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Knee Pain in a 12-Year-Old Girl

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CASE PRESENTATION

History

A 12-year-old Caucasian girl was brought by her parents to an orthopaedist with a chief complaint of left knee pain of 2 weeks' duration. Her primary care physician had obtained plain radiographs of her knees, which revealed no evidence of fracture, physeal injury, or abnormal bone quality. Because her symptoms continued to worsen, she was sent in referral to an orthopaedic surgeon for further evaluation.

The child reported that she had been in her usual state of good health until 2 weeks ago when she had gradual onset of left knee pain. She denied any recent trauma to her knee or any change in her activities prior to her symptoms. Before the onset of her symptoms, she was able to participate in physical activity at school without difficulty but currently was unable to participate because of pain. She reported that initially her symptoms consisted of slight discomfort but now had progressed to more significant pain that limited her ability to walk. Acetaminophen intermittently relieved her pain but did not completely mitigate all her symptoms. Despite the use of ice and anti-inflammatory medications, her knee pain persisted and had evolved to a limp and inability to bear full weight on her left side.

The patient had no history of fever, chills, or recent travel. She had not experienced any constitutional symptoms, including nausea, vomiting, headache, dizziness, or increasing fatigue. A thorough review of the patient's past medical history, social history, family history, and review of symptoms was unremarkable.

Key Point

The obturator, femoral, and sciatic nerves innervate the hip. Each can cause referred pain to the knee when there is hip pathology. As a result, the patient may complain of knee pain rather than hip pain, which can result in a delay in diagnosis.

Physical Examination

The physical examination revealed a well-developed, obese Caucasian girl with a pear-shaped habitus. She appeared to have the appropriate maturity for a 12-year-old female with no evidence of short stature or delayed growth. Evaluation of her head and neck did not reveal any signs of pathology. Auscultation of her heart and lungs was consistent with a normal cardiopulmonary examination. Her abdomen, while obese, was soft and nontender. Her neurologic examination was within normal limits and did not reveal any focal deficits.

Close attention was given to her musculoskeletal examination. The patient was placed supine during the examination of both lower extremities. Inspection of the knees did not reveal any evidence of trauma, gross deformity, or effusion. There was no evidence of erythema, hyperpigmentation, or open wounds. All ligamentous and meniscal structures, including the anterior and posterior cruciate and medial and lateral ligaments, were intact with provocative stress testing. There was no discernable area of tenderness in either knee. She had equal and full sensation and strength bilaterally with palpable pulses in her lower extremities.

Examination of her entire lower extremity, however, revealed that she held her left hip in marked external rotation compared to her right. She was unable to actively fully internally rotate or flex her left hip. Her right side had a full range-of-motion arc in flexion and

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Table. Differential Diagnosis of Knee Pain in the Older Child and Adolescent

Slipped capital femoral epiphysis
Inflammatory diseases
Osteomyelitis
Pigmented villonodular synovitis
Septic arthritis
Hemophilia
Juvenile rheumatoid arthritis
Overuse (repetitive) causes
Osgood-Schlatter disease
Sinding-Larsen-Johansson disease/patellar apophysitis
Minor patellar maltracking/patellofemoral pain
Jumper's knee (patellar tendinitis)
Pathologic plica
Intra-articular conditions
Meniscal tears/ discoid meniscus
Cruciate ligament injury
Osteochondritis dissecans
Pathologic plica
Benign and malignant tumors
Osteochondroma
Nonossifying fibroma
Osteoid osteoma
Chondroblastoma
Osteosarcoma
Ewing's sarcoma
Reflex sympathetic dystrophy

extension as well as internal and external rotation. In contrast to the right hip, passive internal rotation of her left hip was significantly limited. She reported left groin pain with forceful internal rotation of her left hip. She did not exhibit signs of tenderness or palpable masses in her groin or anterior and posterior aspects of her hip. Weight bearing on the affected lower extremity reproduced her pain. Comparison of direct measurements of her leg lengths obtained while she was supine demonstrated that the left leg was approximately 1.0 centimeter shorter than her right. Observing her gait pattern revealed that she held her left leg in external rotation with an antalgic limp. She also did not exhibit full flexion of her hip during her gait cycle and seemed to be slightly dragging her left leg. Her spine appeared to be clinically straight without any evidence of scoliosis. In addition, her pelvis seemed to be stable on stress testing and level when measuring the heights of the iliac wings. Trendelenburg's test could not be performed because of her inability to stand on the affected leg without pain.

Key Point

A history of lower extremity pain that is progressively worsening and causing an inability to weight bear should prompt a full lower extremity examination that includes radiographs because pathology may involve any of the joints or bones of the extremity regardless of the location of the perceived pain.

- **What is the differential diagnosis of knee pain in this patient?**

DIFFERENTIAL DIAGNOSIS OF KNEE PAIN

As with many pediatric orthopaedic diagnoses, the differential diagnosis primarily depends on the age-group. The list of possible diagnoses of an adolescent with knee pain is lengthy (**Table**). Narrowing the differential depends on key historical points and the physical examination. Because the patient is active and may have injured her knee while participating in physical activity at school, overuse causes and intra-articular lesions are higher on the differential for causes of knee pain. Osteomyelitis, septic arthritis, juvenile rheumatoid arthritis, and hemophilia are less likely to be responsible for her knee pain as the patient did not give any past medical history for recent infectious process or hemophilia. Finally, because the plain radiographs of the knee did not demonstrate any obvious lesions, tumors are less likely to be responsible for the pain. In this case, the presentation is typical of a patient with a possible diagnosis of slipped capital femoral epiphysis (SCFE). SCFE is a displacement of the proximal femoral epiphysis on the femoral neck, most commonly occurring in adolescents.[1–4]

- **What findings in this patient suggest a diagnosis of SCFE?**

SLIPPED CAPITAL FEMORAL EPIPHYSIS

Clinical Features

The case patient's presentation is consistent with SCFE. Patients with SCFE often initially present in the primary care setting with vague complaints of hip, groin, thigh, and perhaps knee pain due to referred pain from the obturator, femoral, and sciatic nerves that innervate the hip.[1,3,5] Although most patients (85%) with a diagnosis of SCFE present with a primary complaint of pain in the hip, groin, or proximal thigh, 15% of patients present with a primary complaint of distal thigh or knee pain only.[5] The clinician should initially keep a broad differential in this age group,

including disorders of both the hip and knee.[3,5] With the pain, the patient may develop a limp and problems with weight bearing. Slips are characterized as stable or unstable based on the ability of the patient to bear weight on the affected extremity. When examining a patient with suspected SCFE, the clinician should inquire about the duration of pain because an acute or chronic classification is based on whether the pain has been present for more than 3 weeks.

As with the history, the physical examination of the case patient is quite typical of SCFE. The child will hold his or her extremity in external rotation at the hip due to the posteroinferior displacement of the epiphysis.[6] The affected extremity may be shortened compared to the contralateral side, and range of motion at the hip joint is limited. A decrease in internal rotation and flexion should be documented to support the diagnosis. It is important to examine both hips, not only for comparison, but also because of the possibility of bilateral disease. Failure to evaluate the hip and contralateral knee in patients with unilateral knee pain is a common mistake.

- **What demographic and physical factors are associated with the development of SCFE?**

Epidemiology

SCFE is the most common hip disorder in adolescents.[2] A worldwide incidence of 2 per 100,000 individuals and a US incidence of 1 per 100,000 individuals have been reported.[3] SCFE should be considered in an obese adolescent with complaints of hip, groin, or knee pain or in those with an inability to bear weight and a subsequent limp. Demographic factors, including patient age, sex, and ethnicity as well as predisposing factors, most notably weight, can aid in narrowing the differential. The average age at which SCFE develops in girls is 11 to 13 years and in boys 13 to 16 years.[3] Children with Polynesian heritage have the highest prevalence, estimated to be 4.5 times that of Caucasian children.[2] African-American children have a higher likelihood of developing SCFE than Caucasian children.[2,3] It is estimated that boys are 1.5 times more likely to have a SCFE than girls.[2,3] In some parts of the world, such as the Mediterranean area, boys may be as much as 4 times more likely to have a slip than girls.[2] However, the most important factor in the development of a SCFE is weight. Adolescents who are obese and have a large body habitus have a much higher rate of developing a slip. As many as 60% of individuals diagnosed and treated for a SCFE have been above the 90th percentile for weight in their respective age group.[2,7]

Key Point

The hallmark characteristics of SCFE are pain in the affected hip or groin, a change in hip range of motion, a gait abnormality, and a radiograph that demonstrates a displacement of the femoral neck from the capital femoral epiphysis through the physeal plate.

- **How is the diagnosis of SCFE confirmed?**

Diagnostic Methods

The primary modality to confirm the diagnosis of SCFE is plain radiography. Anteroposterior (AP) and frog-leg lateral pelvic views are examined to identify the displacement of the femoral neck on the proximal femoral epiphysis. The physis should be carefully examined for possible widening without the posterior displacement indicative of SCFE. Both hips should be included in the radiographs despite unilateral complaints to rule out bilateral involvement. A line should be drawn along the superior border of the femoral neck (Klein's line), and this line should bisect the femoral epiphysis. Failure to intersect the epiphysis confirms the diagnosis of SCFE.

RADIOGRAPHIC AND LABORATORY STUDIES IN CASE PATIENT

Plain radiographs including AP and lateral images of the left knee did not show evidence of bony pathology. AP and frog-leg lateral views of the pelvis depicted a slipped epiphysis of the proximal femur on the left side (**Figure 1**). The physis on the left side was widened compared to the right side. Additionally, the radiographs demonstrated that the capital epiphysis had slipped posteroinferiorly. Klein's line failed to intersect the lateral aspect of the epiphysis indicating the presence of a SCFE. There was no evidence of any other pelvic or proximal femoral fracture. The bone quality on the images appeared to be appropriate for an adolescent girl. Of note, there was no evidence of osteonecrosis of the femoral head.

Laboratory investigations included a complete blood count, a basic metabolic panel with blood urea nitrogen and creatinine measurements, and a thyroid-stimulating hormone level to assess thyroid function. All of these values were within normal limits.

Key Point

It is imperative to obtain both AP and frog-leg lateral radiographs of the hip when evaluating for a SCFE. Additionally, hypothyroidism has been associated with an increased rate of SCFE, particularly bilateral SCFE. Endocrinopathies such as hypothyroidism should be considered as a factor when evaluating patients with SCFE, particularly in children younger than 10 years of age who present with a SCFE.

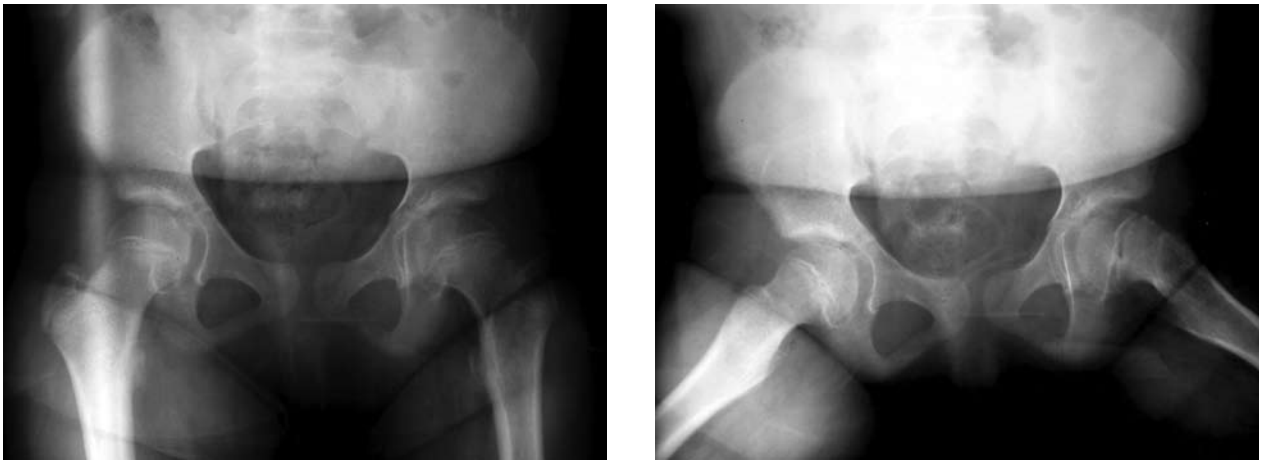

Figure 1. Anteroposterior and frog-leg lateral views of the pelvis of a 12-year-old girl with a chief complaint of left knee pain for 3 weeks. Note the widened and irregular physis on the anteroposterior view and the inferior displacement of the capital femoral epiphysis on the frog-leg lateral image.

- **What are the causes of SCFE?**

Etiology

A clearly defined cause for SCFE has not been identified, although many theories have been proposed.[4,8–12] A traumatic event may cause a fracture through the physis, but most cases of SCFE cannot be attributed to trauma. Most cases of SCFE occur in individuals who are obese, and investigators have reported that mechanical factors may play a role in the disorder.[9–11] In an immature proximal femur, compressive forces tend to stabilize the epiphysis on the metaphysis. With excessive weight, an increase in shear stresses may cause the epiphysis to displace posteriorly and produce the clinical manifestations of a SCFE. These increased vector forces on the proximal femur also play a role in another theory of SCFE.[11] In an adolescent hip, the femoral head is oriented more posteriorly in relation to the femoral shaft than in adults, a quality termed retroversion. This femoral retroversion allows the shear forces to overcome the physis and displace it.[12]

Additional factors that have been cited in the etiology of SCFE include endocrinopathies and nutritional deficiencies. Many orthopaedists, in fact, consider that the presence of bilateral slipped epiphyses warrants an investigation into metabolic abnormalities, specifically hypothyroidism and osteodystrophies.[4,13] The routine evaluation of hormonal disorders in patients with SCFE, however, remains controversial, with most orthopaedic surgeons opting to evaluate these disorders in patients with bilateral slips and in children under the age of 10 years.[4]

Finally, radiation therapy to the proximal femur for any nearby malignancies increases the risk for physeal dysfunction.[14] Chemotherapeutic agents may enhance the effects of radiation on the capital physis. Post-radiation SCFE tends to occur in children who are younger and of normal weight and is less likely to be bilateral.[14]

- **What is the approach to treatment of SCFE?**

Treatment

The primary goals of treatment in SCFE are prevention of further slippage and stabilization of the epiphysis on the metaphysis. The treatment of SCFE is urgent. Unstable SCFE, in which patients are unable to bear full weight, requires admission and surgical stabilization at the earliest possible time. Stable SCFE also requires prompt attention and surgical correction. Regardless of the classification, patients should be given crutches and immediately made non-weight bearing on the involved side to prevent further slipping. Patient noncompliance can result in further slipping after the diagnosis has been made. The risk and severity of any subsequent complication from a SCFE depends on prevention of slip progression and prompt stabilization.

The published literature suggests that the most effective and appropriate management of SCFE is surgical intervention.[15–19] Most SCFEs today are fixed with in situ single-screw fixation.[16,19,20] Care must be taken to surgically place the screw from the metaphyseal area of the femur into the epiphysis, ensuring that the epiphysis remains as a unit with the metaphysis and that both regions move in unison during range of motion of the hip.[20] In situ fixation involves stabilizing the epiphysis

in its displaced position without realigning the proximal femur to its pre-slip position.[17,19] Many orthopaedists believe that forceful reduction of the slip before screw fixation may aggravate the hip and increase the incidence of complications, including osteonecrosis, chondrolysis, and fracture. Others, however, recommend the use of 2 screws rather than a single screw in the treatment of unstable slips, reporting that secure fixation outweighs the increase in complications.[17,18]

The most controversial aspect in the treatment of SCFE is prophylactic screw fixation of the contralateral asymptomatic hip. The prevalence of bilateral SCFE has been estimated to be from 20% to 30%.[1] Nearly all patients who develop SCFE in the contralateral hip do so within 18 months of diagnosis of the first slip. Therefore, patients with unilateral SCFE should be followed closely to detect a possible slip in the opposite hip. Prophylactic screw fixation of the asymptomatic hip is not routinely done by most orthopaedists today. However, prophylactic screw fixation may be useful in high-risk populations with predisposing factors for subsequent slip. These clinical scenarios include patients who have a history of hypothyroidism, renal osteodystrophy, endocrinopathies, history of irradiation, and strong family history of SCFE. The rationale is that securing both hips in a single setting avoids the risk of 2 episodes of anesthesia. When electing to surgically secure the asymptomatic hip, the surgeon must weigh the benefits of prophylactic surgery against the possibility of complications in an initially asymptomatic hip.[21]

Key Point

Nearly all patients who develop SCFE in the contralateral hip do so within 18 months of diagnosis of the first slip. Therefore, patients with unilateral SCFE should be followed closely to detect a slip in the opposite hip.

- **What complications are associated with SCFE and its treatment?**

Complications

Even with prompt treatment of SCFE, complications may develop.[22,23] The most common are osteonecrosis and chondrolysis of the femoral head. Both result from an interruption of the blood supply to the femoral head. It is uncertain whether the original slip or the surgery disrupts the blood supply to the femoral head. The nutrient vessels that supply the proximal femur form a nexus around the metaphysis and neck of the femur. The entry point of the screw often is placed in this location to secure the epiphysis to the femoral neck.[3] It is plausible that placement of the screw may damage the blood supply. As blood flow to the femoral head decreases, the epiphysis may collapse and cause more pain and a decrease in normal range of motion of the hip joint. Osteonecrosis may not become apparent for as much as 1 year after the initial surgery.[24] Therefore, even though children may have prompt resolution of their symptoms of the SCFE, they should be seen in follow-up for at least 1 year after surgery.

Similar to osteonecrosis, chondrolysis of the femoral head must be evaluated in postoperative visits. Overlying the subchondral bone of the femoral head is a layer of hyaline cartilage that articulates with the acetabulum of the pelvis. This cartilage layer in part allows for a more fluid hip range of motion. If the hyaline cartilage deteriorates, the protective covering of the femoral head slowly diminishes. With bare subchondral bone articulating with the pelvis, the patient may complain of constant hip or groin discomfort. The destruction of the cartilage cap may cascade into the early development of osteoarthritis,[25] which if severe enough, may cause severe disability and discomfort for the child and may lead to significant limitation in activity.[25] Although many alternatives exist in the treatment of osteoarthritis in adults, the options available for children are few. Furthermore, arthritis in young patients is even more challenging than in adults because of their increased activity level and an increased likelihood for early failure.

TREATMENT AND OUTCOME IN CASE PATIENT

The patient was immediately admitted to the hospital for operative fixation of her hip. She was kept non-weight bearing on her left side to prevent further slippage. The patient was taken to the operating room with a diagnosis of an acute SCFE and underwent an in situ percutaneous single screw fixation of her left hip. She did not have any complications during the procedure and was discharged home the next morning after completing crutch training by a physical therapist. Postoperative radiographs of the pelvis demonstrated the screw to be in an acceptable position without penetration into the hip joint (**Figure 2**).

The patient had quick resolution of her knee pain. Her gait improved over the 3 months following surgery, and she was able to bear weight without difficulty. Despite minor residual external rotation at the hip, her limp also improved. She returned to her full activities in school and was able to participate in physical education. At the 1-year and subsequent postoperative follow-up visits, radiographic evaluation of her hip did not reveal any complications, such as screw migration

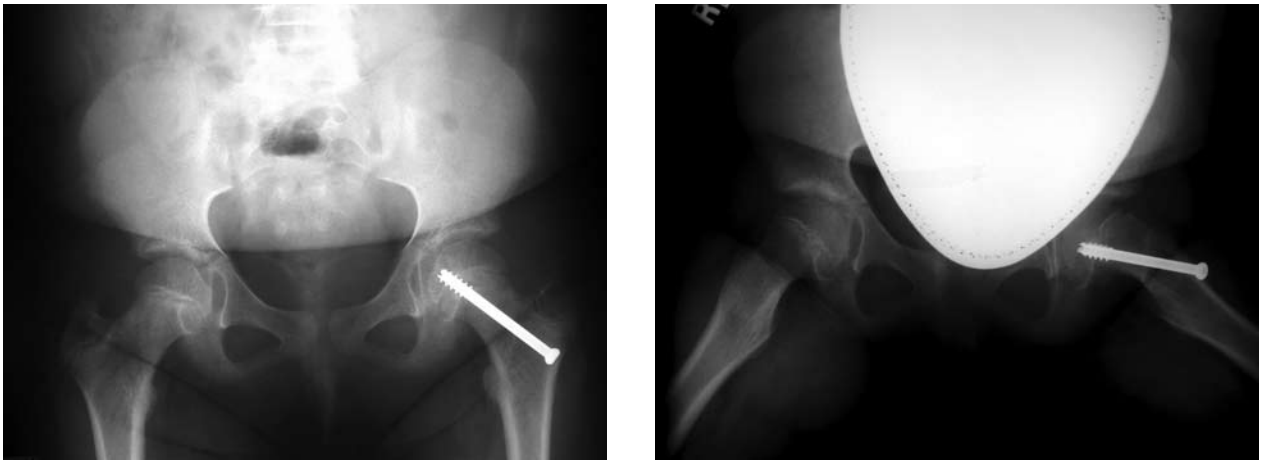

Figure 2. Postoperative radiographs demonstrating in situ single screw fixation of the left hip after the diagnosis of a slipped capital femoral epiphysis. Note that the screw captures the epiphysis but does not penetrate into the hip joint.

or failure or osteonecrosis or chondrolysis of the femoral head. She currently is asymptomatic.

CONCLUSION

Although the complications of SCFE can be devastating, treatment for this condition usually has a good outcome.[22] The key to successful treatment of SCFE, as with all conditions, is an awareness of the disease and an increased vigilance in the diagnosis of atypical cases. SCFE should be included in the differential diagnosis of an adolescent with hip, groin, or knee pain. A complete history and physical examination should be obtained to discern predisposing factors that might aid in the diagnosis. Confirmatory AP and frog-leg lateral radiographs should be evaluated for SCFE. Once diagnosed, the child should receive prompt orthopaedic consultation to discuss the need for surgical fixation. If treated appropriately, most children with SCFE become pain free and return to their activities. **HP**

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