Acute and Chronic Growth Plate Injuries

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Practice Gaps

1. To deliver appropriate care to patients who have sustained acute or chronic growth plate injuries, clinicians should be able to identify the most common sites of injury, know the signs and symptoms associated with particular injuries, conduct a system-specific physical examination, obtain necessary radiologic data, and provide appropriate management.

2. Clinicians should be aware of common complications associated with growth plate injuries and understand when to refer patients to a specialist for further care.

Objectives

After completing this article, readers should be able to:

1. Identify the major anatomic areas of a long bone and recognize their importance in acute and chronic growth plate injuries.

2. Explain the mechanism of injury of growth plate injuries and its relation to the severity of injury.

3. Recognize clinical signs and symptoms of growth plate injuries.

4. Differentiate between the various types of Salter-Harris fracture classifications based on patient presentation, physical examination findings, and radiologic evidence.

5. Recognize the most common complications associated with Salter-Harris fractures.

6. Identify and diagnose various chronic growth plate injuries based on patient presentation, physical examination findings, and radiologic evidence.

7. Appropriately manage both acute and chronic growth plate injuries.

8. Know when to refer patients who have growth plate injuries to a specialist for further care.

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ABBREVIATION

SH Salter-Harris
INTRODUCTION

Growth plate injuries are commonly encountered by pediatricians. Growth plate trauma can occur acutely with an injury or chronically with repetitive stress. Injuries to growth plates are unique to those who are skeletally immature and warrant special attention for several reasons. Although most fractures of physes heal rapidly without any adverse effects, limb-length discrepancy from complete growth disturbance of a physis, angular limb deformities from incomplete physeal closure, and joint surface misalignment potentially leading to premature joint arthritis are complications that can have long-lasting and devastating effects on a growing child. In addition, the apophysis is vulnerable to acute and chronic injuries of varying severity. A working knowledge of the anatomy of the physis and apophysis, evaluation and initial management of acute and chronic injuries, definitive management of select conditions, and when to refer to a specialist are essential for any pediatrician.

EPIDEMIOLOGY

Growth plate fractures account for 20% to 35% of all fractures in children. (1)(2) Although the incidence varies with age group, they are more common in adolescents (3) and affect males more often than females by a 2:1 ratio. (2) The most common locations for a growth plate fracture are the distal radius, distal tibia, and distal fibula. (2)

TERMINOLOGY

There are 4 major anatomic areas to any long bone (Fig 1). The epiphysis is the bulbous end of a long bone covered in articular cartilage between the physis and the joint. (1) The physis, the growth plate itself, is the area of the long bone responsible for longitudinal growth. (1) The metaphysis is the flared portion of the long bone between the physis and the shaft. Finally, the diaphysis is the shaft of the long bone. Larger long bones such as the humerus, radius, ulna, femur, tibia, and fibula have physes at both ends while smaller tubular bones such as the metacarpals, metatarsals, and phalanges only have physes on one end. (1)

ANATOMY

There are 4 zones within the physis. Moving from the epiphysis to the metaphysis, they are the germinal zone, the proliferative zone, the hypertrophic zone, and the zone of provisional calcification. The germinal zone is composed of cells that stimulate longitudinal growth and maturation of the physis. (4) The proliferative zone contains extracellular matrix between columns of cells. The matrix contributes to biomechanical changes within the zone, which stimulates proliferation. (1)(4) In the zone of hypertrophy, the cells are aligned in columns as they hypertrophy and are eventually replaced by osteoblasts. (4) The zone of hypertrophy is the most common site of fractures within the physis. The zone of provisional calcification (or endochondral ossification) allows penetration of the metaphyseal vessels that break down the cartilaginous matrix and stimulate remodeling, removal, and replacement of the matrix by mature spongy bone. (4) The margins of the physis are composed of 2 areas that are important to mechanical strength and longitudinal growth. (1)(4) Tented the zone or groove of Ranvier, this microscopic structure, which is triangular in appearance, contains fibroblasts, chondroblasts, and osteoblasts. (1)(4) A fibrous structure called the perichondral ring of LaCroix overlies the zone of Ranvier. The ring of LaCroix connects the periosteum of the metaphysis to the cartilaginous epiphysis and functions to stabilize both the metaphysis and epiphysis. (1)(4)

The physis is supplied by 2 primary arteries: the epiphyseal artery and the metaphyseal artery. Complications of growth plate injuries are frequently caused by disruption to this blood supply rather than by actual stress to the physis itself. (3) The primary arterial vessel comes from the epiphyseal artery and supplies the zones of germination and proliferation. (3) The second set of vessels comes from the medullary canal of the diaphysis to supply the metaphyseal side of the physis, the zone of provisional calcification. (3) The zone of hypertrophy remains avascular; it is also the site where most injuries occur. (1)(3)

MECHANISM OF INJURY

The rate, direction, and magnitude of force associated with the injury determine the severity of physeal fractures. (1)
Studies of animal models have shown that compression forces affect the zone of provisional calcification and the metaphysis, shear forces affect the proliferative and hypertrophic zones, and torque forces affect all 4 layers of the physis. (1) The energy associated with an injury also determines the extent of damage to the physis. (1) High-energy injuries are more frequently associated with physeal fractures that result in growth disturbance. (1)

The most common injury to the physis is a fracture resulting from trauma, most often due to a fall while running or playing. (1)(4) However, the physis can also be adversely affected by tumor, infection, repetitive stress, and vascular insult. (1) Growth plates are less resistant to stress, shear, and tension forces than articular cartilage, ligaments, or the adjacent bone itself. (4) Mechanisms of injury that in an adult would produce a torn ligament or joint dislocation are more likely to produce growth plate separation in a child. (4) This likelihood of growth plate injury is especially pronounced during periods of rapid growth, such as adolescence, when the strength of physeal cartilage is decreased. (4) Bone mineralization may lag behind linear growth during growth spurts, which can make the bone more porous and, therefore, more susceptible to injury. (4)

**ACUTE INJURIES**

**Patient Evaluation**

Children with suspected growth plate fractures present with chief complaints of pain, swelling, or deformity after a traumatic injury. Although many orthopedic injuries are isolated fractures, patients involved in motor vehicle crashes, falls from a height higher than 5 feet, and other high-energy mechanisms should receive a thorough initial evaluation for more serious injuries to the head, spine, and thoracoabdominal area. A secondary survey of the extremities should then be performed to diagnose other associated injuries. Clinicians should palpate the potentially fractured limb for tenderness and crepitus, not just at the obvious site of injury but proximally and distally to the adjacent joints. Further examination includes evaluating for signs of soft-tissue injury, bleeding, and exposed bone. The motor and sensory function of the affected limb should be assessed and the vascular status evaluated by checking distal pulses and testing capillary refill. Grossly deformed or unstable fractures are ideally splinted and open wounds are covered with a sterile dressing before sending the patient for radiographs. High-quality anteroposterior and lateral views of the injured limb should be obtained, with the joints above and below the fracture site visualized clearly.

**Salter-Harris Classification of Physeal Fractures (Table)**

There are several classification systems for growth plate injuries, but the system most widely used was developed by Salter and Harris and published in 1963. (5) The Salter-Harris (SH) classification system is based on premature growth plate closure and poor functional outcomes. It is a 5-part classification system, with higher numbers associated with a greater chance of growth disturbance and poor outcome (Fig 2).

**Salter-Harris I Fractures.** SH type I fractures transect the physis on a horizontal plane. The patient has tenderness
over the physis and varying degrees of soft-tissue swelling. Radiographs for this type of fracture usually appear normal, but there often is soft-tissue swelling. There may also be an effusion, epiphysial displacement, or widening of the physis (Fig 3). (2) In most situations, radiographs should be taken of the joint above and below the fracture site in anteroposterior and lateral planes for proper assessment of all fractures. Due to the essentially normal radiographic appearance of the osseous structures, tenderness at the physis after trauma is the key to diagnosis of this type of fracture. If immobilized shortly after the injury, patients experience tenderness to palpation at the site of the physis even 5 to 7 days after the injury. If left untreated, patients can remain persistently tender for weeks or longer. Other imaging modalities can be helpful in making the diagnosis, including magnetic resonance imaging and ultrasonography when evaluating for epiphyseal separations in infants. (1) However, a good physical examination and radiographs to evaluate for displacement or other bony injury are sufficient for making the diagnosis. The fracture in SH type I injuries is usually through the zone of hypertrophy because it is the weakest point of the physis. The germinal and proliferative zones are generally spared. Because vascular injury is also unlikely with SH type I fractures, the chance of growth disturbance is very small at less than 1%. (1)(2) The preferred method of treatment for an SH type I injury without displacement is 3 to 4 weeks of immobilization of the joint with a cast or brace. The prognosis is excellent, and patients should have no tenderness at the physeal site after the appropriate period of immobilization. Displaced fractures are best treated with closed reduction and casting that, in the case of unstable injuries, are augmented with pin fixation placed percutaneously or in conjunction with an open fracture reduction.

Salter-Harris II Fractures. SH type II fractures transect the physis and extend a short distance into the metaphysis. This fracture is the most common type of physeal injury, accounting for approximately 75% of SH fractures. (2) Radiographs show a Thurston-Holland fragment, the small metaphyseal bone spike (Fig 4); widening of the physis where the fracture line occurs; and at times, displacement of the fracture fragment. Because the fracture extends through the physis, similar to SH type I fractures, but exits through the metaphysis, the germinal and proliferative zones are usually not affected. (1) SH type II fractures do not affect the articular surface and have a low chance of associated growth disturbance, only slightly higher than that for SH I fractures. (1)(2) However, the chance of growth disturbance is higher for SH fractures of the distal femur and distal tibia, approaching as high as 40%, which is attributed to the undulating shape of these physes. (1)(2) Nondisplaced fractures are treated similarly to SH I fractures, with a short period (3-6 weeks) of cast immobilization. Appropriate treatment for displaced fractures includes closed reduction and casting but may also involve fixation with pins or screws placed percutaneously or in conjunction with an open reduction. Reduction of physeal fractures is ideally performed within 5 to 7 days of injury because healing is rapid, making realignment difficult and potentially more damaging to the already injured physis.
Seymour Fracture. A Seymour fracture is an SH type II fracture of the distal phalanx, typically of the great toe or the finger phalanges. It requires special consideration because it is associated with displacement of nail, laceration of the nail bed under the proximal nail fold, and is an open fracture (Fig 5). Injuries that appear to have no entrapment of the nail bed in the fracture site and are minimally displaced on radiographs can initially be treated with irrigation in the emergency department, antibiotics, and immobilization with close monitoring. These types of fractures, however, often require surgical irrigation, open nail bed repair, and fracture reduction and fixation.

Salter-Harris III Fractures. SH type III fractures transect the physis and the epiphysis. The fracture pattern starts at the physis, crosses the epiphysis, and exits out the articular surface. This type of fracture involves not only the articular surface but also the germinal and proliferative zones of the physis, which can lead to serious complications, including premature osteoarthritis from joint line malalignment and growth disturbance from physeal malalignment that leads to bar formation and growth tethering or damage of growing cells. Radiographs should be closely inspected for alignment along the joint line (Fig 6) as well as the physis. Anatomic realignment, often in the form of open reduction coupled with internal fixation, is required for successful treatment and full functionality. Following restoration of proper alignment, immobilization with a cast is usually required for 4 to 8 weeks for appropriate healing. Non-displaced SH type III fractures have the best prognosis. Anatomic realignment and fixation of displaced fractures improves the prognosis.

Salter-Harris IV Fractures. SH type IV fractures transect the metaphysis, physis, and epiphysis (Fig 7). They are caused by vertical shear forces, sometimes in combination with torsional forces, and involve the articular surface as well as all 4 layers of the physis. They may result in metaphyseal-epiphyseal cross-union if displaced and growth disturbance. As for SH type III fractures, anatomic restoration of the joint line is critical to prevent premature cartilage wear and arthritis. The treatment considerations are identical to those outlined for SH III fractures. Except for the rare nondisplaced SH IV fracture, surgery is usually warranted, with open reduction and internal fixation as the standard treatment, followed by immobilization.

Salter-Harris V Fractures. SH type V fractures are high-energy crush injuries through the physis that Salter and Harris postulated cause premature closure of the physis. This type of fracture is associated with very poor functional outcomes. Radiographs may show compression of the physis or the adjacent metaphysis, but they typically appear...
normal. Other imaging modalities such as magnetic resonance imaging can be helpful in identifying this type of injury when initial radiographs appear normal. (1) SH type V fractures are rare, but they are associated with 100% growth disturbance, by definition, due to premature closure of the physis.

Complications of Salter-Harris Fractures

Acute traumatic fractures have important complications that must not be missed, including neurovascular compromise, especially poor limb perfusion, compartment syndrome, and in the case of open fractures, infectious complications such as gas gangrene and osteomyelitis. However, physeal injuries are unique in their potential for growth disturbance, resulting most commonly in limb-length discrepancy or angular deformities. The disturbance is usually due to a slowing of growth, but in some uncommon situations, an acceleration of growth may also occur (Fig 8). (1) Clinicians must monitor injuries with a risk of growth disturbance until normal growth has been re-established, typically a minimum of 2 years for most displaced fractures and any fracture due to a high-energy mechanism. Often, such monitoring involves radiographically evaluating the appearance of a Harris growth arrest line parallel to the physis 4 to 9 months after the injury (Fig 9). In the lower limb, radiographic measurements of limb length and overall limb alignment are also useful. The treatment for growth disturbance is usually surgical, with multiple procedures available to restore proper length to the affected limb. (1) Depending on the type of growth disturbance and the amount of growth remaining, joint misalignment from SH III and IV fractures that are not realigned within 2 mm of anatomic position leads to premature wear of articular cartilage, with resultant pain, stiffness, and osteoarthritis. Although both nonsurgical and surgical methods are available for treatment, restoring

Figure 6. Radiograph of Salter-Harris III fracture.

Figure 7. Radiograph of Salter-Harris IV fracture.

Figure 8. Radiograph of physeal arrest.
anatomic alignment of the joint brings the best functionality and long-term outcomes.

**Apophyseal Avulsion Fractures**

Another type of acute growth plate injury is an apophysis avulsion fracture, an injury that occurs most commonly about the pelvis and lower extremities. An apophysis is a secondary ossification center, essentially an osteocartilaginous protuberance that is the origin or insertion for muscles and tendons on bone (Fig 10). Although apophyses do not contribute to longitudinal growth, they do add to the shape and contour of the bones with which they are associated. Examples include the anterior superior iliac spine of the pelvis and the tibial tubercle of the proximal tibia (Fig 11). Injuries to apophyses are common in older children and adolescents and most frequently result from extreme concentric or eccentric muscular contraction. These avulsion fractures occur at the site of major muscle attachments, such as the hamstrings on the ischium or the sartorius muscle on the anterior-superior iliac spine. Because many acute apophyseal avulsion fractures occur in physically active adolescents, the best prevention is a regular stretching program and a proper warm-up before intense physical activity.

Patients with acute apophyseal avulsions typically present saying that they felt a “pop” or had acute pain in a discrete site that they can localize after landing or jumping. The examination reveals point tenderness and pain with movement of the affected limb. Radiographs can show displacement of the apophysis or can appear normal if the cartilaginous component of the apophysis that avulsed is not yet ossified. Treatment of apophyseal avulsion fractures depends on the injury site, displacement, and time frame of diagnosis. In most cases, apophyseal avulsion fractures are stable and treatment consists of anti-inflammatory medications, weight-bearing as tolerated (sometimes initially assisted with crutches), and restriction of all competitive activities for 3 to 4 weeks, followed by progressive return to sports. Surgery is rarely required unless there is significant displacement, painful nonunion of the avulsed fragment after 3 to 6 months of nonsurgical treatment, or severe functional impairment. An exception, among some others, to the rule of nonsurgical treatment is the relatively common displaced avulsion fracture of the tibial tubercle where the quadriceps inserts via the patellar tendon (Fig 11). Without anatomic reduction and restoration of the extensor mechanism surgically, severe disability results.

**CHRONIC INJURIES**

In addition to being vulnerable to acute injuries, physes and apophyses are vulnerable to chronic injuries. Usually a combination of inflexibility from growth, overuse, and...
improper techniques contribute to both excessive stress on a physis or apophysis and the insidious onset of pain and dysfunction. The hallmark of management is relative rest while correcting the underlying contributing pathophysiology.

**Little League Shoulder**
Proximal humeral epiphysitis, commonly known as Little League shoulder, is caused by repetitive stress injury to the physis of the proximal humerus. This condition is most often seen in young baseball pitchers due to repeated traction and rotational forces that adversely affect the growth plate. (4) This type of injury has also been reported in other sports involving overhead motion, including cricket, gymnastics, swimming, and volleyball. (4) Patients complain of gradual and progressive pain around the shoulder, especially with overhead arm motions. (5) Athletes may also experience worsening performance. (6) When examined, patients exhibit tenderness to palpation around the proximal humeral physis, decreased shoulder range of motion, and pain with resistance to shoulder elevation or external rotation. (6)(7) Radiographs appear generally normal but can also show widening of the physis or sclerosis of the epiphysis. (6)(7) Usually this injury fully resolves with complete rest for a period of approximately 6 weeks. In very few instances, premature closure of the physis may occur. (4) Return to activity should be delayed until the underlying stiffness or weakness, the deficiency in athletic form, and/or the excessive repetitive training that led to the pathologic stress on the shoulder have been addressed. (6) There should be a gradual return to preinjury throwing volume and intensity.

**Gymnast Wrist**
Distal radial epiphysitis, also called gymnast wrist, is the most commonly reported physeal stress injury in the wrist. (4) It is due to repetitive weight-bearing on the hands, which causes compressive, loading, shearing, and rotational forces on the wrist while it is dorsiflexed. (6)(7) Athletes complain of pain that is worse with activity. (6)(7) Physical examination reveals tenderness to palpation over the distal radial physis. (6) Range of motion is usually normal, although it may be limited by pain. (6) Radiographic findings are typically normal, but they can include an asymmetrically widened and irregular physis. (4)(6) Treatment consists of complete rest from weight-bearing on the upper extremities for at least 6 to 12 weeks. Most athletes experiencing this injury make a full recovery with rest and do not experience premature physeal closure or growth arrest. (4) Severe cases can result in premature closure of the physis, which can lead to positive ulnar variance, thereby causing chronic wrist pain and arthritis. (6)

**Chronic Apophysitis**

**Sever Disease and Osgood-Schlatter Disease.** Similar to the vulnerability of physes to chronic stress, apophyses can insidiously develop inflammation. Most commonly, overuse, inflexibility, and weakness produce inflammation at the tibial tubercle and calcaneal apophysis, causing Osgood-Schlatter and Sever disease, respectively. Patients with chronic apophysitis present with the insidious onset of activity-related pain. The hallmark of the physical examination is tenderness at the apophysis. In addition, identification of muscle tightness or weakness around the affected apophysis during the physical examination is crucial. With Osgood-Schlatter disease, the inflammation is often a result of quadriceps or hamstring tightness or hip abductor and external rotator weakness. With Sever disease, the inflammation is usually due to heel cord tightness. Once the inflamed apophysis and offending muscular instigator have been identified, the hallmark of treatment is relative rest, ice, anti-inflammatory medications, physical therapy or home exercises to address the offending muscular deficiency, and a gradual return to athletic activity.

**Little League Elbow.** Another problematic apophysitis is medial epicondyle apophysitis, better known as Little League elbow. It most commonly affects young baseball pitchers who have fatigued their shoulders, causing shoulder stiffness and resultant excessive stress on the elbow while throwing. The athletes usually complain of medial elbow pain during or after throwing accompanied by stiffness or impaired performance. (6)(7) Examination reveals point tenderness over the medial epicondyle and limited range of motion, especially with elbow extension. (6) As for any “overhead” athlete who performs repetitive overhead motion, as in swimming, baseball, softball, tennis, and volleyball, and presents with elbow pain, clinicians should also examine the shoulder. Underconditioning and overtraining can result in scapular dyskinesia and loss of internal rotation of the glenohumeral joint. Radiographs usually appear normal, but widening of the space between the medial epicondyle and the humerus or fragmentation of the medial epicondylar apophysis may be seen. (6) As with other chronic growth plate injuries, treatment consists of complete rest from throwing for 4 to 6 weeks. (6) Stretching and range-of-motion exercises should be employed during the rehabilitation phase, and return to full activity can be expected.
once range of motion is pain-free and strength has returned to normal. Underlying scapular dyskinesia and internal rotation deficit of the shoulder must be resolved before initiating a return-to-throwing protocol. With shoulder involvement, the expected length of time to full activity is another 4 to 6 weeks, with return to full competition in 8 to 12 weeks. (6)

WHEN TO REFER TO A SPECIALIST

As with any injury, knowing when to refer a patient to a specialist is key to proper management. Acute injuries consistent with SH I fractures, SH II fractures (with the exception of the distal femur and tibia), and stable apophysis avulsion fractures (eg, pelvis and fifth metatarsal base) can regularly be managed in a primary care physician’s office with slings, wrist braces, finger splints, walking boots, and crutches. Patients with SH III, IV, or V fractures require prompt referral for proper evaluation regarding the need for surgical intervention. In addition, repeat fractures, fractures due to high-energy mechanisms, and unstable avulsion fractures (eg, medial epicondyle and tibial tubercle) should be referred to a specialist. Given the need for substantial activity restriction and risk of growth arrest, chronic physeal stress injuries should be referred for further management. Chronic apophysitis can regularly be managed by the primary care physician. Finally, if an acute or chronic injury does not improve with usual care, alternative diagnosis and referral to sports medicine or pediatric orthopedics must be considered.

Summary

• Growth plate injuries are common fractures experienced by children, and recognizing the various types of acute and chronic physeal injuries is essential for the pediatrician.

• The Salter-Harris classification, the most commonly used classification for growth plate injuries, is a 5-part system based on premature growth plate closure and functional outcomes, with higher numbers correlating with increased likelihood of premature closure and poor outcome.

• Based primarily on consensus due to a lack of relevant clinical studies, the patient history, physical examination results, and radiologic evidence are key to establishing the correct diagnosis and appropriate management strategy for growth plate injuries to obtain the best possible outcome that minimizes growth disturbance and poor functionality.

• Based primarily on consensus due to lack of relevant clinical studies, chronic growth plate injuries are principally due to a combination of inflexibility, overuse, and improper technique, and the hallmark of management is rest while correcting the underlying pathophysiology.

• Based primarily on consensus due to lack of relevant clinical studies, patients with Salter-Harris type III or higher fractures as well as those with repeat injuries, injuries due to high-energy mechanisms, unstable fractures, or chronic physeal injuries require referral to a specialist for prompt evaluation to determine the need for surgical management.

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Parent Resources from the AAP at HealthyChildren.org

• Knee Pain and Osgood-Schlatter Disease: https://www.healthychildren.org/English/health-issues/injuries-emergencies/sports-injuries/Pages/Knee-Pain-and-Osgood-Schlatter-Disease.aspx

• Little League Elbow: https://www.healthychildren.org/English/health-issues/injuries-emergencies/sports-injuries/Pages/Little-League-Elbow.aspx

• Children And Broken Bones: https://www.healthychildren.org/English/health-issues/injuries-emergencies/Pages/Children-And-Broken-Bones.aspx

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This journal-based CME activity is available through Dec. 31, 2019, however, credit will be recorded in the year in which the learner completes the quiz.

1. You are discussing the anatomy of the growth plate with a medical student. Which of the following is a correct statement describing the structure of the physis?
   A. The epiphyseal and metaphyseal arteries feed the hypertrophic zone.
   B. The hypertrophic zone is rich in extracellular cartilage.
   C. The majority of physis injuries occur in the hypertrophic zone.
   D. The metaphyseal artery supplies the germinal and proliferative zones.
   E. The zone of provisional calcification is avascular.

2. A 12-year-old girl sustained an ankle injury in a fall while running. She was evaluated in the emergency department and diagnosed with a Salter-Harris type II fracture of the distal fibula. Which of the following findings is expected to be seen upon review of this patient’s radiographs?
   A. A fracture that crosses through the epiphysis.
   B. Malalignment along the joint line.
   C. Soft-tissue swelling only.
   D. Widening of the physes only.
   E. Widening of the physes and a metaphyseal fragment.

3. A 9-year-old boy is brought to the physician for evaluation of a 2-week history of heel pain that occurs while playing soccer and resolves with rest. On physical examination, there is mild tenderness localized to the posterior calcaneus. The most likely diagnosis is:
   A. Achilles tendinitis.
   B. Osgood-Schlatter disease.
   C. Salter-Harris type I fracture.
   D. Sever disease.
   E. Seymour fracture.

4. A 12-year-old boy was brought to you for evaluation of gradual onset of elbow pain and decreased power while pitching. On physical examination, you note tenderness over the medial epicondyle. There is no restriction of range of motion of the elbow, and shoulder examination yields normal results. Radiographs of the elbow appear normal and you diagnose “Little League elbow” (medial epicondylitis). Which of the following is the most appropriate next step in management of this patient?
   A. Complete rest from throwing for 4 to 6 weeks and until all pain and tenderness has resolved.
   B. Daily pitching exercises under the supervision of a coach to perfect the pitching technique.
   C. Immobilization of the elbow in 90-degree flexion.
   D. Referral to an orthopedist for immediate pinning of the unstable apophysis.
   E. Vitamin D supplementation.

5. You are discussing specialist referral patterns and appropriate resource utilization with a resident rotating in your office. Which of the following fractures may be most appropriately managed in the primary care setting?
   A. Acute, nondisplaced avulsion of the fifth metatarsal base.
   B. Acute, displaced avulsion of the tibial tubercle.
   C. Salter-Harris type II fracture of the distal femur.
   D. Salter-Harris type II fracture of the distal tibia.
   E. Salter-Harris type III fracture of the distal radius.
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