

Legg-Calvé-Perthes Disease and Slipped Capital Femoral Epiphysis: Major Developmental Causes of Femoroacetabular Impingement

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Abstract

Problematic femoroacetabular impingement frequently is seen following Legg-Calvé-Perthes disease (LCPD) in young children and following slipped capital femoral epiphysis (SCFE) in older children and adolescents. Although symptoms may be mild in adolescents and young adults, chondral damage following LCPD and SCFE deformity is cumulative and irreversible, which has led to a recent emphasis on the consideration of early treatment. The surgical dislocation approach and improved MRI and three-dimensional CT have revealed common patterns of deformity and structural damage. The surgical dislocation approach is a superb diagnostic tool unmatched in assessing complex dynamic impingement patterns, and it allows direct treatment of deformity through recontouring of the head and neck and, in unhealed SCFE, epiphyseal realignment. The contemporary hip-preserving management of deformity following LCPD and SCFE is changing rapidly, necessitating careful evaluation of new treatment methods.

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Problematic Hip Deformity in Adolescents and Young Adults Following Legg-Calvé-Perthes Disease

Legg-Calvé-Perthes disease (LCPD) is an idiopathic osteonecrosis of the femoral capital epiphysis occurring in otherwise healthy young children.¹ LCPD typically presents in the 4- to 9-year-old child with an acute onset of unilateral limp and hip joint stiffness. The extent of femoral head necrosis varies; the bony necrosis inevitably heals, but often with residual proximal femoral deformity. Typically, the femoral head becomes relatively enlarged (coxa magna) and

aspherical. The proximal femoral neck becomes short, and the greater trochanter becomes more prominent. Some patients present with a shorter lower extremity on the affected side. Containment treatment of LCPD in childhood is designed to minimize subsequent deformity of the proximal femur.

Although the functional outcome often is initially satisfactory in late childhood, hip joint symptoms commonly develop in mid adolescence or early adulthood. Stulberg et al² radiographically classified the variable morphologic outcome of LCPD at skeletal maturity and suggested a correlation between long-term clinical

cal outcome and Stulberg classes I through V. The most current literature indicates that patients with Stulberg classes I and II hips, which have no asphericity, do well for years, whereas patients with Stulberg class III hips, in which the femoral head is nonspherical but not flat, often have an onset of hip symptoms—typically pain, stiffness, and limp—occurring as early as the third decade of life.^{3,4} Patients with Stulberg classes IV and V hips, which display notable coxa magna with asphericity and, often, femoroacetabular incongruency, can experience a problematic loss of hip function in the second decade of life.

Patient Evaluation

In all patients with prior LCPD, hip pain and associated loss of function occur secondary to femoroacetabular impingement (FAI), and some patients experience structural instability resulting from associated acetabular dysplasia. Pain associated with problematic LCPD typically is located anteriorly in the groin or laterally about the greater trochanter, or in both regions. On examination, flexion, internal rotation, and abduction motion are restricted variably and typically are painful on assessment (ie, positive impingement test anteriorly with flexion, adduction, and internal rotation and laterally with abduction).

Plain radiography and CT define femoral head pathomorphology, typically including coxa magna or head asphericity, often with an oval or mushroom-shaped femoral head. The femoral neck is relatively short, and the trochanter is prominent proximally (ie, high riding). Acetabular dysplasia often occurs second-

ary to acetabular remodeling in response to the aspherical femoral head. Labral and acetabular cartilage pathology, which often are present, are assessed with magnetic resonance arthrography.

Management

Initial management includes counseling regarding the natural clinical history of hip joint deformity after LCPD, activity modification, and use of nonsteroidal anti-inflammatory drugs as needed. Historically, surgical approaches such as proximal femoral valgus osteotomy, anterolateral cheilectomy, and distal trochanter transfer have been variably effective.⁵ The recent development of the safe surgical hip dislocation⁶ has resulted in improved understanding of the pathomechanics of comprehensive joint reconstruction of the problematic hip following LCPD and the technical skill needed to perform the procedure. Consequently, a notable improvement in outcomes and, in some cases, associated instability, has been seen following surgical management of problematic FAI in patients with prior LCPD.⁷⁻¹⁰ Given the increase in hip joint flexibility and the decrease in pain, hip joint function improves in most patients.

Appropriate patient selection is essential to maximize the potential clinical improvement for patients undergoing this comprehensive joint reconstruction. Younger patients in their second and third decades of life should anticipate and appreciate more improvement than older patients in their fourth and fifth decades. More specifically, patients who will likely experience maximal potential improvement in function

are those who have preoperative pain with motion assessment only at the extremes, who lack marked arthritic changes on radiographs, and in whom hip joint congruency is anticipated following joint preservation surgery. However, significant pain throughout the range of motion (ROM) assessment and arthritic changes on radiographs portend a more guarded outcome following joint preservation surgery.

Safe surgical hip dislocation provides surgeons a means of visualizing and optimally reshaping the often extremely deformed proximal femur and of correcting intra-articular acetabular pathologies. Extensive resection of the peripheral head and neck (ie, osteochondroplasty) and even reduction of the aspherical and enlarged central head can transform the femoral head into a relatively more normal spherical shape and size. In turn, the hip ROM improves. The technique of relative femoral neck lengthening and distal trochanter transfer eliminates the trochanteric impingement against the acetabulum, which further improves abduction and internal rotation motion.^{7,11} Direct repair of the labral or chondral injury also is possible. Joint instability, if present before surgery or potentiated with the reshaping of the proximal femur, can be corrected with a Bernese periacetabular osteotomy^{9,10,12} (Figure 1).

Although challenging, extensive reconstructive surgery has been demonstrated to be efficacious in the correction of pathomorphology directly related to prior LCPD.¹³ Early functional outcomes (ie, increased joint flexibility and stability) have been encouraging for patients and sur-

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Figure 1

Preoperative (A) and 1-year follow-up (B) AP radiographs of an 18-year-old man who initially presented with left hip pain. He had features of femoroacetabular impingement and acetabular dysplasia and was treated with a combined surgical dislocation, including femoral osteoplasty, relative neck lengthening, and trochanteric advancement. The hip was stabilized with a Bernese periacetabular osteotomy. The patient had an excellent clinical result.

geons. It is hoped that the early successes following joint preservation surgery will delay, for many patients, the need for total hip replacement for many years. Longer-term outcome studies are necessary to determine how best to identify the patients who are optimally suited to such a comprehensive surgical approach to the complex hip pathology secondary to deformity following LCPD.

Impingement Following Slipped Capital Femoral Epiphysis

Slipped capital femoral epiphysis (SCFE) is the second developmental hip disorder that often leads to the development of FAI. In the patient with SCFE, a gradual or acute disruption of the capital femoral physis occurs, resulting in posterior translation of the femoral head, an anterior prominence of the proximal femoral metaphysis, and an abnormally shaped femur that causes inclusion-type cam impingement

and early labral and cartilage damage.¹⁴⁻¹⁶ In mild SCFE, even the small metaphyseal prominence is injurious to the anterior acetabular cartilage and rim⁹ by means of the commonly associated femoral and acetabular retroversion and deep hip socket. More prominent metaphyseal deformity, as seen in moderate or severe SCFE, exerts damaging loads on the acetabular labrum and rim¹⁵ and usually is associated with severe clinical dysfunction in the form of limited motion. Long-term studies show a relationship between the degree of deformity and the risk of osteoarthritis.¹⁷ With appropriate management, however, most patients experience at least satisfactory function for decades.^{17,18}

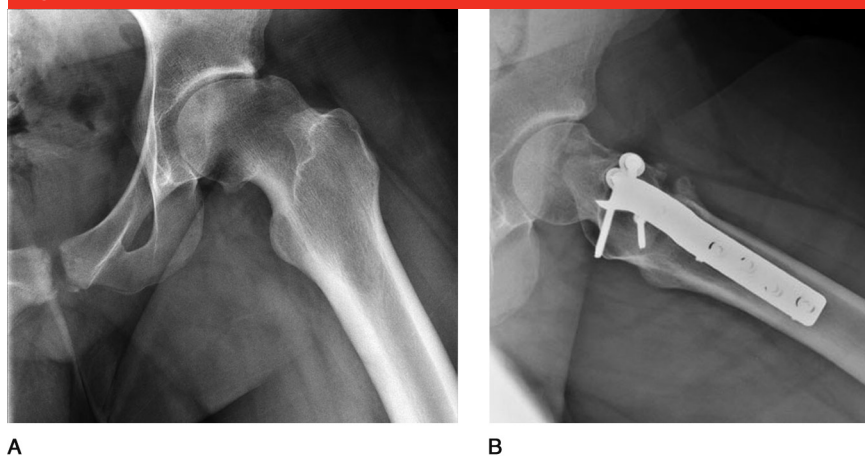
The optimal management of the hip with SCFE depends on several variables, including the status of the physis (ie, open or closed), the mechanical stability of the slip, the degree of deformity and associated impingement, and the experience of the treating surgeon in the various surgi-

cal options, including anterior and surgical dislocation approaches for open reduction and osteoplasty (Figure 2). The goal of treatment is to achieve the best possible short- and long-term hip function, while considering the potential benefits and risks, especially the risk of osteonecrosis, at each stage of treatment.

Patient Evaluation

Appropriate and timely patient evaluation is important for successful management. Evaluation should include a history, physical examination, and imaging. Symptom history is important because any slip that produces acute symptoms may result in an intra-articular hematoma, which could compromise the blood supply to the femoral head. Decompression by needle or arthrotomy should be considered if a closed reduction method is chosen.

The physical examination should include assessment of gait, hip motion, and pain caused by various maneuvers. The inability to walk, although not completely specific or

Figure 2

Preoperative AP (A) and 1-year postoperative lateral (B) radiographs of the left hip in a 16-year-old girl with a residual slipped capital femoral epiphysis deformity. She was treated with a combined surgical dislocation, including osteoplasty and relative neck lengthening, and flexion/derotation intertrochanteric osteotomy. Deformity correction and removal of the impinging metaphyseal prominence is noted in panel B. The patient had an excellent clinical result at 1-year follow-up.

sensitive for intraoperatively noted mechanical instability, does suggest physeal instability.¹⁹ Unstable SCFE requires urgent stabilization because the femoral head circulation is at risk, and delay may increase the risk of osteonecrosis.²⁰ Evaluation of the passive hip ROM should note the amount of internal rotation in 90° of flexion; internal rotation measuring ≤10° suggests anterior impingement.

Imaging should include an AP pelvic radiograph that shows both hips and extends below the greater trochanters. Some additional lateral projection of the proximal femur is needed, as well. If mechanical instability is suspected, a 45° Dunn or true lateral view may be performed instead of a frog-lateral view. The degree of actual deformity often is greater than that projected on routine views. In certain cases, CT or radial sequence MRI offers a more precise evaluation of the deformity. However, treatment should not be delayed in patients who require urgent care.

Management

The primary goals of treatment are to achieve mechanical stability with preservation of femoral head circulation while minimizing the amount of residual deformity that could lead to impingement. An unstable slip can be managed with closed or open reduction. Because all slips likely have some new bone growth on the posterior neck, complete anatomic reduction by manipulation is risky for slips with any degree of stability. The safest control of the blood supply during reduction is afforded by the surgical dislocation approach,⁶ which allows the development of an extended retinacular flap as well as direct visualization and removal of callus and other obstacles to anatomic reduction without tension on the blood supply. Intra-articular hematoma also may be removed at this time. The anterior approach also allows decompression of hematoma, direct anterior visualization of the physis, and straightforward reduc-

tion to the point of chronic slip,²⁰ but it does not allow direct visualization of posterior callus. If no surgeon experienced in open reduction methods is available, acute stabilization of the unstable slip may be performed in conjunction with the safest possible reduction method. Evaluation of the hip after stabilization should be performed as soon as is practical, and at most within a few weeks, at a center with surgeons experienced in the realignment of SCFE deformity, with transfer for further care arranged if appropriate.

The amount of deformity is a major determinant of long-term functional outcomes.¹⁷ Thus, for the stable slip or following stabilization of the unstable slip, the major concern is reducing the residual deformity. Although major deformity is well tolerated in some patients, minimizing deformity after SCFE should be considered when factoring the risk of various interventions. The mild stable deformity with a slip angle of approximately ≤30° may not justify realignment using osteotomy or acute reduction, although osteoplasty of the anterior metaphyseal prominence by open anterior arthrotomy or arthroscopy after physeal stabilization is an option. Hips with more severe deformity may benefit from femoral head realignment to improve motion, reduce impingement, and delay the onset of osteoarthritis, provided no complications occur as a result of the realignment.

Options for realignment include a modified Dunn osteotomy through the physis and flexion intertrochanteric osteotomy (ITO), with or without simultaneous resection of the metaphyseal prominence.¹³ With deformity so severe that realignment by ITO would not be sufficient, the open physis can be mobilized, even if SCFE has been managed with pinning, and a modified Dunn-type osteotomy can be performed by an ex-

perienced surgeon.²¹ The risk of osteonecrosis in this intervention is higher, however, than in intertrochanteric realignment because osteotomy through a closed physis is more complex and risky for the retinacular vessels. In this situation, distal neck osteotomy or ITO may be performed if enough deformity remains to suggest the need for realignment. Open approaches allow assessment and management of associated deformity, including both the ubiquitous anterior metaphyseal prominence, which damages the rim and labrum, and, in certain cases, overcoverage. Management of the damage to the labrum and anterior acetabular cartilage is sometimes performed, but no long-term results yet exist to allow comment on the therapeutic effect of these measures. Prophylactic stabilization of the contralateral hip is controversial but is probably indicated in certain high-risk cases, such as in the young patient with open tri-radiate cartilage at the time of the first SCFE or endocrine abnormalities.

Although most series report adequate long-term hip function in most treated patients, unless the deformity is severe or complications of treatment occur, trends show a slow loss of function.¹⁷ Greater attention to the potential for impingement in the pediatric hip with SCFE may further improve long-term outcomes.

Summary

Residual LCPD and SCFE deformities represent challenging prearthritic hip conditions, with FAI being a major component of the disease pathomechanics. The diversity of disease patterns and multiple contemporary treatment options pose challenges for future clinical outcome studies. Future studies should include multicenter, prospective analysis in which large numbers of patients are treated

with various surgical interventions. Longitudinal cohort designs may be most practical for resolving the current controversies regarding surgical management of these complex deformities.

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