aspherical femoral head (cam-type FAI) or may be secondary to acetabular overcoverage

(pincer-type FAI) attributable to acetabular or femoral retroversion [7]. FAI has recently been associated with early-onset osteoarthritis (OA) of the hip [3, 12, 19]. Previous studies have demonstrated that 20% to 54% of patients who have LCPD will develop OA by 40 to 50 years of age and may require a THA [14, 17, 40]. The current challenge in the treatment of residual LCPD deformity is to identify patients at risk for the development of early OA and surgically intervene, ultimately altering their natural history. The ultimate treatment goal is to establish an impingement-free hip ROM and restore joint congruency because femoral head sphericity and congruency have been reported as the most important predictors of OA [33].

Cheilectomy alone is often not effective at preventing early OA in LCPD hips with deformed femoral heads [28]. Proximal femoral valgus intertrochanteric osteotomy (ITO) has traditionally been described to correct residual hinge abduction deformity after LCPD [2, 24]. However, valgus ITO may fail to correct the deformity when the location of the major aspherical portion of the femoral head is more anterior than lateral. In this instance, the classic valgus-extension osteotomy is contraindicated, because the extension component will further add to the anterior impingement [39]. In addition, anterior FAI and hinge flexion have been reported as the major contributors to hip pain in adults with the sequelae from healed LCPD [7]. Therefore, when treating FAI in healed LCPD, often a combination of procedures is necessary to address the pathologic morphology and mechanics.

Developments in surgical technique now permit surgical dislocation of the hip with a low complication rate [9]. The key feature of this approach is that it permits identification of the major aspherical portion of the femoral head that contributes to abnormal hip mechanics while simultaneously protecting the soft tissues containing the critical blood supply of the femoral head [4, 9]. Surgical dislocation is attractive because it allows the surgeon to dynamically inspect the hip and identify the deformities that lead to FAI and then undertake a variety of procedures guided by these observations [25]. However, only a handful of small retrospective studies reporting four to 14 patients have described the use of the surgical hip dislocation approach for the treatment of FAI associated with LCPD [1, 8, 27, 29]. These studies demonstrate the surgical dislocation approach allows for complete evaluation of the altered mechanics and treatment with a variety of procedures designed to restore normal biomechanics. In a previous report of our initial experience with the surgical hip dislocation approach in 15 patients with hip deformity secondary to LCPD, we also concluded the surgical dislocation approach was a useful technique to assess proximal femoral deformity in LCPD [27]. However, our

cohort was small and length of followup was short, making it difficult to make any concrete conclusions in this patient population.

Our objectives were to determine whether (1) femoral head-neck osteochondroplasty and other procedures performed through a surgical hip dislocation approach provide short-term clinical improvement in pain and function; and (2) define the rate of complication associated with LCPD reconstruction performed through an open dislocation approach.

Patients and Methods

We retrospectively reviewed hospital records of all 47 patients with residual deformity secondary to healed LCPD who were treated with joint reconstruction through a surgical hip dislocation approach between January 2001 and December 2009. In 2009, we reported on the first 15 patients with LCPD treated at our institution through this approach and 10 patients in this current series report were included in that report [27]. The indications for surgery were a combination of (1) groin pain aggravated by physical activities and positions of hip flexion such as sitting for long periods; (2) presence of a positive anterior impingement sign [12, 30] during physical examination; and (3) radiographic evidence of hip deformity secondary to healed LCPD. We did not perform surgical hip dislocations in patients with advanced radiographic OA or in patients during the fragmentation phase of LCPD. Mean time from diagnosis of LCPD to surgical dislocation was 9 years (range, 1–27 years). We excluded 18 of the 47 children (38%) because of incomplete clinical followup (missing preoperative and/or postoperative WOMAC scores). The study group included 29 patients (19 males and 10 females, 16 right hips and 13 left hips) with a mean age at surgery of 17 years (range, 9–35 years). All patients had a clear diagnosis of LCPD (mean age at diagnosis, 8.1 years; range, 2–15 years) and five had bilateral involvement. All patients had a minimum clinical and radiographic followup of 1 year (mean, 36 months; range, 12–70 months). Ten patients had a total of 17 surgical procedures before their surgical hip dislocation (eight ITOs, four pelvic shelf procedures, four hip arthroscopies, and one adductor release) (Table 1). No patients were lost to followup. No patients were recalled specifically for this study; all data were obtained from medical records and radiographs. This study was approved by our Institutional Review Board before commencement.

All surgeries were performed by the senior authors (MBM, YJK) using the technique described by Ganz et al. [9]. At the time of capsulotomy, with the capsule open, the hip was moved through an arc of motion to assess and

Table 1. Patient demographics and details on surgical procedures

Patient number	Sex	Age (years)	Side	Stulberg	Prior hip surgery	Treatment	Secondary surgery	Preoperative WOMAC	Postoperative WOMAC	Second postoperative WOMAC	Followup (years)
1	M	16	L	II	–	FHNO		6, 3, 10	1, 1, 5		1.1
2	M	15	L	IV	AR + varus ITO and valgus ITO	FHNO + RFNL	–	10, 1, 5	0, 0, 0		2.1
3	F	13	L	III	Pelvic shelf and varus ITO	FHNO + RFNL	SDH + FHNO	5, 0, 10	0, 1, 0	0, 0, 0	3.0
4	M	18	L	III	–	FHNO + RFNL	–	14, 5, 28	8, 5, 29		2.2
5	F	21	L	IV	–	FHNO + RFNL	ALD	11, 3, 10	7, 5, 17	5, 5, 10	3.8
6	M	15	L	V	Pelvic shelf	FHNO + RFNL	–	5, 3, 9	2, 1, 6		1.0
7	F	14	L	III	Arthroscopy	FHNO + LD	–	9, 1, 25	0, 0, 2		4.1
8	M	13	L	III	–	FHNO + RFNL + LD	–	6, 4, 10	0, 0, 0		5.8
9	F	14	R	III	–	FHNO + RFNL + LD	Flexion-Valgus ITO	0, 1, 5	0, 1, 5	0, 0, 0	4.5
10	F	24	R	IV	–	FHNO	–	6, 3, 7	0, 0, 2		4.8
11	M	19	L	II	–	FHNO + RFNL	–	5, 4, 11	0, 0, 0		1.0
12	M	16	L	V	–	FHNO + RFNL + LD	–	12, 5, 38	5, 4, 23		3.3
13	F	35	R	V	–	FHNO + RFNL	THA	20, 6, 56	0, 1, 25		1.0
14	M	16	R	V	–	FHNO + RFNL + PAO	–	11, 3, 24	2, 2, 9		1.0
15	F	19	R	III	–	FHNO + RFNL	–	9, 2, 15	3, 1, 1		1.2
16	F	19	R	V	Pelvic shelf	FHNO + RFNL	ALD – THA	13, 5, 45	13, 5, 39	18, 6, 53	3.9
17	M	25	R	IV	–	FHNO	–	10, 6, 28	0, 1, 10		1.0
18	F	18	R	IV	Flexion ITO + arthroscopy	FHNO + RFNL + Valgus ITO	–	13, 5, 26	3, 3, 14		2.5
19	M	14	L	III	–	FHNO + RFNL + flexion ITO	ALD	3, 4, 23	4, 3, 14	2, 0, 10	1.9
20	M	19	R	IV	Pelvic shelf and valgus ITO	FHNO + flexion-valgus ITO + LD	ALD	12, 7, 29	10, 5, 15	0, 2, 7	3.1
21	M	12	L	II	–	FHNO + RFNL + flexion ITO	–	12, 5, 28	0, 0, 0		2.7
22	M	12	R	III	–	FHNO + flexion-valgus ITO	–	8, 2, 24	0, 0, 0		4.7
23	M	14	R	III	–	FHNO + RFNL + valgus ITO	–	19, 7, 63	18, 7, 46		2.9
24	M	12	R	V	–	FHNO + flexion-valgus ITO	–	0, 2, 3	0, 2, 0		1.4
25	F	35	L	III	Arthroscopy	FHNO + flexion-valgus ITO	ALD	15, 6, 43	16, 6, 38	11, 5, 38	3.7
26	M	16	R	V	–	FHNO + flexion-valgus ITO	THA	6, 1, 13	11, 6, 44		6.0
27	M	14	R	IV	Valgus ITO + arthroscopy	FHNO + flexion-valgus ITO	–	10, 7, 35	6, 3, 13		2.7
28	M	18	R	II	–	FHNO + RFNL + valgus ITO	–	8, 2, 11	2, 0, 5		3.9
29	M	9	L	V	Varus ITO and valgus ITO	FHNO + RFNL + valgus ITO	–	0, 2, 3	0, 0, 0		4.4

M = male; F = female; L = left; R = right; FHNO = femoral head-neck osteochondroplasty; RFNL = relative femoral neck lengthening with distal transfer of the greater trochanter; LD = labral débridement; PAO = periacetabular osteotomy; ITO = intertrochanteric osteotomy; SDH = surgical dislocation of the hip; ALD = arthroscopic labral débridement; WOMAC scores are illustrated as pain, stiffness, function.

localize areas of impingement dynamically. The hip was then dislocated anteriorly. The acetabular rim and the labrum were inspected. In five cases the labral was partially torn and partial débridement was performed. Procedures were tailored according to the patient's femoral pathomorphology (Fig. 1).

A common feature for all patients was the presence of intraarticular impingement secondary to the aspherical femoral head (cam-type FAI). A femoral head-neck osteochondroplasty (FHNO) was performed as a first step to remove the aspherical portion of the femoral head in all hips (Table 1). The extent of the FHNO was assessed using a spherical template (Wright Medical Technology, Arlington, TN, USA). FHNO was judged to be sufficient once the spherical template was congruent with the femoral head. There were six complex cam-type deformities in which the aspherical portion of the femoral head was too large to enter the acetabulum and a pincer-induced indentation lesion in the anterosuperior aspect of the femoral head/neck was identified. In these hips, the aspherical anterolateral portion of the femoral head was too large to be completely resected without jeopardizing the structural integrity of the femoral head-neck junction [22]. After FHNO, a flexion-valgus ITO was deemed necessary to remove the anterolateral prominence away from the joint during flexion with internal rotation of the hip.

Extraarticular impingement of the neck or the anterosuperior trochanteric bed resulting from a high-riding greater trochanter and a wide and short femoral neck was identified in 19 patients (Table 1). For these abnormalities we developed a periosteal retinacular flap followed by a relative femoral neck lengthening (RFNL) with distal

transfer of the greater trochanter (GT) as described by Ganz et al. [10, 11]. We attempted to position the GT distally such that the tip of the GT was in line with the center of the femoral head. In six patients, an additional ITO was necessary to reorient the articular surface of the femoral head. A flexion-internal rotation ITO was performed in two hips to address persistent anterolateral impingement and retroversion of the articulating portion of the femoral head (functional retroversion [16]). A valgus ITO was chosen in four hips in which hinge abduction and femoral incongruity associated with functional retroversion remained after FHNO and RFNL. For all ITOs, blade-plate fixation was used, transfixing the trochanteric wafer with the blade and then inserting the blade into the head-neck fragment. One patient underwent a planned staged peri-acetabular osteotomy (PAO) to reorient the acetabulum.

Postoperatively patients' weightbearing was restricted to one-sixth of body weight and they were placed on ROM precautions (full extension, adduction, and external rotation avoided) for 4 weeks. Passive abduction of 10° was permitted initially and active abduction was encouraged only after trochanteric union was appreciated. Active and passive flexion to 80° was encouraged and facilitated by the use of a continuous passive motion machine cycling from 30° to 80° at least 8 hours a day for the first 2 postoperative weeks.

Patients returned at 4, 8, and 12 weeks postoperatively to monitor clinical and radiographic progress. Clinical outcome was assessed by means of self-administered questionnaires including the WOMAC index [5], an outcome instrument that has been proven to be responsive to change in adolescents and young adults with clinical signs

Fig. 1 Algorithm showing the type of impingement for the 29 hips as classified by Novais et al. [25] during the surgical dislocation and the treatment of the FAI that was performed for each. FHNO = femoral

head-neck osteochondroplasty; ITO = intertrochanteric osteotomy; RFNL = relative femoral neck lengthening with distal transfer of the greater trochanter.

and radiographic evidence for FAI and labral pathology [20]. All patients completed preoperative and postoperative questionnaires at the minimum 1-year followup clinic visit. The pre- and postoperative individual scores for the pain, function, and stiffness domains of the WOMAC index were recorded. The pain domain scale ranges from 0 to 20 with 0 to 5 considered mild pain, 6 to 10 moderate pain, and more than 10 severe pain. For the function domain, the scale ranges from 0 (no disability) to 68 (extreme disability) and for the stiffness domain, the scale ranges from 0 (no stiffness) to 8 (severe stiffness). Complications related to the surgery were graded in five types according to a recent classification system developed for complications associated with surgical hip dislocation [31]. This classification has five grades based on the type of treatment required and long-term morbidity of each complication. Grade I complication requires no change in postoperative care, Grade II requires treatment on an outpatient basis, Grade III involves invasive (surgical or radiological) procedures, Grade IV includes potential life-threatening complications or complications with high morbidity, and a Grade V complication involves death. Patients who underwent subsequent THA were considered failures as well as patients with a higher WOMAC pain score at final followup when compared with their preoperative score.

Preoperative AP pelvis and bilateral frog or true lateral radiographs were available for all patients. One of us (BJS) not involved in the surgical treatment measured all the radiographs before surgery and at most recent followup. We used the classification of Stulberg et al. [33] and the staging system of Waldenström [34] to classify the deformity and the stage of LCPD, respectively (Table 2). Previous studies reported good interobserver variance of the Stulberg classification with a percentage agreement ranging from 71% to 91% [13, 38]. Preoperative radiographs were further evaluated for measurement of the lateral center-edge angle (LCEA) of Wiberg [37] and the acetabular roof obliquity angle of Tönnis [35]. A false-profile pelvic radiograph was available for 11 patients and was used to measure the anterior center-edge angle (ACEA) of Lequesne and de Sèze [18]. Trochanteric height was measured pre- and postoperatively according to the method described by Stulberg et al. [33], in which the

femoral head was divided into four quadrants and the tip of the trochanter was related to the femoral head. If the trochanter was at the level of the middle of Quadrant 2, it was given the numerical value of 2.0; if it was halfway between Quadrants 2 and 3, the value was 2.5. Change in trochanteric height was calculated to quantify the radiographic effects of RFNL. We obtained MR images with radial reconstruction around the femoral neck axis to help identify the areas of asphericity of the femoral head.

The mean change in WOMAC scores and trochanteric height before and after surgery were compared using a paired Student's *t*-test (SPSS statistical package Version 19.0; SPSS Inc /IBM, Chicago, IL, USA).

Results

The mean WOMAC pain scores improved from 8.4 to 3.5 at most recent followup (Table 3). Twenty-six of the 29 patients (90%) experienced improved pain after the surgical treatment, whereas three patients (10%) had worsening of their pain. At last followup, 48% of patients were pain-free (WOMAC = 0); 28% had mild pain, 10% moderate pain, and 14% severe pain. Similar trends were seen in functional improvement and stiffness in which 26 patients reported increased physical function and decreased stiffness after surgery, whereas three patients experienced decreased physical function and increased stiffness after surgery (Table 3).

The mean preoperative trochanteric height was 4.1 and postoperatively the mean trochanteric height decreased ($p < 0.001$) to 2.9.

There were two Grade II complications with superficial wound infections resulting in delayed wound healing requiring oral antibiotics. There were no cases of osteonecrosis, implant failure, deep infection, or osteotomy nonunion during the observation period. Four (14%) patients were considered failures. In three patients (10%), the followup WOMAC pain score was higher than the preoperative score. Two of these patients were converted to a THA after 3.9 and 6 years after the index surgery at ages 24 and 22 years, respectively. The third patient had recurrent groin pain and underwent an anterior arthrotomy

Table 2. Radiographic parameters

Sex	Number	Waldenström stage		Stulberg class				GT height		Preoperative		
		Reossification	Residual	II	III	IV	V	Preoperative	Postoperative	LCEA	TA	ACEA*
Male	19	4	15	4	5	4	6	3.8 (1.3)	2.9 (1.0)	6.4 (16.3)	15.1 (11.5)	18.6 (8.28)
Female	10	0	4	0	5	4	1	4.5 (0.6)	3.3 (1.0)	9.3 (13.8)	11.0 (7.4)	

* Available for 11 patients; GT = greater trochanter; LCEA = lateral center-edge angle; TA = Tönnis angle; ACEA = anterior center-edge angle; values are shown as mean (SD).

Table 3. Mean WOMAC scores before and after surgery

WOMAC score	Preoperative Mean (95% CI)	Postoperative Mean (95% CI)	Difference Mean (95% CI)	p value
Pain	8.4 (6.3-10.5)	3.5 (1.5-5.5)	4.9 (2.8-6.9)	< 0.0001
Function	21.2 (14.9-27.6)	12.5 (6.5-18.5)	8.7 (3.9-13.7)	0.0009
Stiffness	3.7 (2.9-4.4)	2.00 (1.7-2.8)	1.7 (0.9-2.5)	0.004

with osteochondroplasty with moderate improvement (most recent WOMAC pain score was 4 compared with 3 before the index surgery). One additional patient required THA 1 year after surgical dislocation of the hip and FHNO. The patient was 35 years old at the time of surgery with a preoperative WOMAC pain score of 20. We identified no radiographic or intraoperative findings in these three patients who underwent THA that would put seem to place them at risk for clinical failure, although all three patients were treated in the first 2 years of learning this approach. Seven patients underwent subsequent surgical procedures after the index surgery: five hip arthroscopic labral débridements, one revision surgical dislocation of the hip with FHNO, and one flexion-valgus ITO.

Review of the 18 excluded patients revealed a mean followup time of 3 years with mean WOMAC scores for pain, stiffness, and function of 4, 2, and 11, respectively. One patient required a THA at 5 years postsurgical dislocation for severe aspherical incongruity and substantial OA. Two other patients underwent secondary procedures of shelf pelvic osteotomy and valgus flexion osteotomy at approximately 3 years postsurgical dislocation.

Discussion

Healed LCPD can result in a spectrum of complex femoral head and acetabular deformities that may lead to FAI and early degenerative joint disease. The surgical hip dislocation approach is attractive because it allows for dynamic inspection of hip motion and identification of the deformities that lead to FAI. The versatility of this approach affords the surgeon the opportunity to apply a variety of procedures depending on the particular abnormalities observed. Despite the advantages of this approach, there has been only a handful of small studies describing this technique in the treatment of healed LCPD [1, 8, 25, 27, 29]. In this study, we present the surgical hip dislocation approach as a tool to guide the decision-making process associated with correcting the deformities associated with healed LCPD. We questioned whether (1) femoral head-neck osteochondroplasty and other procedures performed in conjunction with the surgical hip dislocation approach provide short-term clinical improvement in pain and function; and (2) if these procedures combined with the

surgical dislocation approach would have a low complication rate.

We note some limitations to our study. First, our short-term results should be interpreted cautiously. Although we demonstrate a low risk of Grade I and II-type (6%) complications with this surgical approach, there was a high conversion rate to arthroplasty (10.3%) and a moderate clinical failure rate of 13.8%. Despite not being able to identify any clinical predictors for failure in these patients, we recognize that all of these failures were treated in the first 2 years of learning this technique, perhaps demonstrating the learning curve associated with this approach. A longer period of followup is required to test whether this strategy is truly efficacious in altering the natural history of the healed LCPD hip. Second, although we attempted to report an algorithm for the decision-making process through description of specific procedures to correct each encountered operative finding, we did not have enough subjects to make treatment recommendations. However, the number of subjects in this series was enough to draw conclusions about the versatility and safety (low complication rate) of this approach for the treatment of the healed LCPD hip. Third, three of our patients demonstrated little preoperative pain or functional disability according to the WOMAC score (Table 1: Patients 17, 24, and 25). Despite these low scores, the clinical records for each patient demonstrate that all three were having difficulty with daily function and had disability. This finding illustrates one of the weaknesses of the WOMAC instrument in that a patient's perceived dysfunction does not always correlate with their WOMAC score. Finally, our study involves a small number of patients; however, it represents the largest cohort of patients with LCPD treated with a surgical hip dislocation approach in the literature. There were 18 patients from the original cohort who had missing data (lacking pre- or postoperative WOMAC scores) who were not included in the final analysis. Although removing these patients could have increased our selection bias, we have reported their failures and complications to the best of our knowledge. We elected to study only patients with complete data to be able to report the overall short-term clinical improvement and objectively identify failure (conversion to THA or a higher WOMAC pain score at final followup).

We have found the surgical hip dislocation approach reliably allows us to dynamically identify areas of

impingement between the aspherical femoral head and the acetabulum and to perform procedures necessary to correct associated abnormalities. The complex pathologic morphology of the healed LCPD hip precludes an isolated approach with cheilectomy [28], valgus ITO [2, 26, 39], or greater trochanteric advancement [15, 21]. Valgus ITO has historically been indicated to treat hinge abduction in the sequelae of LCPD [2, 26, 39]. However, anterior FAI and hinge flexion have been reported as the major contributors to hip pain in the adult with sequelae from LCPD [7]. The role of valgus extension osteotomy may be indicated in the early stages of LCPD; however, Kim and Wenger [16] found that in the later stages of LCPD, valgus extension osteotomy is in fact contraindicated. Valgus ITO may fail to correct the deformity when the location of the major aspherical portion of the femoral head is more anterior than lateral [39]. Rowe et al. [28] reported 25-year results on five patients undergoing simple cheilectomy for hinge abduction in LCPD. In their study, they reported that all patients demonstrated early arthritis by age 30 years and concluded that cheilectomy does not address the extraarticular impingement and is not effective at preventing early OA in LCPD hips with deformed femoral heads [28]. Isolated greater trochanter transfer may correct extraarticular impingement and weakness of the gluteus medius muscle but does not alter the intraarticular impingement [15]. With the surgical hip dislocation approach, the pathomorphology of the hip may be analyzed and the area of impingement (extraarticular versus intraarticular) determined [25]. In this series, we were able to perform simultaneous osteochondroplasty of the femoral head-neck junction with or without a relative femoral neck lengthening and/or a femoral intertrochanteric osteotomy using the surgical hip dislocation approach.

The procedures performed through the surgical hip dislocation approach resulted in short-term clinical improvement in WOMAC scores in patients with symptomatic LCPD. Ninety percent of patients experienced an improvement in pain and function at a mean followup of 3 years. Although surgical hip dislocation appears to be a reasonable approach for the healed LCPD hip, the literature is limited with few retrospective studies [1, 8, 27, 29] (Table 4). Eijer et al. [8] was the first group to present the results of joint reconstruction using the surgical dislocation approach in 11 patients with FAI secondary to LCPD. At 33 months followup, 50% of their patients were pain-free and all demonstrated some degree of pain improvement compared with their preoperative examination. No complications were seen and 10 patients demonstrated improved ROM postoperatively. In our initial experience with surgical dislocation of the hip [27], we reported a

variety of pediatric and adolescent hip disorders. In that study, there were 15 patients with LCPD who demonstrated improved short-term function with minimal complications. Similar improvements after joint reconstruction were seen in the current study with global improvements in the WOMAC domains of pain, stiffness, and function. Shin et al. [29] reported the results of using the Ganz surgical dislocation approach for the treatment of various pediatric hip diseases. In their study, four children had LCPD. Most recently, Anderson et al. [1] reported on 14 patients with LCPD disease (average age, 19.6 years) treated with surgical dislocation of the hip and trochanteric advancement. They found a high rate of osteochondritis dissecans lesions of the femoral head in LCPD hips and overall clinical improvement. Contrary to our study, they treated discrete labral tears with labrum takedown, débridement, and refixation of degenerated labrum. Similar to these studies, our data demonstrate the surgical hip dislocation approach allows for various procedures required to treat the intra- and extraarticular pathology associated with LCPD.

Our low complication rate is comparable to the other handful of retrospective studies that used the surgical hip dislocation to correct deformities secondary to LCPD [1, 8, 27]. We identified two cases of superficial wound infection, whereas Eijer et al. [8] and Anderson et al. [1] described no complications related to the surgery. In this series, 14% of the patients were considered clinical failures. Anderson et al. [1] reported failure in three of nine hips with Stulberg Class IV deformities. After a mean followup of 45 months, all the patients in their series had their native hip preserved. In our series, three (10%) patients required a THA after an average of 3.6 years. No hip was converted to THA at a mean followup of 33 months in the series by Eijer et al. [8]. Nine patients had subsequent surgical procedures performed after the index procedure. Again, we could not identify any unifying clinical or radiographic predictors in these patients. We suspect that the high rate of arthroscopy postdislocation reflected our philosophy of labral débridement rather than takedown and refixation during this study period. WOMAC scores in these patients illustrated limited pain and functional improvement; however, the small sample size did not warrant statistical analysis. Apart from the repeat arthroscopy, we have not found any other functional deficit in these patients.

In conclusion, our observations suggest the surgical hip dislocation approach allows the surgeon to dynamically evaluate the hip, identify sources of impingement, and treat intraarticular and extraarticular abnormalities. Head and neck osteochondroplasty performed through the surgical dislocation approach, combined with other procedures such as RFNL, ITO, and labral débridement, relieved pain and

Table 4. Summary of the literature on surgical dislocation in LCPD

Study	Number of patients	Age at surgery	Mean followup (months)	Primary procedure	Additional procedures	Complications and secondary surgeries	Outcome
Rebello et al. [27]	15 (57)	19.3	20	15 FHO	2 ITO, 4 ITO + RFNL	3 Failures* All underwent THA	WOMAC Pain 9 to 5 Stiffness 4 to 3 Function 23 to 14
Shin et al. [29]	4 (21)	15.7	15	2 FHO	2 CD, 2 ITO (F/V), 2 HD	1 AVN non-LCPD patient	Hip ROM Flexion 85° to 115°
Anderson et al. [1]	14	19.6	45	15 FHO	14 RFNL 4 OCD D/F	2 PAO 3 Failures According to Harris hip scores	Harris hip Preoperative 62 Postoperative 95 Tönnis grade 4/14 1 Tönnis grade deterioration 1/14 2 Tönnis grade deterioration
Current study	29	17	36	29 FHO	18 RFNL 7 LD 7 ITO F/V 2 ITO F 2 ITO E/V 1 ITO V	7 Arthroscopies 3 Failures* All underwent THA	WOMAC Pain 8 to 4 Stiffness 4 to 2 Function 21 to 13

* The same three patients were classified as failures and underwent THA in both studies; LCPD = Legg-Calvé Perthes disease; FHO = femoral head neck osteoplasty; ITO = intertrochanteric osteotomy; ITO (F/V) = flexion and valgus intertrochanteric osteotomy; ITO F = flexion intertrochanteric osteotomy; ITO V = valgus intertrochanteric osteotomy; ITO E/V = extension and valgus intertrochanteric osteotomy; LD = labral débridement; CD = core decompression; RFNL = relative femoral neck lengthening; HD = hip distraction arthroplasty; OCD D/F = osteochondral defect, débridement, and fixation; PAO = periacetabular osteotomy; AVN = avascular necrosis.

restored function in most patients with no major complications. Our findings are, however, preliminary and should be interpreted cautiously, recognizing that mid- and long-term followup studies are critical to demonstrate if this surgical approach provides durable pain-free hip function and avoidance of later THA.

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