CE
1.5
ANCC
Contact
Hours

# Adolescent Avulsion Injuries of the Pelvis

## A Case Study and Review of the Literature

Erden Ali ▼ Vikas Khanduja

Avulsion fractures of the pelvic apophyses are a result of repetitive strain injuries or sudden, forceful eccentric or concentric contractions of corresponding muscle groups in the leg. Using a case study approach, we present the clinical and radiological features, and management of a 14-year-old boy who presented to our hospital with an avulsion fracture of the anterior inferior iliac spine. The literature on the subject, along with the management of the condition, is reviewed and presented. A condition often treated nonoperatively, the focus of treatment is based on effective nursing and rehabilitation of the patient on an outpatient basis. Without this vital role, patients are at risk of unnecessary hospitalization that also has adverse socioeconomic effects.

## Introduction

Avulsion fractures of the pelvis (Ischial Tuberosity) were first described by Berry in 1912 (Berry, 1912) with the first report of an anterior inferior iliac spine (AIIS) avulsion injury being reported in 1929 (Kohler, 1929). They are seen in adults and more commonly in the athletic male adolescents, with some arguing that they are most common in those athletes competing in sporting activities such as football and gymnastics (Rossi & Dragoni, 2001). As the sports industry grows at such a rapid rate, with female competitors becoming more common, the incidence of avulsion fractures in adolescents is continuing to increase (McKinney, Nelson, & Carrion, 2009). This is confounded by high expectations of coaches and trainers and the inclusion of younger year groups into competitive sport (Sundar & Carty, 1994).

## Anatomy

The pelvis is composed of three bones, the ilium, the ischium, and the pubis, which meet in the acetabulum to form the "Mercedes" symbol (see Figure 1). The pelvis is made up of three important joints: the acetabulofemoral joint or hip joint, the sacroliliac joint, and the pubic symphysis. The muscles of the hip and pelvis are arranged so that their anatomical position dictates their action on the hip joint. The anterior group is responsible for hip flexion and is composed of the iliopsoas, sartorius, and rectus femoris muscles; adduction of the hip is produced by the action of gracilis, pectineus and the adductors brevis, longus, and magnus; extension of the hip is governed posteriorly by the gluteus maximus and the hamstring muscles—biceps femoris, semitendinosus, and semimembranosus; abduction is produced by gluteus medius and minimus and lateral rotation by obturator internus and externus, piriformis, and the superior and inferior gemelli.

## Mechanism of Injury

The etiology of injury has been ascribed to chronic repetitive traction on a developing apophysis or as a result of sudden, forceful, or unbalanced contraction of an attached musculotendinous unit while engaged in a sporting event (El-Khoury, Brandser, Kathol, Tearse, & Callaghan, 1995; Kujala & Orava, 1993; Tehranzadeh, 1987; Salvan & Weiker, 1977). These fractures are often associated with the time of ossification of the apophyses and their subsequent fusion to the corresponding pelvic tuberosities. Two distinct patterns exist for development of the hip and pelvis; this in turn with the degree of skeletal maturity has a direct effect on the incidence of injury (Houghton, 2009). Growth of the acetabulum is from its cartilaginous periphery and the triradiate cartilage. Developmental disruption of this cartilage can predispose patients to acetabular dysplasia and degenerative joint disease in later life (Trousdale & Ganz, 1994).

There are three ossification centers in the proximal femur—the capital femoral epiphysis and the greater and lesser trochanters. The pelvis and hip are allowed circumferential growth through several apophyses or secondary ossification centers. These sites of ossification also have muscle attachments and, because of the increased tensile strength of surrounding soft tissues, avulsion injuries are

Erden Ali, BSc, MBBS, Doctorate Student, Magdalene College, University of Cambridge, United Kingdom.

Vikas Khanduja, MB, BS, MRCS (G), MSc, FRCS, FRCS (Tr & Orth), Consultant Orthopaedic Surgeon, Department of Trauma and Orthopaedic Surgery, Addenbrooke's Hospital, Cambridge University NHS Foundation Trust, Cambridge, United Kingdom.

The authors and planners have disclosed no potential conflicts of interest, financial or otherwise.

DOI: 10.1097/NOR.0000000000000115

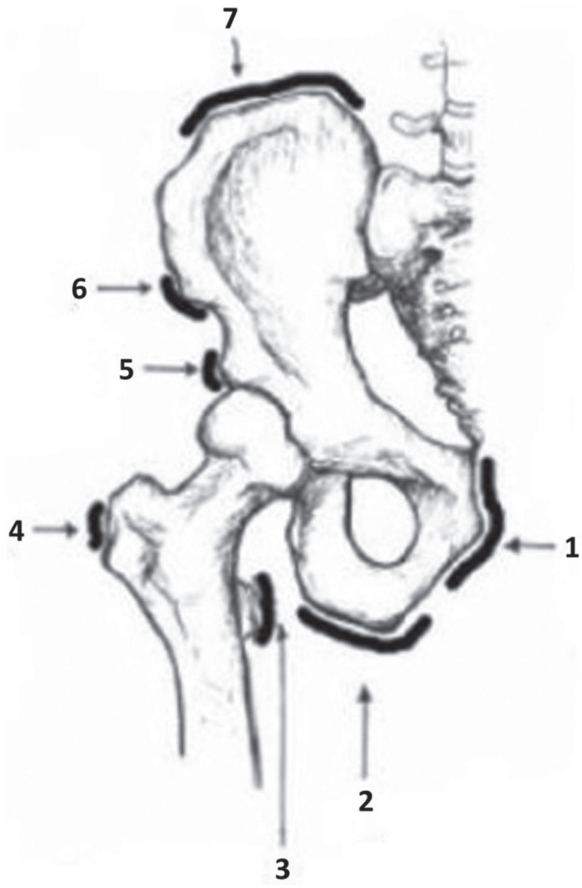


**Figure 1.** Medical illustration demonstrating anatomy of the hip and pelvis and sites of muscular attachments. 1—Pubic symphysis, gracilis, and adductor attachments; 2—Ischial tuberosity, hamstring attachments; 3—Lesser trochanter, iliopsoas attachment; 4—Greater trochanter, gluteal attachment, and lateral rotator attachments; 5—Anterior inferior iliac spine, rectus femoris attachment; 6—Anterior superior iliac spine, sartorius attachment; 7—Iliac crest, abdominal, pelvic, and back muscle attachments.

more common than musculotendinous injuries in skeletally immature individuals (Houghton, 2009).

## Patterns of Injury

Specific patterns of injury exist. Fractures of the iliac crest, anterior superior iliac spine (ASIS), AIIS, greater trochanter, lesser trochanter, and ischial tuberosity have been recorded with the muscle groups responsible being the rectus abdominis, sartorius, rectus femoris, gluteus medius, iliopsoas, and the hamstrings, respectively. The sites of these muscular attachments are demonstrated in Figure 1. Fusion of the apophyses dictates the time at which avulsion injuries are seen. The ischial tuberosity fuses at the age of 20–25 years, the AIIS at the age of 16–18 years, the ASIS at the age of 21–25 years with the lesser trochanter at the age of 15–17 years (Moeller, 2003).

## Clinical Features

The history is classically of an acute event, for example, jumping or kicking a ball (Kujala & Orava, 1993; Tehranzadeh, 1987), leading to a sudden muscle contraction. The individual then complains of instant pain in the distribution of the fracture site with subsequent loss of function (Söyüncü & Gür, 2004). Examination reveals swelling and tenderness with pain on passive motion. A lump may be palpated, which represents the avulsed fragment (Atalar, Kayaoğlu, Yavuz, Selek, & Uraş, 2007).

## Investigations and Imaging

Acute injuries are often associated with avulsed bony fragments (Stevens, El-Khoury, Kathol, Brandser, & Chow, 1999) (see Figure 2). Both subacute injuries and healing avulsions can have radiological appearances that are classically seen in malignant or infective etiologies. These can be seen as mixed areas of lysis, sclerosis, or destruction that are appearances associated with osteomyelitis or Ewing's sarcoma (Brandser, El-Khoury, & Kathol, 1995; Combs, 1994). In these cases, if fine needle biopsy was undertaken, it is likely to reveal the reactive nature of the process (Resnick et al., 1996). Chronic or old inactive injuries are frequently associated with a mass of new bone formation seen at radiography that, like subacute injuries, can be mistaken for infection or malignancy. With these injuries, diagnosis becomes difficult when an unclear history of trauma is elicited. In these instances, further imaging is undertaken instead of more invasive procedures such as fine needle aspiration. Computed tomography can be implemented to clarify the diagnosis (Brandser, El-Khoury, Kathol, Callaghan, & Tearse, 1995). Computed tomography has also been used to plan management in cases where impingement on the sciatic nerve is suspected (Miller, Stedman, Beisaw, & Gross, 1987). Magnetic resonance imaging is also being used to detect injury site and extent, with some centers using it to predict the amount of time an athlete will be disabled for and therefore help define the best treatment plan (De Paulis, Cacchio, Michelini, Damiani, & Saggini, 1998). Magnetic resonance imaging appears to be most useful when assessing

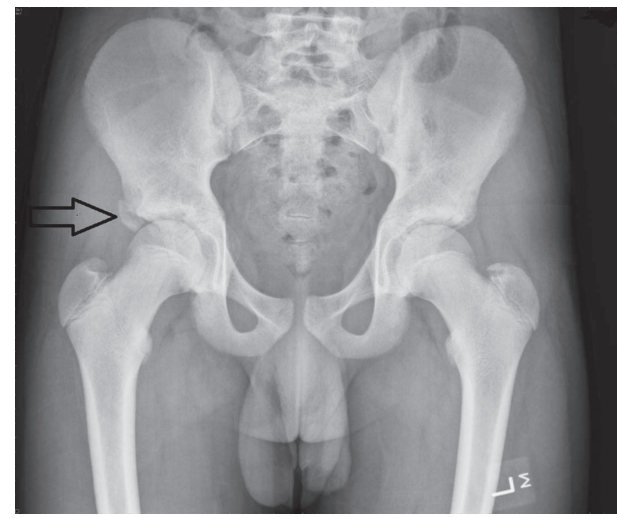

**Figure 2.** Anteroposterior pelvic radiograph. The avulsed fragment of the lateral aspect of the right acetabulum is identified by the arrow.

if injury has occurred to muscles, tendons, or ligaments. Some published data have demonstrated that radiography has poor sensitivity in evaluating hip and pelvic pain in patients who present acutely (Kirby & Spritzer, 2010). Despite this, diagnosis of pelvic avulsion fractures is best established with anteroposterior pelvic radiographs in most cases, whereas AIIS fractures may be seen only with oblique views.

## Management

In the majority of patients, conservative management with bed rest and gradual mobilization, analgesia, and physiotherapy is the treatment of choice (Anderson, Strickland, & Warren, 2001; Browning, 2001; Linni, Mayr, & Höllwarth, 2000; O'Kane, 1999). After diagnosis is confirmed, patients are advised to mobilize toe touch weight bearing with the aid of crutches and progression to full weight bearing is made as tolerated. Successful cases of open reduction and internal fixation of pelvic avulsion fractures are reported in the literature (Fitze, Dahlen, & Zwipp, 2008; Kosanović et al., 2002) with surgical intervention having a role in carefully selected cases (Rajasekhar, Kumar, & Bhamra, 2001).

Surgical intervention is indicated in cases where fracture fragments are displaced at 2 cm or greater, nonunion of the fracture has occurred, with formation of exostosis or in those where conservative measures have failed (Milankov, Miljkovic, Savic, & Stankovic, 2005; Pointinger, Munk, & Poeschl, 2003; Servant & Jones, 1998), with some successful cases of surgical intervention being reported as long as 9 months after the initial injury was sustained (Matsuda & Calipusan, 2012). Complications after conservative measures, such as exostosis formation, are well documented in the literature, leading to pain and impaired hip function and being successfully treated with surgical excision (Milankov, Harhaji, Gojković, & Drapsin, 2011). The majority of papers advocate conservative management (Kjellin, Stadnick, & Awh, 2010; McKinney et al., 2009; Yildiz, Aydin, Yildiz, Kalyon, & Basbozkurt, 2003) with some stating that no greater benefit is obtained with surgical intervention (Gomez, 1996). With acute injuries the outcome is more favorable with fewer complications occurring such as decreased sporting ability, pain or cramps on mobilizing, or palpable new bone formation at the fracture site (Moeller, 2003). Even with continued radiological abnormalities, patients are seldom symptomatic.

## Illustrative Case

A fit and well, 14-year-old Caucasian boy presented to the accident and emergency department at Addenbrooke's University Hospital with a 1-day history of pain in the right groin after playing football. The patient stated that on striking a football he heard a "crack," which was immediately followed by intense pain localized to the right groin. The pain was worsened by hip flexion and the patient was unable to fully weight bear on the affected side. On examination, pain was reproduced on palpation and by passive flexion and extension of the right hip. Neurovascular examination revealed no abnormalities in the right lower limb and examination of the left hip was unremarkable.

An anteroposterior radiograph of the pelvis demonstrated an avulsion fracture of the lateral aspect of the right acetabulum (see Figure 2). Magnetic resonance imaging showed an avulsion of a 2-cm-long fragment of bone from the right AIIS attached to the direct head of the rectus femoris muscle. The rectus femoris tendon was intact and there was no evidence of injury to the indirect head (see Figures 3A and 3B).

The patient was discharged and advised not to weight bear on the affected hip. He was reviewed in fracture clinic after 1 week by which time he was instructed to

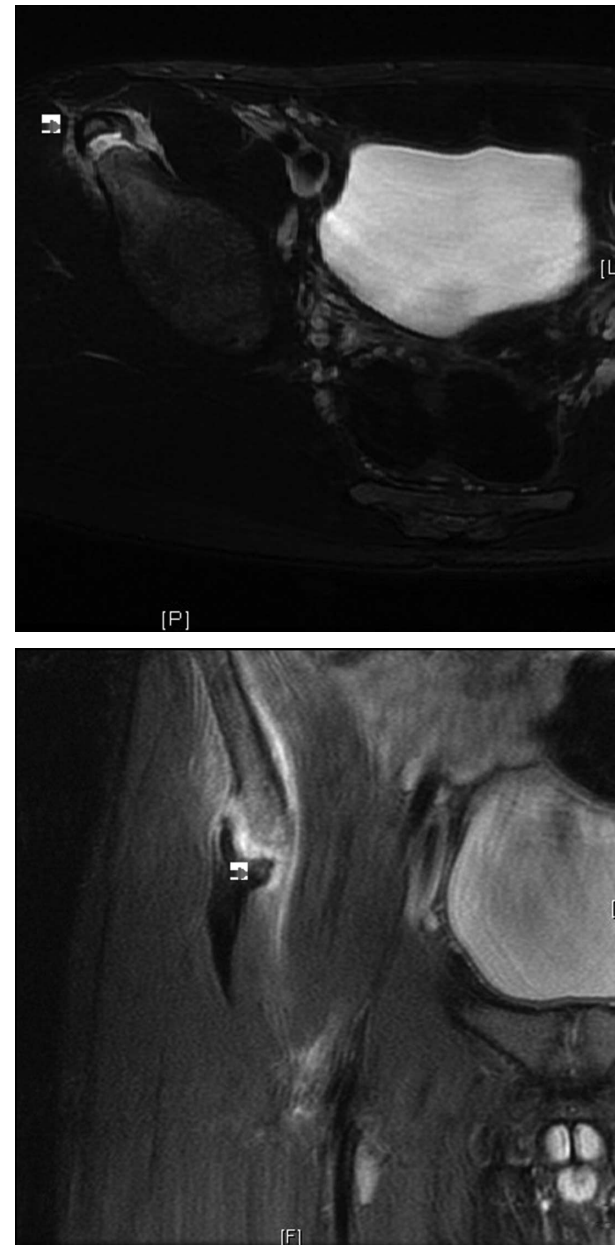


**FIGURE 3.** (A) Axial T2-weighted fat suppressed image showing avulsed fragment with arrow. The image shows a fluid collection around the fragment. (B) Coronal proton density fat suppressed image showing the intact rectus femoris and avulsed fragment. Avulsed fragment identified by the arrow.

partially weight bear as pain allowed on the right side. His symptoms had improved and he was making good progress so a plan was made to see the patient in clinic in a further 6 weeks with a radiograph on arrival.

## Nursing Assessment on Acute Presentation

It is important to appreciate that a majority of patients with an innocuous history of trauma may present with an avulsion injury. A classical history such as the one in this article suggests a pelvic apophyseal avulsion injury. This must alert the nurse when triaging the patient to immediately provide adequate analgesia, which is preferably simple and oral, and request appropriate pelvic x-ray imaging, including a potential oblique pelvic view, to improve the patient pathway. Patient mobility may prove difficult; however, we have attempted to provide reassurance that mobilizing with this condition does not lead to long-term sequelae. A period of nonweight bearing must be adopted so we suggest that walking aids enabling safe nonweight bearing of the affected side be provided to enable the patient to mobilize within the emergency department.

## The Nursing Role on Admission

Some patients may warrant acute admission into hospital for pain control and aid with mobilization. The treatment goal is to provide adequate analgesia and rehabilitation. When nursing the patient, no bed restrictions are required and patients do not need to be placed in traction on the affected side. Regular turning is not required to prevent skin ulceration. Timely and adequate analgesia and adherence to the rehabilitation program set by the admitting team in conjunction with the physiotherapists will lead to a safe and prompt discharge. Those nursing the patient must be aware that a non–weight-bearing program is likely to have been implemented, as such appropriate precautions must be adopted.

It is a condition that does not often require surgical intervention in the acute setting and it is effective nursing while adhering to guidance from the admitting team that leads to prompt and safe discharge. This is essential to optimize patient treatment and the efficiency of ward management, including bed status.

Those who undergo surgical intervention do so for excision of bony lesions. This is often performed as a day case procedure with postoperative guidance providing an adequate management plan, such as mobilization as pain allows. On occasions where patients are admitted, this is most commonly due to inadequate analgesic control where adherence to the guidance set above is crucial. Advice may need to be sought from the pain team to optimize the patient's analgesic regimen but the same guidance set out in this document applies.

## Discussion

Extra-articular hip pathology is more common than intra-articular hip pathology in young patients (Byrd & Jones, 2001). The physician responsible for treating the patient must ensure that a full medical history is taken relevant to any history of preexisting hip disease (Weiss & Ramachandran, 2006). Isolated nontraumatic avulsion fractures of the lesser trochanter in adults have been recognized as a pathognomonic sign of metastatic disease (Bertin, Horstman, & Coleman, 1984; Bui-Mansfield, Chew, Lenchik, Kline, & Boles, 2002; Phillips, Pope, Jones, Keats, & MacMillan, 1988).

The peak incidence of pelvic avulsion fractures is in the second decade. This is linked to the appearance of the apophysis and closure of the physis. During the adolescent period, the physis is at its weakest. Some have concluded that the physis is more easily damaged by powerful muscular contraction compared with repetitive strain (Stanisavljevic, 1953). In the same study, the necessary force required to produce AIIS avulsions was calculated in cadavers. Injuries to the ASIS or AIIS are often associated with forceful knee extension and hip flexion such as kicking a football. Before ossification of the apophyses occurs, avulsion fractures are possible. The diagnosis is often made retrospectively in follow-up radiographs as the fragment is visible only after it is ossified.

History and examination, coupled with radiological investigations, confirm the diagnosis; however, confusion can exist as the radiological appearance can mimic infection or sarcoma. Biopsy is to be avoided as changes seen in the developing new bone can imitate those seen in neoplasia (Fernbach & Wilkinson, 1981; Sanders & Zlatkin, 2008). A typical history strongly excludes a sinister etiology.

Treatment options range from conservative to surgical methods with the latter being reserved for persistent symptoms such as continued pain at a significant time point after the acute event due to bony or fibrous nonunion (Berry, 1912; Martin & Pipkin, 1957). Surgical intervention involves removal of nonunified fragments and reports have revealed symptom resolution with this technique (Rogge & Romano, 1956; Schlonsky & Olix, 1972). Conservative management is the mainstay of treatment with excellent results using a graded physiotherapy program in acute injuries (Metzmaker & Pappas, 1980). Avulsions of the ischial tuberosity often lead to chronic pain and therefore injuries of this nature are more likely to require surgery for symptom relief.

Overall outcome for patients with avulsion fractures of the pelvis is favorable. The vast majority of patients return to normal functional level with modification of their sporting activities and simple analgesia; however, rarely do elite athletes return to the same level of sporting ability. It is an interesting diagnosis and one that should not be missed in adolescents with a classical history and examination findings.

Patients present with impaired physical mobility and increased anxiety; it is important to assist the patient or significant others in order to identify difficulties that may arise from self-care deficits and develop a plan in conjunction with the patient for self-care, adapting to variations in mobility, and organizing care as necessary. Encouraging the verbalization of feeling pain will enable the main symptom of this condition to be identified and treated. It is essential to encourage adequate period of rest and sleep but equally to encourage adherence to

the mobility protocol provided in conjunction with the multidisciplinary team. Discussing the importance of early detection and reporting of changes in condition or any unusual physical discomforts will improve patient care while identifying the required changes in lifestyle that will be required for effective rehabilitation.

As this is a condition largely treated conservatively, it is the specific nursing role that is the mainstay of treatment. Only if patients receive adequate nursing care will their pain requirements be met, mobilization will be encouraged and a safe and timely discharge can be met, which will lead to further hospital bed availability.

In this document, we have attempted to provide further information into this interesting subject while highlighting some of the difficulties encountered with this patient cohort. We have presented guidance of what is required for the initial assessment of this injury, the difficulties that may arise through caring for the patient and what is required for safe and timely discharge. We hope that the essential role of nursing has been highlighted in this article and that nursing staff are more confident to treat this interesting condition.

## References


Anderson, K., Strickland, S., & Warren, R. (2001). Hip and groin injuries in athletes. *The American Journal of Sports Medicine*, *29*, 521–533.

Atalar, H., Kayaoğlu, E., Yavuz, O. Y., Selek, H., & Uraş, I. (2007). Avulsion fracture of the anterior inferior iliac spine. *Ulusal Travma ve Acil Cerrahi Dergisi*, *13*(4), 322–325.

Berry, J. M. (1912). Fracture of the tuberosity of the ischium due to muscular action. *JAMA*, *59*, 1450.

Bertin, K. C., Horstman, J., & Coleman, S. S. (1984). Isolated fracture of the lesser trochanter in adults: An initial manifestation of metastatic malignant disease. *Journal of Bone and Joint Surgery American Volume*, *66*, 770–773.

Brandser, E. A., El-Khoury, G. Y., & Kathol, M. H. (1995). Adolescent hamstring avulsions that simulate tumors. *Emergency Radiology*, *2*, 273–278.

Brandser, E. A., El-Khoury, G. Y., Kathol, M. H., Callaghan, J. J., & Tearse, D. S. (1995). Hamstring injuries: Radiographic, conventional tomographic, CT, and MR imaging characteristics. *Radiology*, *197*, 257–262.

Browning, K. H. (2001). Hip and pelvis injuries in runners. *The Physician and Sports Medicine*, *29* (1), 3. Retrieved from http://www.physsportsmed.com/issues/2001/01_01/browning.htm

Bui-Mansfield, L. T., Chew, F. S., Lenchik, L., Kline, M. J., & Boles, C. A. (2002). Nontraumatic avulsions of the pelvis. *AJR American Journal of Roentgenology*, *178*(2), 423–427.

Byrd, J. W., & Jones, K. S. (2001). Hip arthroscopy in athletes. *Clinical Journal of Sports Medicine*, *20*, 749–761.

Combs, J. A. (1994). Hip and pelvis avulsion fractures in adolescents. *Physician Sports Medicine*, *22*, 41–49.

De Paulis, F., Cacchio, A., Michelini, O., Damiani, A., & Saggini, R. (1998). Sports injuries in the pelvis and hip: diagnostic imaging. *European Journal of Radiology*, *27*(1), S49–S59.

El-Khoury, G. Y., Brandser, E. A., Kathol, M. H., Tearse, D. S., & Callaghan, J. J. (1995). Imaging of muscle injuries. *Skeletal Radiology*, *25*, 3–11.

Fernbach, S. K., & Wilkinson, R. H. (1981). Avulsion injuries of the pelvis and proximal femur. *AJR American Journal of Roentgenology*, *137*(3), 581–584.

Fitze, G., Dahlen, C., & Zwipp, H. (2008). Acetabular avulsion fracture in a 13-year-old patient after a minor trauma. *Journal of Pediatric Surgery*, *43*(3), E13–E16.

Gomez, J. E. (1996). Bilateral anterior inferior iliac spine avulsion fractures. *Medicine & Science Sports Exercise*, *28*, 161–164.

Houghton, K. M. (2009). Review for the generalist: Evaluation of pediatric hip pain. *Pediatric Rheumatology Online Journal*, *18*, 7–10.

Kirby, M. W., & Spritzer, C. (2010). Radiographic detection of hip and pelvic fractures in the emergency department. *AJR American Journal of Roentgenology*, *194*(4), 1054–1060.

Kjellin, I., Stadnick, M. E., & Awh, M. H. (2010). Orthopaedic magnetic resonance imaging challenge: Apophyseal avulsions at the pelvis. *Sports Health*, *2*(3), 247–251.

Kohler, A. (1929). *The borderlands of the normal and early pathological in the skiagram roentgenology*. (1st ed.). New York: William Wood.

Kosanovi , M., Brilej, D., Komadina, R., Buhanec, B., Pilih, I. A., & Vlaovi , M. (2002). Operative treatment of avulsion fractures of the anterior superior iliac spine according to the tension band principle. *Archives of Orthopaedic and Trauma Surgery*, *122*(8), 421–423.

Kujala, U. M., & Orava, S. (1993). Ischial apophysis injuries in athletes. *Sports Medicine*, *16*, 290–294.

Linni, K., Mayr, J., & Höllwarth, M. E. (2000). Apophyseal fractures of the pelvis and trochanter minor in 20 adolescents and 2 young children. *Unfallchirurg*, *103*(11), 961–964

Matsuda, D. K., & Calipusan, C. P. (2012). Adolescent femoroacetabular impingement from malunion of the anteroinferior iliac spine apophysis treated with arthroscopic spinoplasty. *Orthopedics*, *35*(3), e460–e463.

Martin, T. A., & Pipkin, G. (1957). Treatment of avulsion of the ischial tuberosity. *Clinical Orthopaedics*, *10*, 108.

McKinney, B. I., Nelson, C., & Carrion, W. (2009). Apophyseal avulsion fractures of the hip and pelvis. *Orthopedics*, *32*(1), 42.

Metzmaker, J. N., & Pappas, A. M. (1980). Avulsion fractures of the pelvis. *Orthopaedic Transactions*, *4*, 52.

Milankov, M. Z., Harhaji, V., Gojkovi , Z., & Drapsin, M. (2011). Heterotopic ossification following surgical treatment of avulsion fracture of the anterior inferior iliac spine. *Medicinski Pregled*, *64*(11/12), 593–596.

Milankov, M., Miljkovic, N., Savic, D., & Stankovic, M. (2005). Operative treatment of avulsion fractures of the anterior inferior iliac spine: A two-case report. *Journal of Orthopaedic Traumatology*, *6*, 154–157.

Miller, A., Stedman, G. H., Beisaw, N. E., & Gross, P. T. (1987). Sciatica caused by an avulsion fracture of the ischial tuberosity. *Journal of Bone and Joint Surgery American Volume*, *69*, 143–145.

Moeller, J. L. (2003). Pelvic and hip apophyseal avulsion injuries in young athletes. *Current Sports Medicine Reports*, *2*(2), 110–115.

O'Kane, J. W. (1999). Anterior hip pain. *American Family Physician*, *60*, 1687–1696.

Phillips, C. D., Pope, T. L., Jr Jones, J. E., Keats, T. E., & MacMillan, R. H. III (1988). Nontraumatic avulsion of the lesser trochanter: A pathognomonic sign of metastatic disease? *Skeletal Radiology*, *17*, 106–110.

Pointinger, H., Munk, P., & Poeschl, G. P. (2003). Avulsion fracture of the anterior superior iliac spine following apophysitis. *British Journal of Sports Medicine*, *37*, 361–362.

Rajasekhar, C., Kumar, K. S., & Bhamra, M. S. (2001). Avulsion fractures of the anterior inferior iliac spine: The case for surgical intervention. *International Orthopaedics*, *24*(6), 364–365.
Resnick, J. M., Carrasco, C. H., Edeiken, J., Yaskow, A. W., Ro, J. Y., & Ayala, A. G. (1996). Avulsion fracture of the anterior inferior iliac spine with abundant reactive ossification in the soft tissue. *Skeletal Radiology*, *25*, 580–584.
Rogge, E., & Romano, R. L. (1956). Avulsion of the ischial apophysis. *Journal of Bone and Joint Surgery American Volume*, *38*, 442.
Rossi, F., & Dragoni, S. (2001). Acute avulsion fractures of the pelvis in adolescent competitive athletes: Prevalence, location and sports distribution of 203 cases collected. *Skeletal Radiology*, *30*, 127–131.
Saluan, P. M., & Weiker, G. G. (1977). Avulsion of the anterior inferior iliac spine. *Orthopedics*, *2*, 558–559.
Sanders, T. G., & Zlatkin, M. B. (2008). Avulsion injuries of the pelvis. *Seminars in Musculoskeletal Radiology*, *12*(1), 42–53.
Schlonsky, J., & Olix, M. L. (1972). Functional disability following avulsion fracture of the ischial apophysis epiphysis. *Journal of Bone and Joint Surgery American volume*, *54*, 641–644.
Servant, C. T., & Jones, C. B. (1998). Displaced avulsion of the ischial apophysis: A hamstring injury requiring internal fixation. *British Journal of Sports Medicine*, *32*, 255–257.
Söyüncü, Y., & Gür, S. (2004). [Avulsion injuries of the pelvis in adolescents]. *Acta Orthopaedica et Traumatologica Turcica*, *38*(1), 88-92.
Stanisavljevic, S. (1953). Fracture of the anterior inferior spine of the ilium. *Archivio di Ortopedia*, *71*(5), 626–630.
Stevens, M. A., El-Khoury, G. Y., Kathol, M. H., Brandser, E. A., & Chow, S. (1999). Imaging features of avulsion injuries. *Radiographics*, *19*(3), 655-672.
Sundar, M., & Carty, H. (1994). Avulsion fractures of the pelvis in children: A report of 32 fractures and their outcome. *Skeletal Radiology*, *23*, 85–90.
Tehranzadeh, J. (1987). The spectrum of avulsion and avulsion-like injuries of the musculoskeletal system. *Radiographics*, *7*, 945–974.
Trousdale, R. T., & Ganz, R. (1994). Posttraumatic acetabular dysplasia. *Clinical Orthopaedics and Related Research*, *305*, 124–132.
Weiss, J. M., & Ramachandran, M. (2006). Hip and pelvic injuries in the young athlete. *Operative Techniques in Sports Medicine*, *14*(3), 212–217.
Yildiz, C., Aydin, T., Yildiz, Y., Kalyon, T. A., & Basbozkurt, M. (2003). Anterior inferior iliac spine apophyseal avulsion fracture. *Journal of the South Orthopaedic Association*, *12*(1), 38–40.

For 5 additional continuing nursing education articles on sports injuries, go to nursingcenter.com/ce.