PEDIATRIC EMERGENCY MEDICINE REPORTS

Practical, Evidence-Based Reviews in Pediatric Emergency Care

August 2016 VOL. 21, NO. 8

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STATEMENT OF FINANCIAL DISCLOSURE

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A Review of the Limping Child and Painful Hip

Definition of the Problem

The evaluation and management of a child with a limp and/or hip pain is a common issue for the emergency physician. The differential diagnosis is broad and includes disease of the spine, hip, leg, and even foot. These pathologies range from benign inflammatory conditions to more serious conditions, such as septic arthritis or even neoplastic processes. The conditions causing a limp may be chronic or acute. Some acute limp causes include traumatic injuries, foreign body in the foot, septic arthritis, transient synovitis, osteomyelitis, slipped capital femoral epiphysis (SCFE), and diskitis. Other more chronic or indolent causes of limp include rheumatic disease, Legg-Calve-Perthes disease, developmental dysplasia of the hip, neoplastic disease, and overuse injuries.[1-3] It can be difficult to decide when to obtain laboratory tests and imaging on these patients, particularly nonverbal infants or young toddler-age children. The limp or painful hip may be an early sign of significant processes that could result in severe long-term complications if not diagnosed and treated in a timely fashion.[4] Defining a systematic approach tailored for this can reduce time spent in the emergency department (ED) and ensure appropriate testing is performed to achieve the correct diagnosis.[5] This review will focus mainly on the minor musculoskeletal trauma and atraumatic causes of limp and hip pain in the pediatric population.

Epidemiology

Limping and hip pain are familiar chief complaints to emergency physicians and may be atraumatic or traumatic in etiology. One institution noted that 5% of its ED visits were for inability to bear weight or because of a limp.[2] Most of these presentations are secondary to traumatic injuries and will be self-evident.[8] In contrast, atraumatic limp or hip pain can be variable in presentation and can pose a diagnostic dilemma for the emergency medicine practitioner. At one institution, it was found that over a six-month period, the incidence of atraumatic limp was 1.8 per 1,000, and the male to female ratio was 1.7:1, with a median age of 4.35 years.[6] The most common diagnosis for atraumatic hip pain and limping is transient or toxic synovitis, which is diagnosed in as many as 85% of children presenting with this condition.[2] Osteomyelitis and septic arthritis, whose complications include limb deformity secondary to growth arrest, joint stiffness, and osteonecrosis, fortunately are less common, but up to 50% of these occur simultaneously with both joint and bone involvement.[4,7] Other causes include slipped capital femoral epiphysis, Legg-Calve-Perthes disease, developmental dysplasia of the hip, neoplastic disease, overuse injuries, toddler's fracture, rheumatologic processes, and even blood dyscrasias. All of these must be considered when evaluating a pediatric patient with limp or hip discomfort.

Etiology

A child usually limps because he or she has pain in one or both legs or hips with walking. The pain may arise from the soft tissues, bone, joint, or be referred from

EXECUTIVE SUMMARY

- The most common diagnosis for atraumatic hip pain and limping is transient or toxic synovitis, which is diagnosed in as many as 85% of children presenting with this condition.
- Pain characteristics can help with the differential. Constant pain is more concerning for infection or malignancy. Morning pain is more consistent with inflammatory joint disorders. Pain after activity may indicate an overuse injury such as a stress fracture, osteochondritis dissecans, Sever's syndrome, or Osgood-Schlatter disease. Night pain that wakes a child could indicate malignancy. Night pain relieved by nonsteroidal anti-inflammatory drugs (NSAIDs) is characteristic for osteoid osteoma, but not diagnostic.
- Transient synovitis is a self-limiting condition that is treated conservatively with rest and NSAIDs and typically resolves within 3-10 days.
- Because of the complications that can arise from prolonging appropriate treatment for septic arthritis, patients with an intermediate or high probability of septic arthritis should undergo an ultrasound or fluoroscopically guided hip aspiration. Positive cultures, a white blood cell count > 50,000 per mL in the synovial fluid, or a positive Gram stain confirm the diagnosis of bacterial septic arthritis.
- Patients with Legg-Calve-Perthes classically present with a limp, mild pain described as radiating to the groin and localizing to the hip join, and/or limited hip motion, and may present to the ED during any phase of the disease process.
- Slipped capital femoral epiphysis more commonly affects boys, with an average age of 13.5 years for males and 12 years for females. More than half of the patients affected are in the 95th percentile or higher for weight. Bilateral involvement occurs 18-50% of the time.
- Patients who are below the 10th percentile for weight or younger than 10 years of age should be worked up for metabolic causes, including hypothyroidism and osteodystrophy.
- Discoid meniscus is a diagnosis that includes a range of meniscal disorders affecting the shape and stability. On physical exam, a dramatic clunk may be appreciated with McMurray's test due to subluxation of this abnormal meniscal tissue. This finding is present in approximately 40% of patients.

elsewhere. The initial step in establishing a diagnosis is elucidating the exact location of pain. This may be easy in an older child who is able to verbalize and localize where the pain is, but is far more difficult in the toddler or infant. Thus, examination and history will be crucial to establishing the site of pain. Once this is known, the cause can be investigated further. The age of the child and the pattern of gait can further help guide the diagnosis.[3] (*See Table 1.*)

When evaluating a child with a limp, it is imperative to identify the gait abnormality, determine the location of origin, and use this to develop a short differential list.[3] This differential list is used to guide the workup, which includes starting with a thorough history and physical examination.

Table 1. Differential Diagnosis of Antalgic Limp in Children by Age[1,3]

1-5 years	5-12 years	> 12 years
• Fracture (particularly toddler's) • Osteomyelitis • Septic arthritis • Diskitis • Arthritis: juvenile idiopathic arthritis (JIA), Lyme disease • Discoid lateral meniscus • Foreign body in foot • Benign or malignant tumor • Hemarthrosis (hemophilia) • Henoch-Schönlein purpura • Transient synovitis (3 to 10) • Minor musculoskeletal trauma	• Fracture • Osteomyelitis • Septic arthritis • Diskitis • Legg-Calve-Perthes disease • Transient synovitis • Osteochondritis dissecans • Discoid lateral meniscus • Sever's apophysitis • Accessory tarsal navicular • Foreign body in foot • Arthritis: JIA, Lyme disease • Benign or malignant tumor • Spinal dysraphism (tethered cord)	• Fracture (particularly stress) • Osteomyelitis • Septic arthritis • Diskitis • Slipped capital femoral epiphysis • Larsen-Johansson syndrome • Osgood-Schlatter disease • Sever's apophysitis • Osteochondritis dissecans • Chondromalacia patellae • Lyme disease arthritis • Gonococcal arthritis • Accessory tarsal navicular • Tarsal coalition • Benign or malignant tumor • Spinal dysraphism (tethered cord)

Clinical Assessment

History. A history often can be difficult to obtain from a young child or infant and requires input from parents if available. The initial focus of the history should include location of pain, duration of symptoms, traumatic injury, prior pain in the area, and other associated symptoms.[11] If symptom onset is acute and severe, consider infection, trauma, and even malignancy. If gradual and chronic in onset, think about inflammatory or mechanical conditions. Constant pain is more concerning for infection or malignancy. Morning pain is more consistent with inflammatory joint disorders. Pain after activity may indicate an overuse injury such as a stress fracture, osteochondritis dissecans, Sever's syndrome, or Osgood-Schlatter disease.[3] Night pain that wakes a child could indicate malignancy. Night pain relieved by nonsteroidal anti-inflammatory drugs (NSAIDs) is

Table 2. Differential Diagnosis of a Nonantalgic Limp

Trendelenburg Gait	Circumduction Gait	Steppage Gait	Equinus Gait
• Legg-Calve-Perthes disease • Developmental dysplasia of the hip • Slipped capital femoral epiphysis • Muscular dystrophy • Cerebral palsy	• Ankle or knee stiffness • Limb-length discrepancy • Cerebral palsy	• Myelodysplasia • Friedreich's ataxia • Charcot-Marie-Tooth disease • Cerebral palsy	• Limb-length discrepancy • Clubfoot • Tight Achilles tendon • Cerebral palsy

Source: Author adapted.

characteristic for osteoid osteoma, but not diagnostic.

The location of the pain is important, but keep in mind that it could be referred from another location. This is particularly common in painful hip conditions that often refer to the knee. Buttock or lateral thigh pain may be referred from the back and spine. Pain that is located in more than one joint is more likely to be from an inflammatory cause.

History of recent viral upper respiratory tract infection is associated with transient synovitis. History of methicillin-resistant *Staphylococcus aureus* (MRSA) infections may be associated with septic arthritis or osteomyelitis. Tick bites could precipitate a Lyme arthropathy.

Failure to reach motor milestones could point to a neuromuscular disease process. Adolescent patients should be asked about sexual activity, as they may be at risk for gonococcal arthritis.

Evaluation of Gait Patterns. A limp is defined as a deviation from the normal pattern of gait. When evaluating a child with a limp, one must understand the normal walking patterns by age.[2] Children typically begin to walk around 12-16 months of age. They tend to have a wide-based gait, short stride length, and fast cadence.[2,13] The wide-based gait helps provide more stability as the children continue to develop balance with age. Toddlers tend to have frequent falls because of poor balance and immature motor skills, thus increasing the likelihood of traumatic injury. It is not uncommon for them to demonstrate foot slapping with walking.[2] By age 3 years, children tend to walk with more symmetry, but still lack some balance and hip abductor strength to maintain a single leg stance for long. They also tend to have a short stride. By age 7 years, most children exhibit a normal adult gait pattern. Normal gait is smooth, rhythmic, and advances the center of gravity with the least expenditure of energy.[2,3,12] The stance and swing phases are terms used to describe gait cycles.

Gait can be altered by pain, a mechanical problem, or a neuromuscular problem. Evaluating a limping child reveals specific patterns of deviation from normal gait. Antalgic gait is the result of pain in the affected limb. The child attempts to avoid pain in the affected limb by shortening the single-leg stance in this limb. Stride length is shortened on the opposite limb to limit the amount of time spent in single-leg stance phase on the painful limb. This allows the child to return to bearing weight on the non-painful extremity as quickly as possible.[3,12]

A few variations of antalgic gait can be seen in certain disorders. A child with back pain (i.e., diskitis) may lose the normal rhythmic flexion and extension of the lumbar spine. This can be elicited by having the child bend to pick up something off the floor. Another variant of antalgic gait is complete refusal to walk, most often seen in toddlers. This is seen when the patient cannot alter his or her gait to avoid the pain and, hence, completely refuses to walk. Children with a painful limb may ambulate with circumduction of their hips. This excessive hip abduction allows them to clear the foot without motion of the painful joint. This often is seen in pathology of the ankle.[3]

Nonantalgic gait disturbances also may be seen. (*See Table 2.*) Children with a short limb may vault off the short limb or toe-walk to clear the long leg. Equinus gait (toe walking) occurs when ankle dorsiflexion is limited and could be the result of a tight heel cord (gastroc-soleus spasticity or shortening of the Achilles tendon), limb-length discrepancy, clubfoot, or a neurologic disability such as cerebral palsy.[2,3] Trendelenburg gait occurs with altered hip mechanics, particularly weakness of the hip abductors. The child will appear to be shifting his or her weight over the affected hip during stance phase. A variation of Trendelenburg gait is the waddling gait of a child with bilateral hip dislocations. Stance phase is not shortened, as it is in an antalgic gait, and this can help differentiate these two distinct gait patterns.[2,3]

Steppage gait occurs with weak ankle dorsiflexion. To compensate for ankle weakness, the child increases knee flexion in the swing phase to clear the foot. The foot may slap the ground because the ankle dorsiflexors are unable to decelerate the foot between heel strike and flat foot.

Evaluate the gait closely, look at symmetry of gait, abnormal limb rotation, balance, and upper extremity positioning during gait. Careful analysis of the gait pattern will help localize the origin of the limp and thus further guide the diagnostic workup.

Physical Exam. If possible, the child's gait should be assessed first. It is important to have the child remove all or most of his/her clothing so that the extremities, skin, joints, and skin folds can be assessed thoroughly. Evaluate the patient's gait closely, looking for limp and symmetry of gait, abnormal rotation, and overall balance.[3,12] If the child is unable to walk, evaluate the extremities and spine while the child is sitting. Begin with the non-affected side (if the pain or disturbance is localized) and leave the affected limb until the end. Assess the skin for any rashes or skin lesions. These could provide clues to diagnosing Lyme disease, rheumatologic processes, foreign bodies, or traumatic injuries. Be sure to assess the spine and evaluate for tenderness or deformities. Abnormal findings could provide clues for the cause of limp such as trauma, osteomyelitis, or even diskitis. Evaluate the pelvis. Fully range all joints of the extremities. Palpate musculature for masses or areas of tenderness. Perform a full neurological assessment of

the extremity for both motor and sensory nerves.[2]

The workup then should be guided by history and physical exam. There are many etiologies of hip pain and gait disturbance. These will be described in further detail with attention to the more serious, critical, and time-sensitive conditions.

Causes of Limp

Transient Synovitis and Septic Arthritis

Transient synovitis is defined as a benign inflammatory condition affecting the hip that is self-limited and is often diagnosed after other more serious conditions have been ruled out.[15] It has been called several different names, including transitory coxitis, acute transient epiphysitis, coxitis fugax, coxitis serosa seu simplex, phantom hip disease, toxic synovitis, and observation hip.[15] The literature describes an incidence of approximately 0.2%, most often in children between 3 and 8 years of age, and it is more common in males.[15] Infrequently it will occur bilaterally. Most of the epidemiological data are from European countries and are extrapolated. The underlying etiology of transient synovitis is not definite, but there is some correlation with preceding viral symptoms, such as upper respiratory tract infection or vomiting and diarrhea.[16] Older studies have demonstrated a correlation with minor trauma preceding the disease process.

The patient with transient synovitis usually will present with groin or thigh pain, a limp, and will not bear weight on the affected side. Often, the hip will be abducted and externally rotated at rest, and pain will be elicited during various movements, particularly passive range of motion.[16] When the hip is flexed, abducted, and externally rotated, there will be lower intracapsular pressure and, thus, this position will be most comfortable for the patient.[15] Transient synovitis is a self-limiting condition that is treated conservatively with rest and NSAIDs and typically resolves within 3-10 days.

Contrary to the relatively benign course of transient synovitis is that of septic arthritis. The diagnosis is made by clinical assessments and the use of laboratory and imaging studies to exclude other diagnoses. Several studies emphasize the variables used to differentiate transient synovitis from septic arthritis, as their presentations tend to be quite similar.[17-20]

Table 3. Modified Kocher Criteria[17]

Parameter	Threshold Value
Temperature	> 38.6° C
White blood cell count	> 12,000/mL
Erythrocyte sedimentation rate	> 40 mm/hr
C-reactive protein	> 20 mg/L (2 mg/dL)
Functional status	Unable to bear weight

Source: Author adapted.

One study developed an algorithm for predicting the probability of septic arthritis and included fever (temperature > 38.5° C), inability to bear weight, erythrocyte sedimentation rate (ESR) > 40 mm/hour, and serum white blood count (WBC) > 12.0 x 10^6 cells/L. In this group of patients, the probabilities of septic arthritis with one, two, three, and four predictors present were 3%, 40%, 93.1%, and 99.6%, respectively.[17] (*See Table 3.*) When adding a C-reactive protein (CRP) > 1 mg/dL, the predicted probabilities of three, four, and five positive factors were found to be 83%, 93%, and 98%, respectively.[20] Fever was found to be the most significant predictor, followed by increased CRP in one study.[21] However, a CRP > 2 mg/dL was found to be the strongest independent predictor of septic arthritis.[22]

The workup should include plain radiographs, which occasionally show medial joint space widening in transient synovitis but are not considered sensitive for evaluating a joint effusion.[23] More importantly, they can help rule out fracture, Legg-Calve-Perthes disease, and slipped capital femoral epiphysis. Ultrasound is noninvasive and can reliably detect a small hip effusion; however, it cannot distinguish between the causes of hip effusion.[23,24,25] Lack of effusion can be helpful in excluding septic arthritis, but is not definitive, particularly in the early stages of the disease.[25]

Bone scintigraphy is useful in evaluating multifocal musculoskeletal infections, but is not sensitive nor specific to distinguish transient synovitis from septic arthritis.[23,25]

MRI is useful in determining if a patient has septic arthritis or transient synovitis, particularly with an equivocal clinical presentation and ultrasound results. MRI facilities are not always readily accessible and they often require administration of general anesthesia in the youngest pediatric patients.[15]

MRI findings of transient synovitis will reveal a joint effusion and absence of signal intensity abnormalities in the bone marrow. Findings supportive of septic arthritis rather than transient synovitis include decreased perfusion in the femoral head, signal intensity alterations, and contrast enhancement of the soft tissue and increased signal intensity in the bone marrow.[26-28] (*See Figures 1 and 2.*)

Because of the complications that can arise from delayed treatment for septic arthritis, patients with an intermediate or high probability of septic arthritis should undergo an ultrasound or fluoroscopically guided hip aspiration. Positive cultures, a WBC > 50,000 per mL in the synovial fluid, or a positive Gram stain confirm the diagnosis of bacterial septic arthritis.

Treatment for septic arthritis within 72 hours of symptom onset can reduce complications, such as sepsis, growth abnormalities, and loss of motor function.[14] Surgical debridement and antibiotic therapy are the mainstays of therapy. Initial antibiotic choice should include broad coverage for MRSA.[35] (*See Table 4 for details.*) Researchers have proposed that a short course of adjuvant dexamethasone can promote earlier improvement of both laboratory and clinical parameters as well.[38]

Osteomyelitis

Pediatric bone and joint infections peak at a rate of 80 per 100,000.[7] Osteomyelitis and soft tissue infections may present with limping and antalgic gait. These may be difficult to diagnose, and exam findings may not be obvious, particularly early in the disease course. Patients may present with a local cellulitis or induration of the extremity, point tenderness, or painful range of motion of the affected joint.

Initial workup should include an X-ray, although these may be falsely negative; it takes 7-10 days for the periosteal reaction along the infected bone to be evident. Lab markers, including WBC, ESR, and CRP, will be elevated in most cases. MRI with contrast is the study of choice for diagnosing these infections and other soft tissue infections. Treatment includes antibiotics with or without surgical debridement in extensive or non-responsive cases. Pathogens are similar to those for septic arthritis and occasionally these will occur together.[2]

Developmental Dysplasia of the Hip

Developmental dysplasia of the hip (DDH) is the most common defect in newborns, with an incidence ranging from 1-35 per 1,000 live births.[9] The definition encompasses a spectrum of abnormal findings of the developing hip. These range from subtle findings on X-rays to subluxation and dislocation of the hip joint. It is suspected that some cases of DDH are a result of specific genetic polymorphisms, although they can be multifactorial. In the absence of family history, the risk of a child being born with DDH is 0.2%, whereas children with parents with DDH have a 12% risk, and siblings of those with DDH have a 6% risk. There is a female predominance of 8:1. The risk is increased in breech deliveries.[8,9,10]

Infants can be clinically evaluated using the Barlow and Ortolani tests. The Barlow test is done by pressing posteriorly on the flexed, adducted thigh. If the hip is dislocated at rest or with posterior stress, then the examiner should determine if the hip is reducible. This is the Ortolani maneuver, which is performed by moving the flexed hip into abduction while pressing the greater trochanter toward the acetabulum.[9] Leg length discrepancy and a limp may be the presentation in children over 1 year of age. In infants younger than 6 months, ultrasound is the gold standard for diagnosis. In older children, X-rays are the used.

Orthopedic referral is indicated and treatment in infants usually encompasses the use of a Pavlik harness or, in refractory cases, splinting and casting. Rarely, patients will require surgical intervention by an orthopedist.[9]

DDH without dislocation can be clinically silent in children, and these patients may not develop symptoms until adolescence or adulthood. They often present with chronic hip pain and/or degenerative disease.[10]

Figure 1. Coronal T1 Fat Suppressed Gadolinium Enhanced Image

Note the right femoral epiphysis is hypoenhancing

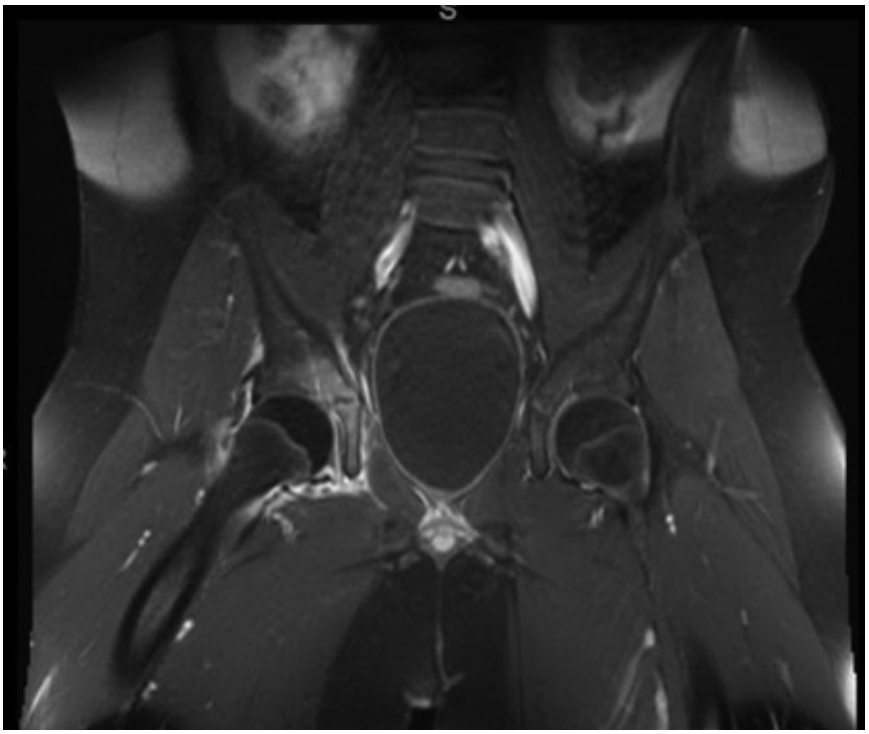
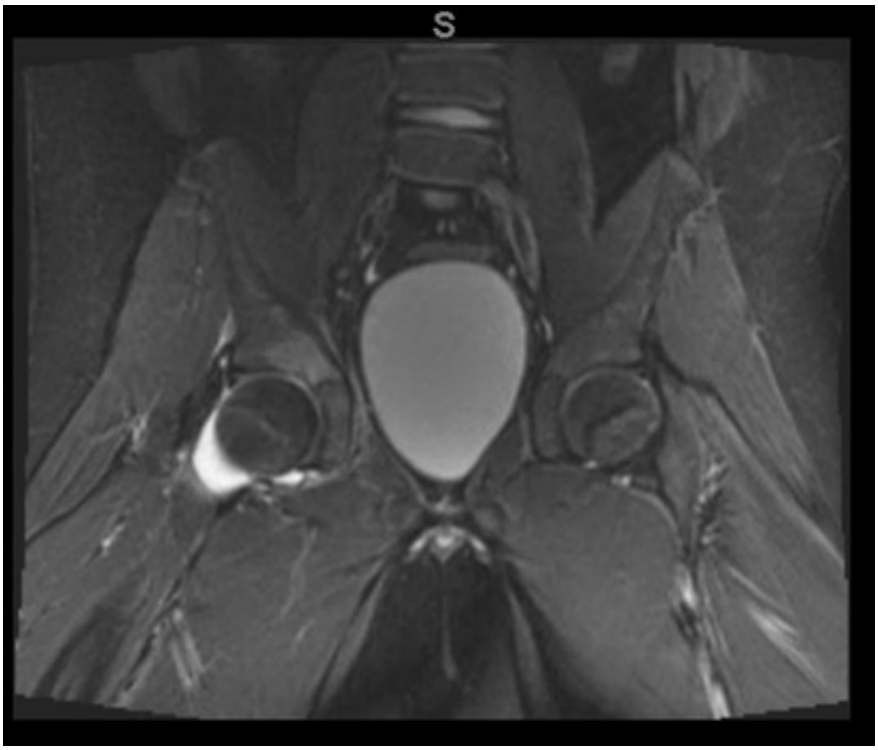


Figure 2. Coronal STIR Image with Right Joint Effusion and Enhancement of Acetabulum



Legg-Calve-Perthes Disease

Legg-Calve-Perthes disease has been

Table 4. Empiric Antibiotic Recommendations for Musculoskeletal Infections in Pediatrics[7,35]

Age Group	Antibiotic	Dose (mg/kg)	Route	Frequency
Neonates (< 1 month)	Ampicillin/Sulbactam + Gentamicin	150 2	IV IV	q6h q8h (titrate after 3rd dose)
Neonates (1-3 months)	Vancomycin + Ceftriaxone	15 100	IV IV	q6h (initially) q24h
Pediatrics and adolescents	Clindamycin ± Vancomycin	10 15	IV IV	q6h q6h (initially)

Source: Author adapted.

perplexing orthopedists and physicians for more than 100 years and still has unknown etiology. It affects children most commonly between 4-8 years of age, but has been reported from 2 to 15 years of age. The incidence is approximately 1 in 1,200 children, with geographic variation. The male-to-female ratio is 5:1. It occurs bilaterally only 10-15% of the time.[39]

The pathophysiology is complex, but the key event is disruption of blood supply to the femoral head. There is a four-stage process to the disease, including the initial vascular insult, fragmentation of the bone, reossification, and healing/remodeling phases. Ischemia to the bone in the femoral head leads to necrosis. Many microfractures occur from normal daily wear and tear forces across the joint, but there are no viable bone cells to repair them secondary to the lack of blood flow. The microfractures accumulate. Then blood flow is reestablished to the area. The necrotic bone is resorbed, further weakening the mechanical strength of the femoral head by resorbing bone. Normal activities place a lot of load through the hip joint, eventually causing focal bone collapse and death of articular cartilage. This is called the fragmentation phase. It usually lasts one year. The next phase is the reossification phase, where the bone repairs the areas of bone necrosis and collapse with new bone. This process lasts three to five years.[40] Femoral head deformity may worsen or improve during this phase. The degree of resultant deformity determines outcome of the disease, which is pain, hip function, and the early development of hip joint arthritis.

Patients classically present with a limp, mild pain, and/or limited hip motion and may present to the ED during any phase of the disease process. The onset is typically insidious. Pain usually is described as radiating to the groin and localizing to the hip joint. Occasionally, pain also radiates to the knee, like with other conditions affecting the hip. Pain often is worse with internal rotation and abduction. The effects on the hip joint are progressive over time and the disease severity varies. At first, hip motion will remain good, but the joint can have a synovitis and be irritable at times. This can produce a limp with an antalgic gait.

More severe disease can affect hip function and produce a Trendelenburg gait as the femoral head collapses and the abductor muscles are shortened and have less tension. On radiographs, variable amounts of femoral head collapse and deformity are seen. There may be no abnormal findings, especially early in the disease process. An MRI of the hip will show the areas of focal femoral head avascular necrosis.[41]

Key factors for long-term outcome are age at onset, how spherical the femoral head is, and how congruently the femoral head matches the acetabulum. Children with a disease onset at 6 years of age or younger tend to do well with nonoperative treatment. This includes observation and sometimes protected weight-bearing during the fragmentation phase. Children 8 years of age or older at onset fared better with outpatient operative procedures. These include osteotomies of both the femur and the acetabulum to improve the mechanics of the hip joint, with the goal to prevent or delay early onset of arthritis.

In diagnosing Legg-Calve-Perthes disease, other causes of osteonecrosis must be considered. These include sickle cell disease and corticosteroid therapy. These children are affected bilaterally though, whereas Legg-Calve-Perthes disease is usually unilateral. If Legg-Calve-Perthes disease is bilateral, then most often the disease process is in different stages on each side. The femoral head deformity will not look symmetric like it will with a systemic skeletal dysplasia.[39]

Slipped Capital Femoral Epiphysis

SCFE affects children later than Legg-Calve-Perthes disease. The average age for affected boys is 13.5 years old and for girls is 12 years old. These ages are decreasing over time because of the increase in childhood obesity. At least half of patients affected are in the 95th percentile or higher for weight. Bilateral involvement occurs 18-50% of the time.[42] Patients who are below the 10th percentile for weight or younger than 10 years of age should be evaluated for metabolic causes. These metabolic causes that predispose patients include hypothyroidism and osteodystrophy.

Patients present with a pain in the groin, thigh, and sometimes the knee. They may or may not be able to walk. A limp will be present to varying degrees. The gait is antalgic in the early phase and becomes more of a Trendelenburg gait in chronic untreated cases. In severe cases, the child will not be able to bear weight. Hip motion is affected with internal rotation of the hip decreased.[42]

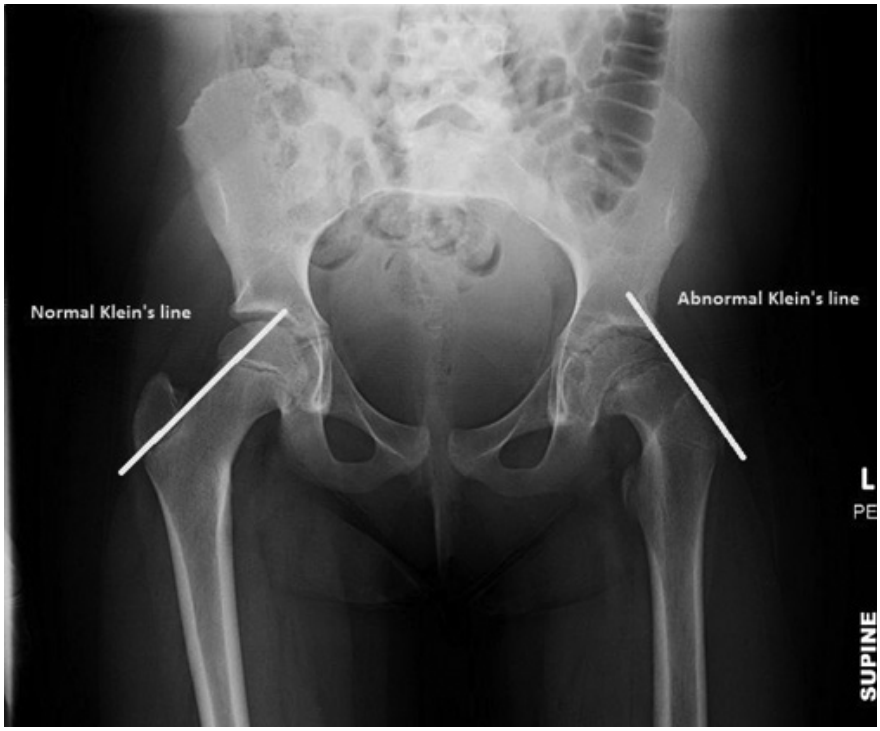
SCFE is defined as acute if symptoms have been present for less than three weeks, whereas chronic SCFE has symptoms present for more than three weeks. Acute-on-chronic SCFE also can occur when a patient has chronic symptoms (more than three weeks) but an acute exacerbation due to a more abrupt and pronounced

slippage.[43] A combination of biomechanical and biochemical factors contribute to a weakening of proximal femur epiphysis. Mechanical factors, such as obesity, increase force across the physis. It is hypothesized that rapid growth during puberty causes the physis to become even more susceptible to SCFE. The proximal femur metaphysis slips or shifts so that the femur moves anterior and superior relative to the femur epiphysis, which remains seated in the acetabulum. This has the effect of making the femoral head appear to have slipped posteriorly and inferiorly, although the femur moves relative to the femoral head. This displacement is most easily appreciated on the frog leg lateral X-ray view, but subtle SCFE can be seen on the anterior-posterior X-ray. Klein's line is a line that runs along the anterosuperior femoral neck drawn on the anterior-posterior pelvis. (*See Figure 3.*) This line should intersect some portion of the epiphysis of the femoral head.[44] In patients with SCFE, this line is flush or does not intersect the epiphysis. There is a variable amount of displacement seen with these slips.

Clinical classification of SCFE defines stable and unstable slips. If a patient is able to bear any weight on the affected leg, even partial weight-bearing with crutches, then the slip is considered stable. Inability to bear any weight at all defines an unstable slip. This is important because the rate of future associated femoral head osteonecrosis is 50% if the slip is unstable and nearly 0% if it is stable.[43] Regardless of whether the slip is stable, this is a surgical condition that needs treatment to prevent further displacement. Treatment consists of percutaneous screw fixation. If a patient has a metabolic condition that contributes to a SCFE (i.e., hypothyroidism, renal osteodystrophy) then the other side is often prophylactically surgically treated with in situ screw fixation.

Figure 3. Frontal View of 10-year-old Girl with Left SCFE

Normal and abnormal Klein's line highlighted



Osteochondritis Dissecans

Osteochondritis dissecans is an acquired lesion in the knee in which the articular cartilage and bone develop cracks that cause locking, catching, and painful joints. It has a low incidence and commonly affects children 10-15 years of age. These lesions are divided between those that occur in skeletally immature patients with open physes (juvenile) and those that occur after skeletal maturity (adult form). This lesion occurs in the subchondral bone, with 70% of lesions located on the posterolateral aspect of the medial femoral condyle. The etiology of this process is unknown but can result in delamination and separation of the cartilage overlying the affected subchondral bone.[46] It is hypothesized that repetitive microtrauma leads to this condition. Lesions are described as stable if they have secure attachment, and the cartilage has not displaced. Unstable lesions can become a loose body in the knee.

The clinical presentation is variable and depends on the size and stability of the lesion. Pain localizes to the knee. Stable lesions may have minimal symptoms. More severe or unstable lesions can cause patients to present with knee pain, often with an antalgic limp. If loose bodies are present, then the patient may experience locking or catching symptoms in the knee. The knee may have an effusion.

The workup should include knee radiographs. These will show a radiolucent lesion, again commonly on the medial femoral condyle. A notch view X-ray is the best view to visualize these lesions. MRI will characterize the lesion size, status of the subchondral bone, and presence of loose bodies, but this can be done in follow-up.

Treatment depends on the stability of the lesion. This is not an urgent condition, so patients seen in the ED should be given a knee immobilizer, remain non-weight-bearing, and follow up with an orthopedic surgeon. If the lesion is stable, conservative treatment is pursued with activity modification and/or weight-bearing restriction, temporary knee immobilizer use, and observation. For stable lesions, 50-75% will heal with nonoperative treatment.[47] The presence of open physes (juvenile form) in general has a better prognosis than the adult form, regardless of stability. Unstable lesions and loose bodies often require surgery to address the cartilage lesion/defect and remove the loose body.[47]

Discoid Meniscus

Discoid meniscus is a diagnosis that includes a range of meniscal disorders affecting the shape and stability.[49] These occur in approximately 3-5% of the U.S. population.[50] The true incidence is unknown, as many people likely have mild variants and no symptoms. It most often affects the lateral meniscus. The morphology varies, but the discoid meniscus occupies more space in the lateral knee than a normally developed meniscus. The structure is often block shaped as opposed

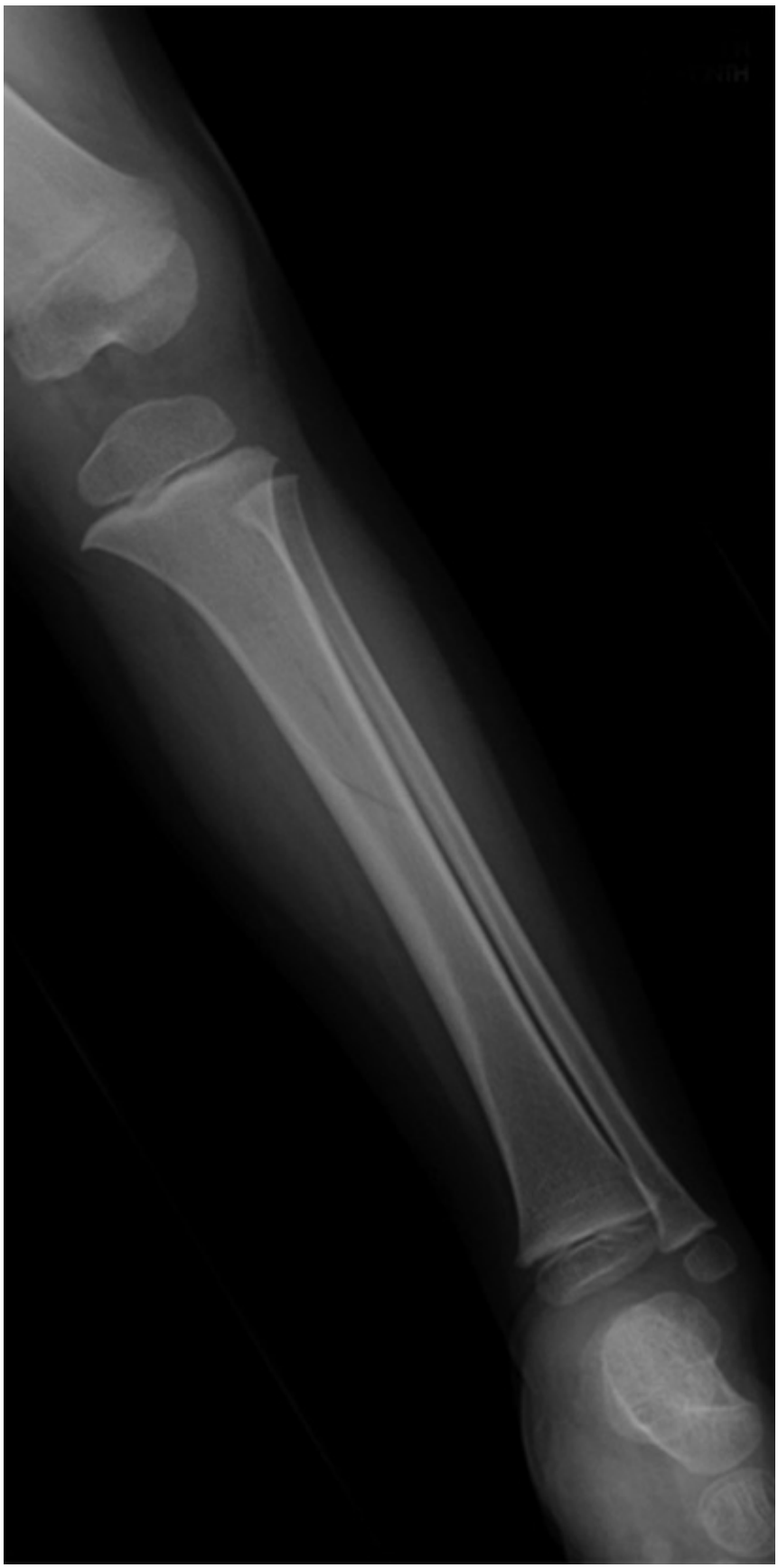
to the crescent shape of a normally developed meniscus.[49,51] These discoid menisci can be stable or unstable. Children commonly present with a palpable and often audible snapping of the knee when the knee moves from flexion to extension.[49] In young children (3-4 years of age), this snapping is often asymptomatic. Older children (8-10 years of age) can experience pain with activity. On physical exam, a dramatic clunk may be appreciated with McMurray's test due to subluxation of this abnormal meniscal tissue. This finding is present in approximately 40% of patients.[57]

Patients will present to the ED with knee pain and symptoms of popping and clicking in the knee. Radiographs are often normal in patients with discoid menisci. In severe cases, squaring of the lateral femoral condyle or widening of the lateral joint line can be seen. MRI shows the anatomy of the meniscus and the evidence of tearing, if present, but again this can be obtained in follow-up. Discoid meniscal tissue is abnormal and more friable. In combination with the increased size of the meniscus, this leads to meniscal tears. Traumatic meniscal tears in children older than 10 years of age usually occur in the setting of discoid meniscus.[48] With meniscus tears, there can be a knee effusion, locking, catching, or popping in the knee. If the patient has a meniscus tear or a painful discoid meniscus, treatment should include a knee immobilizer, protected weight-bearing, and referral to an orthopedic surgeon. Stable discoid menisci are treated with observation. Unstable discoid menisci or meniscal tears are treated with arthroscopic surgery to repair/stabilize the meniscus or debride the tear.[49]

Toddler's Fracture

Fractures of the tibial shaft are common in children and adolescents, accounting for 15% of long bone fractures.[52] A toddler's fracture describes a tibia shaft fracture that occurs from a low-energy twist or fall, which is why the nomenclature is trending toward childhood accidental spiral tibial fracture. Children with a developing gait will sometimes plant their lead foot and step to the side causing a rotational force on the distal tibia that leads to fracture. These are minimally or nondisplaced fractures, often in a short oblique or spiral pattern on X-ray. (*See Figure 4.*) The fibula may or may not be

Figure 4. Anterior-Posterior X-ray of a Toddler's Fracture



fractured as well.[53] A history of limping after a minor event is a common clinical presentation, and the actual traumatic injury may not have been witnessed. An initial X-ray may not show any evidence of fracture, although the evidence will appear on radiographs after 10-14 days when the healing process ensues.[2] Point tenderness over the distal tibia or pain with ankle dorsiflexion on exam may be the only diagnostic finding. These fractures are treated in a long-leg splint. They most often remain non-displaced and heal in approximately four weeks with immobilization.[52] Since this fracture can occur with minimal or at least unobserved trauma, there is often little history to accompany the injury. However, a toddler's fracture is one of the few spiral fractures that does not necessarily represent an abusive injury. In a newly ambulatory child, this fracture can be reasonably explained without a corresponding history and does not necessitate a full abuse evaluation unless there are other concerning factors about the child. Between 13-43% of toddler's fractures are not visible on initial X-rays during the index ED visit, but may be seen on subsequent X-rays 7-10 days later. The emergency provider should keep this in mind and may consider empirically placing a long-leg splint on children who limp after minor trauma.[61]

Juvenile Idiopathic Arthritis

Juvenile idiopathic arthritis (JIA) was previously known as juvenile rheumatoid arthritis. Ninety-seven percent of children with JIA are rheumatoid factor negative, and this is one of the reasons the name of this condition was changed.[54] JIA most commonly presents in children between 2-4 years of age and 6-12 years of age, and has an initial onset at younger than 16 years of age. The onset of JIA is often insidious with persistent pain in a joint for more than six weeks and does not have another cause for arthritis. This is a diagnosis of exclusion, after a thorough history and physical have ruled out other causes of arthritis, such as septic arthritis, gonococcal arthritis, and leukemia. Laboratory data can be negative for systemic inflammation with JIA. JIA is divided into several different subtypes with systemic, oligoarticular, and polyarticular being the most common. Systemic JIA is the most pronounced form, presenting with more than two weeks of daily fever and one or more symptoms of rash, lymphadenopathy, hepatosplenomegaly, and serositis.[56] Oligoarticular JIA (formerly known as pauciarticular arthritis) is the most common subset, affecting 60% of children with JIA.[55] This involves four joints or less. Half of patients with oligoarticular JIA have involvement of just one joint. The knee and ankle joints are most commonly affected. Polyarticular JIA has pain in at least five joints during the first six months of the disease. This type occurs in approximately 30% of patients.[55] Treatment involves NSAIDs and referral to a pediatric rheumatologist.[55]

Rheumatic Fever

In acute rheumatic fever, joint pain may be sudden. The patient may have one or more hot, swollen, and tender joints. There may be a history of intermittent joint pains. If fever, sore throat, elevated ESR, high ASO titer, and even carditis present, consider acute rheumatic fever in the diagnosis.[54]

Neoplastic Disease and Blood Dyscrasias

Symptoms concerning for neoplastic disease include night pain, weight loss, overall fatigue, night sweats, and pain at rest.[59] Patients with leukemia can present with poly- or oligoarthritis, but monoarticular arthritis of the knee is actually the most common presentation.[60] Severe pain out of proportion to the amount of swelling is characteristic of leukemia and can differentiate this from other causes of arthritis, such as JIA.

Acute leukemia can present with bone pain and limping in untreated and undiagnosed patients.[8] The leukemic cells proliferate in the marrow and under the periosteum. Intraosseous tension is increased and causes resulting pain. Subperiosteal bleeding from thrombocytopenia can also cause raised periosteum and pain in this disease. X-rays may reveal transverse lines of reduced density below the metaphyseal ends of bones or destructive changes or periosteal elevation and new bone formation. This diagnosis is usually apparent by a peripheral blood smear.[32]

Henoch-Schönlein purpura can cause pain in the knee and ankle joints most commonly. Pain is usually not severe but can cause a limp. With this, providers will see a dependent rash on the buttocks, elbows, ankles, and adjacent dependent areas of the lower extremities. The rash can be purpuric, urticarial, and pink maculopapular. The child also may complain of abdominal pain in this circumstance.[32]

Sickle cell anemia can cause intravascular sickling, stasis, and thrombosis in vessels within the soft tissues or bones of the legs and can cause acute pain and limping. These children also can have associated osteomyelitis.[32]

With recent increased prevalence of syphilis, it must be noted that congenital syphilis can cause pain and pseudoparalysis of a limb in the early months of life. This occurs before walking. However, there may be a limp associated with one of the later manifestations of congenital syphilis, namely hydrarthrosis of the knees (Clutton's joints).[32]

Intra-abdominal Pathology

The emergency medicine practitioner also should consider abdominal pathology when evaluating the child with a limp. Acute appendicitis can cause muscle spasm of the iliopsoas muscle and can refer pain into the hip or groin.[32] An occult psoas abscess also could present in this way. Similarly, adolescent females may present limping from pelvic pain due to gynecologic pathology, such as pelvic inflammatory disease or ruptured ovarian cysts. These can be hard to diagnose and will require a high index of suspicion. Investigation with an MRI or CT with contrast will help evaluate these further.

Summary

The child presenting to the ED with a limp can present a diagnostic challenge for the provider. A meticulous and systematic assessment can help narrow the differential diagnosis and help guide the workup of these patients. Broken bones and muscle injuries resulting from trauma are the most commmon causes of limp in the pediatric patient, but are often evident. The minor musculoskeletal injuries, infectious, inflammatory, hematologic, and neoplastic diagnoses require a broader knowledge base and astute clinical evaluation.

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CME/CE Questions

1. When evaluating an 8-year-old girl walking down the hall in the ED, you see her leaning her trunk to the right when the right foot is planted on the ground. The stride length and stance phase timing are normal. This gait pattern is characteristic of:
   a. spastic gait.
   b. toe-walking gait.
   c. antalgic gait.
   d. Trendelenburg gait.
   e. ataxic gait.
2. A 3-year-old boy presents to the ED with a one-day history of pain in the left leg. The patient has pain with ambulation and displays an antalgic gait on the left side. He has a history of a respiratory tract infection last week. On examination, he has a flexed, externally rotated, and abducted hip. He is resistant to hip motion and describes pain with internal rotation of the hip. Temperature is 100° F. White blood cell count is 11,000/microL. ESR is 10 mm/h. CRP is 0.5 mg/L. Hip radiographs do not reveal any abnormalities. What is the most likely diagnosis?
   a. Septic arthritis
   b. Juvenile idiopathic arthritis
   c. Transient synovitis
   d. Toddler fracture
   e. Slipped capital femoral epiphysis
3. An 8-month-old infant is brought into the ED with a fever that began 12 hours ago. The parents note that the child has not been kicking her right leg much since the fever began. On examination, the patient is holding the right hip in a flexed, externally rotated, and abducted position. The infant becomes irritable and cries when the right hip is moved through a range of motion. Temperature in the ED is 39° C. A temperature of > 38.5° C has been found to be the best predictor of this condition. What is the second best predictor?
   a. Elevated white blood cell count
   b. Elevated rheumatoid factor
   c. Elevated C-reactive protein
   d. Elevated erythrocyte sedimentation rate
   e. Presence of bacteria on blood gram stain
4. A 6-year-old fully vaccinated female presents to the ED with fever and a limp. She is notably tender over her left femur where there is visible erythema. Periosteal reaction is noted on X-ray over the tender site. After blood cultures have been drawn, which of the following antibiotic regimens is most appropriate?
   a. Ampicillin/gentamicin
   b. Cefazolin
   c. Vancomycin/ceftriaxone
   d. Ceftriaxone alone
   e. Clindamycin/vancomycin
5. Which of the following causes of limp must be managed surgically during the index ED visit to prevent further damage?
   a. Osteochondritis dessicans
   b. Discoid meniscus
   c. Legg-Calve-Perthes
   d. Slipped capital femoral epiphysis
   e. Developmental dysplasia of the hip
6. An 18-month-old male is brought in by parents refusing to bear weight on his right leg. The patient began walking at 13 months. Parents deny a history of trauma, fever, or recent viral infection. On exam, the patient has tenderness of the distal tibia and cries with ranging of the ankle and knee. X-rays of the knee, lower leg, and ankle are unremarkable. CBC, CRP, and ESR are also normal. After NSAID therapy, the child still refuses to bear weight. Which of the following is the most appropriate management strategy?
   a. Empiric antibiotics for suspected osteomyelitis
   b. Continued NSAID therapy for suspected transient synovitis
   c. Long-leg splint and repeat X-rays in 1 week for suspected toddler's fracture
   d. Ace wrap for suspected ankle sprain
   e. Orthopedic surgery referral for suspected developmental dysplasia of the hip
7. A 12-year-old mildly overweight girl presents to the ED with left knee pain that began yesterday. She denies any injury or traumatic event before the pain started. She has not had any fevers or recent illnesses. On examination, she walks with an antalgic gait. Her temperature is normal in the ED. There is no swelling or tenderness to palpation around the knee. There is mild pain with knee range of motion. Radiographs of the knee are performed and are normal. On repeat physical examination, the patient has some pain with hip flexion and internal rotation. What is the next study to determine the diagnosis?
   a. C-reactive protein
   b. AP and frogleg pelvic films
   c. Knee MRI scan
   d. Blood culture and Gram stain
   e. White blood cell count

PEDIATRIC EMERGENCY MEDICINE REPORTS™ (ISSN 1082-3344) is published monthly by AHC Media LLC, One Atlanta Plaza, 950 East Paces Ferry Road NE, Suite 2850, Atlanta, GA 30326. Telephone: (800) 688-2421 or (404) 262-7436.

Editorial and Continuing Education Director: Lee Landenberger

Executive Editor: Leslie Coplin

GST Registration No.: R128870672

Periodicals Postage Paid at Atlanta, GA 30304 and at additional mailing offices.

POSTMASTER: Send address changes to ***Pediatric Emergency Medicine Reports,*** P.O. Box 550669, Atlanta, GA 30355.

Back issues: $65. Missing issues will be fulfilled by customer service free of charge when contacted within one month of the missing issue's date.

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PEDIATRIC EMERGENCY MEDICINE **REPORTS**

Practical, Evidence-Based Reviews in Pediatric Emergency Care

A Review of the Limping Child and Painful Hip

Empiric Antibiotic Recommendations for Musculoskeletal Infections in Pediatrics[7,35]

Age Group	Antibiotic	Dose (mg/kg)	Route	Frequency
Neonates (< 1 month)	Ampicillin/Sulbactam + Gentamicin	150 2	IV IV	q6h q8h (titrate after 3rd dose)
Neonates (1-3 months)	Vancomycin + Ceftriaxone	15 100	IV IV	q6h (initially) q24h
Pediatrics and adolescents	Clindamycin ± Vancomycin	10 15	IV IV	q6h q6h (initially)

Source: Author adapted.

Differential Diagnosis of a Nonantalgic Limp

Trendelenburg Gait	Circumduction Gait	Steppage Gait	Equinus Gait
• Legg-Calve-Perthes disease • Developmental dysplasia of the hip • Slipped capital femoral epiphysis • Muscular dystrophy • Cerebral palsy	• Ankle or knee stiffness • Limb-length discrepancy • Cerebral palsy	• Myelodysplasia • Friedreich's ataxia • Charcot-Marie-Tooth disease • Cerebral palsy	• Limb-length discrepancy • Clubfoot • Tight Achilles tendon • Cerebral palsy

Source: Author adapted.

Differential Diagnosis of Antalgic Limp in Children by Age[1,3]

1-5 years	5-12 years	> 12 years
• Fracture (particularly toddler's) • Osteomyelitis • Septic arthritis • Diskitis • Arthritis: juvenile idiopathic arthritis (JIA), Lyme disease • Discoid lateral meniscus • Foreign body in foot • Benign or malignant tumor • Hemarthrosis (hemophilia) • Henoch-Schönlein purpura • Transient synovitis (3 to 10) • Minor musculoskeletal trauma	• Fracture • Osteomyelitis • Septic arthritis • Diskitis • Legg-Calve-Perthes disease • Transient synovitis • Osteochondritis dissecans • Discoid lateral meniscus • Sever's apophysitis • Accessory tarsal navicular • Foreign body in foot • Arthritis: JIA, Lyme disease • Benign or malignant tumor • Spinal dysraphism (tethered cord)	• Fracture (particularly stress) • Osteomyelitis • Septic arthritis • Diskitis • Slipped capital femoral epiphysis • Larsen-Johansson syndrome • Osgood-Schlatter disease • Sever's apophysitis • Osteochondritis dissecans • Chondromalacia patellae • Lyme disease arthritis • Gonococcal arthritis • Accessory tarsal navicular • Tarsal coalition • Benign or malignant tumor • Spinal dysraphism (tethered cord)

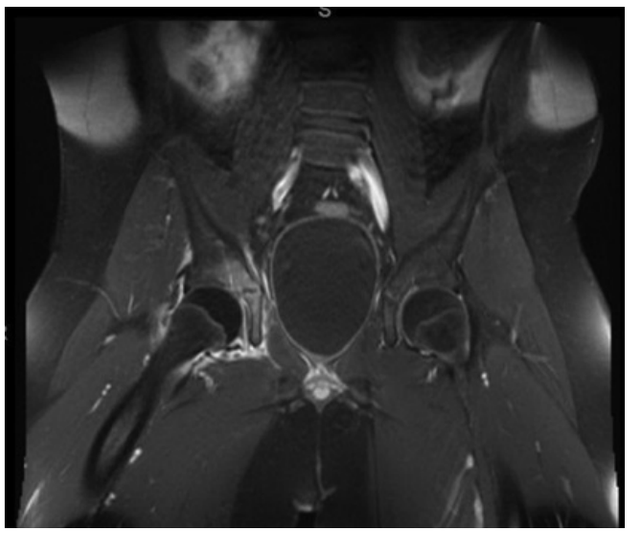
Modified Kocher Criteria[17]

Parameter	Threshold Value
Temperature	> 38.6° C
White blood cell count	> 12,000/mL
Erythrocyte sedimentation rate	> 40 mm/hr
C-reactive protein	> 20 mg/L (2 mg/dL)
Functional status	Unable to bear weight

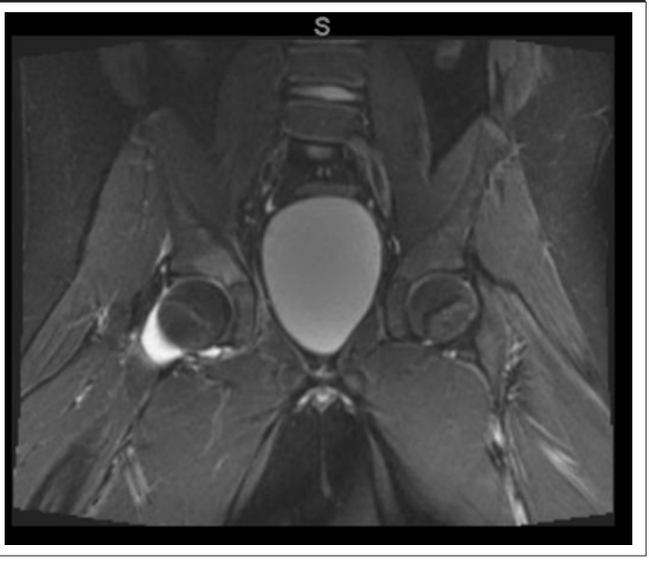
Source: Author adapted.

Coronal T1 Fat Suppressed Gadolinium Enhanced Image

Note the right femoral epiphysis is hypoenhancing

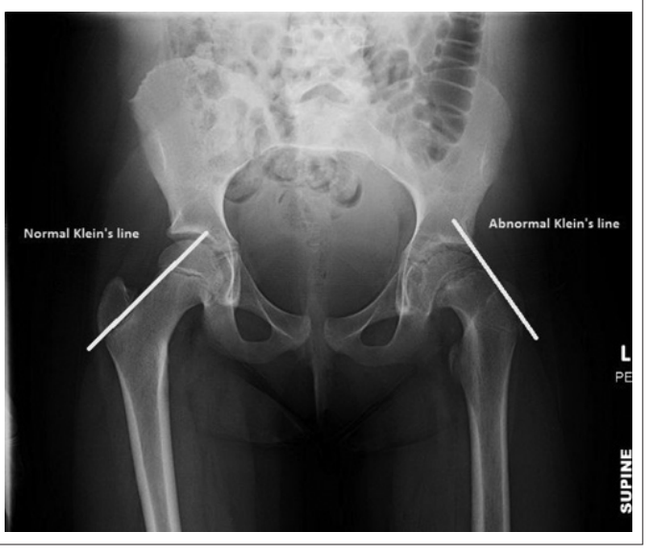


Coronal STIR Image with Right Joint Effusion and Enhancement of Acetabulum



Frontal View of 10-year-old Girl with Left SCFE

Normal and abnormal Klein's line highlighted



Supplement to *Pediatric Emergency Medicine Reports*, August 2016: "A Review of the Limping Child and Painful Hip."
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