

Avulsion fractures of the pelvis

M Naudé (MB ChB, H Dip Ort, MSc Sports Medicine)¹

B G P Lindeque (MB ChB, MMed Ort, FCSSA, (Ort) PhD)²

D C J v Rensburg (MB ChB, MSc Sports Medicine, MMed PhysMed)³

¹Waterkloof High School Sportsbureau, Erasmuskloof, Pretoria, and Department of Orthopaedics, Section Sportsmedicine, University of Pretoria

²Department of Orthopaedics, University of Pretoria

³Department of Orthopaedics, Section Sportsmedicine, University of Pretoria

Abstract

Objectives. Avulsion fractures of the pelvis occur predominantly in adolescent athletes. This article reviews the different types of avulsion fractures, their clinical presentation, special investigations in aid of a diagnosis, as well as the treatment of these fractures. It is important for doctors, coaches and the rest of the medical team to understand and treat these injuries correctly.

Data sources. Medline, Ovid.

Data extraction. A systematic review was done of all studies on avulsion fractures of the pelvis in adolescents. Twenty-five studies from 1953 to the present day were selected by searching Medline and Ovid. These studies, as well as case studies, were selected for their in-depth data and well-researched information.

Data synthesis. This was a qualitative synthesis based on all the selected studies and case studies.

Conclusion. This article reviews the diagnosis and treatment of avulsion fractures of the pelvis in adolescents. The clinical diagnosis is described in detail, and the most appropriate special investigations are discussed. The treatment consists of a non-operative regimen for uncomplicated undisplaced avulsion fractures, and surgical intervention for severely displaced avulsion fractures.

Introduction

Avulsion fractures of the pelvis occur predominantly in adolescent athletes as a result of forceful muscular contraction. Actions like kicking and sudden starts and stops while running make the adolescent athlete more prone to avulsion fractures.¹¹

CORRESPONDENCE:

M Naudé
 PO Box 2219
 Wingate Park
 0153
 Tel: 012-347 3162
 Fax: 012-347 0556
 E-mail: merchen@absamail.co.za

Tendons are much stronger than muscles for any cross-sectional area. Consequently, when a sudden strain is applied to a muscle-tendon bone unit, the muscle will rupture, or the tendon will avulse at its insertion, together with a fragment of bone to which it is attached.^{4,15} Studies have concluded that a rapidly applied force more easily injures the physis than an equal force applied more gradually.¹⁷

In the adolescent athlete, tendons attach to developing bone apophyses not yet firmly united with the parent bone.^{4, 15} Consequently, a rapidly contracting muscle can avulse the apophysis to which it is attached - resulting in an avulsion fracture.¹⁵ The apophyses most commonly fractured are the anterior superior iliac spine (ASIS), to which the sartorius muscle attaches, the anterior inferior iliac spine (AIIS), to which the rectus femoris muscle (of the quadriceps group of muscles) attaches, the ischial tuberosity, which contains origins of the hamstring muscles, and the lesser tuberosity of the femur, to which the iliopsoas muscle attaches (Fig. 1).¹⁵

Clinical presentation of avulsion fractures of the pelvis

Anterior superior iliac spine (ASIS)

The sartorius muscle originates from this apophysis. This apophysis ossifies at about the age of 15 years, and unites with the body of the ilium between the 20th and 25th year.⁷

Strong contraction of the sartorius muscle, especially with

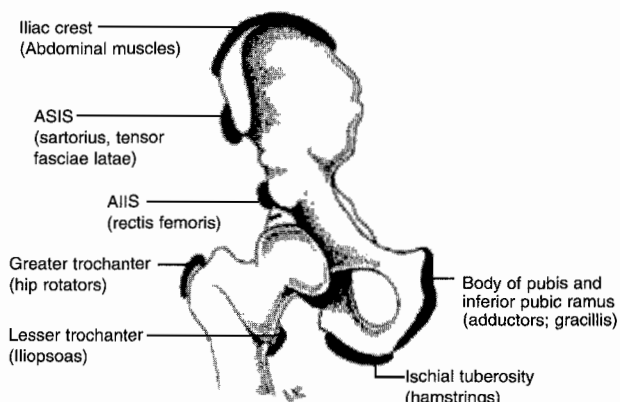


Fig. 1. Diagrammatic drawings of the six apophyseal sites.⁴

the knee flexed,^{13, 14} during strenuous manoeuvres such as sprinting or jumping may lead to avulsion of the ASIS.^{15, 22}

Repetitive injury to the ASIS apophysis can lead to the formation of a long exostosis extending in a curvilinear fashion towards the hip joint (Fig. 2). This bony spur may cause chronic hip pain, a major complication of chronic, repetitive avulsion of the ASIS.^{19, 24}

Clinical presentation. The athlete is forced to discontinue activity, because of immediate and severe pain which radiates from the iliac spine down the anterior thigh. In 45% of cases a snap or pull is felt by the athlete.⁷ Flexion and extension of the hip or knee reproduce the pain. Swelling followed by ecchymosis occurs at the site of the avulsion.¹⁵ The avulsed apophysis may be palpated.⁷

Anterior inferior iliac spine (AIIS)

Avulsion of the AIIS may be caused by excessive exertion on the direct head of the rectus femoris muscle¹⁵ (of the quadriceps group of muscles), which has its origin on the AIIS.

Maximum exertion of the muscle occurs when the hip is hyper-extended and the knee is flexed. This injury occurs most frequently in sports that involve kicking, for example soccer and rugby.^{12, 15} It is less common than avulsion of the ASIS, possibly because the AIIS fuses earlier (Fig. 3).¹³

Clinical presentation. Avulsion of the rectus femoris portion of the quadriceps muscle causes sudden pain in the groin after running, jumping or kicking. Tenderness in the groin is present, though difficult to pinpoint owing to the depth of the lesion. Active and passive flexion of the hip and knee reproduces the pain.^{12, 15}

Ischial tuberosity

As the athlete suddenly accelerates or stretches the hamstring muscle, the ischial tuberosity's apophysis is avulsed. This occurs especially in hurdling (athletics), gymnastics and

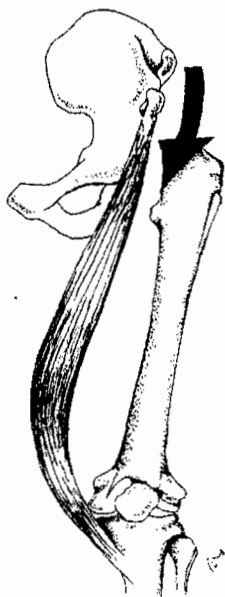


Fig 2. The sartorius muscle avulsing the anterior superior iliac spine.¹⁵

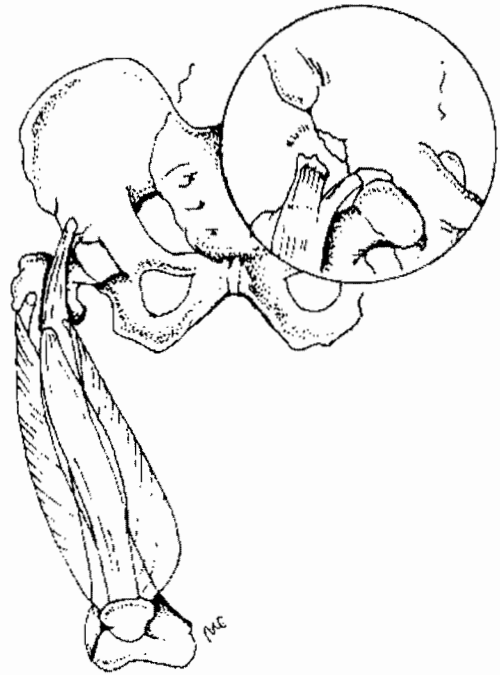


Fig. 3. The straight head of the rectus femoris muscle avulsing the anterior inferior iliac spine.¹²

football (Fig. 4).^{3, 13}

Clinical presentation. Avulsion of the apophysis of the ischial tuberosity by the hamstring muscle causes acute pain in the buttocks. The athlete has difficulty in standing and walking. The pain radiates into the hamstring muscles, and continued participation is impossible. This pain must be differentiated from sciatic pain. Active or passive straight leg raising accentuates the pain. In this position, the hip is moved into abduction. Patients may also have pain while sitting or moving on the involved tuberosity.¹³

With physical examination, tenderness at the ischial tuberosity is found, but is often diffuse because the injured muscle lies deep beneath thick layers of adipose tissue and the belly of the gluteus maximus muscle.⁶ There may be some swelling of the buttocks.

Lesser trochanter of the femur

Avulsion of the lesser trochanter is a rare injury that is seen more in adolescent or older athletes unaccustomed to physical activity.^{4, 15} The iliopsoas muscle (the strongest hip flexor) attaches to the lesser trochanter. Rapid, uncontrolled hip flexion or rotation of the torso on a fixed externally rotated femur can avulse the lesser trochanter. This usually occurs in tennis (Fig. 5).¹⁵

Uncommon avulsion fractures of the pelvis

There are other avulsion fractures of the pelvis that are rare injuries in athletes, and these are mentioned briefly. Avulsion of the greater trochanter of the femur occurs owing to a sudden contraction of the gluteus medius and minimus muscles against resistance. Though a rare injury in athletes,⁴ should it occur, reduction and immobilisation should be accomplished, owing to the importance of the abductor mechanism (Fig. 6).¹⁵



Fig. 4. The ischial tuberosity avulsed by the hamstring muscle.¹¹

On rare occasions, the iliac apophysis will partially avulse if the athlete receives a blow to the lateral abdominal muscles, e.g. in football. Pain and tenderness over the iliac crest with swelling and ecchymosis are present. X-rays of both sides are necessary to determine the degree of displacement. Treatment is usually non-operative. Return to non-contact sport may be allowed after four weeks (Fig. 7).^{4,15}

Special investigations for suspected fractures of the pelvis

X-rays

X-rays are the first in line in special investigations. It is important to take comparison X-rays of the contralateral apophysis to ensure that what appears to be an avulsion fracture is not a normal adolescent anatomic variant. With avulsion of the ASIS, the poorly outlined apophysis is seen to be separated from the ilium (comparison with the opposite side is often necessary to identify the lesion).¹⁵ The avulsed ASIS is displaced inferiorly and laterally, owing to the downward action of the sartorius and tensor fascia lata muscles (Fig. 8).⁷

Avulsion of the rectus femoral part of the quadriceps muscle from the AIIS shows minimal displacement owing to the attachments of the reflected head of the rectus femoris muscle and the hip joint capsule. Occasionally, both heads may be torn, with distal migration (Fig. 9).¹⁵

With avulsion of the apophysis of the ischial tuberosity, X-rays show the avulsed fragment of bone, which is easily identifiable since separation is usually marked (Fig. 10).¹⁵

It is important to differentiate between the healing process of an avulsion fracture, which shows exuberant callus formation (exostosis),²⁴ and neoplasms,^{4,5,8,12} for example Ewing tumor.¹⁹ Confusion is more likely to occur when there is no recollected history of trauma, as in chronic injuries.¹⁹ In

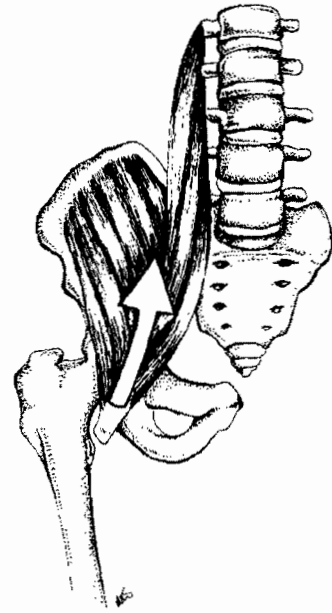


Fig. 5. The lesser trochanter of the femur avulsed by the contracting iliopsoas muscle.¹⁵

a case report a young man was treated for an ischial mass. After excision of the mass, it was found to be overgrowth of bone. The man had a previous avulsion fracture of the ischial tuberosity, and presented only three years later with a painful bony mass in his left buttock.¹

It is therefore important to remember a healed avulsion fracture in the differential diagnosis of a bone mass in the ischium.¹ Osteosarcoma may present as a pathologic fracture. The presence of a sports-related injury still does not rule out the possibility of an underlying malignancy.¹²

Computed tomography (CT)

CT may be of use in chronic avulsion injuries when a definite history of injury does not exist.



Fig. 6. The gluteus medius and minimus muscles avulsing the greater trochanter of the femur.¹⁵

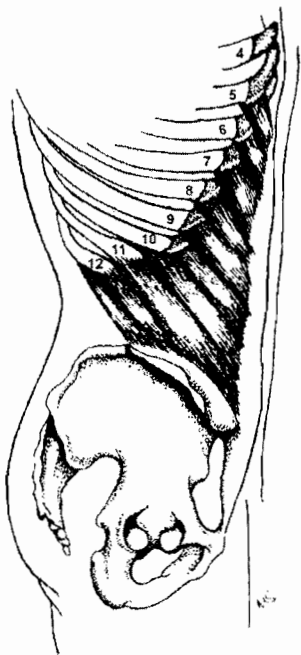


Fig. 7. Avulsion of the iliac crest in the young athlete.¹⁵

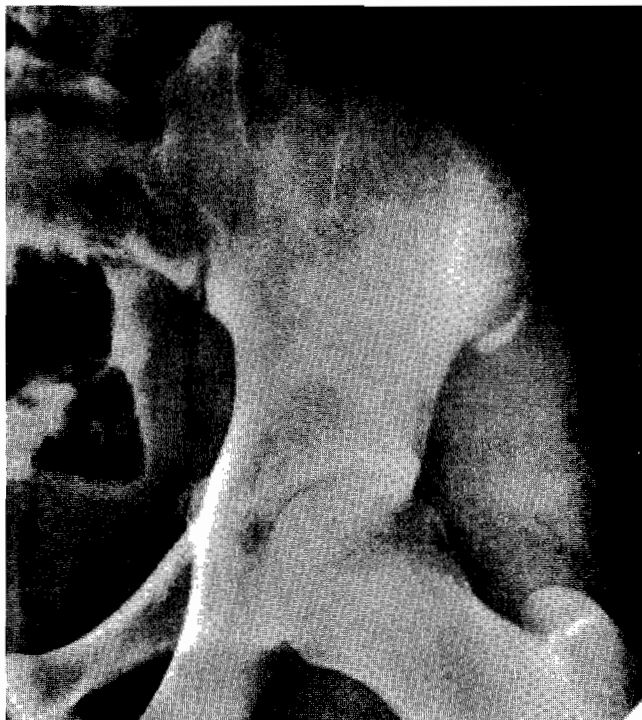


Fig. 8. An antero-posterior plain film X-ray of the pelvis of a 16-year old athlete showing avulsion of the ASIS by the sartorius muscle.⁹

If an avulsion fracture cannot be defined on X-rays, or if more precise measurement of a displaced fragment is needed for surgical intervention, CT can be used.^{18, 21}

CT has a very high resolution. With the use of the bony-window feature that excludes all soft tissue imaging one can concentrate on bone alone. CT also shows thigh muscle atrophy owing to avulsion fractures of the ischium.²¹



Fig. 9. Avulsion of the anterior inferior iliac spine.²⁰



Fig. 10. An antero-posterior plain film X-ray of the hip of a 26-year old runner demonstrates avulsion of the ischial tuberosity.⁵

MRI (magnetic resonance imaging)

MR imaging of the hip and pelvis is usually not required. MR imaging is best suited for the evaluation of injuries to muscles, tendons and ligaments.¹⁸

Other diagnostic means include soft-tissue diagnostic ultrasound and nuclear imaging.⁸

Recognition of characteristic imaging features and familiarity with musculo-tendinous anatomy will assist in the accurate diagnosis of avulsion injuries. History and conventional radiography are usually all that is needed to make a proper diagnosis.

Treatment of avulsion fractures of the pelvis

Non-operative treatment

The most important aim of treatment is to stretch and mobilise the tissues within the limits of pain tolerance from the outset.²³ Treatment involves rest, ice and analgesics initially, followed by a course of anti-inflammatory medication.¹¹

Protected weight bearing with crutches for the first three weeks is suggested by most authors.¹⁵ A range of motion exercises for the hip and knee are initiated to restore full motion at both joints. Isometric and progressive resistance exercises can then be started. Athletic activity may be resumed when full strength and range of motion in the hip and knee have been restored.¹² Avulsed fractures treated conservatively will usually require 6 - 8 weeks to heal.¹¹

With avulsions of the apophysis of the ischial tuberosity by the hamstring muscles, treatment depends on the amount of displacement. Minimally displaced fractures are treated as above.^{3, 15} Displacement of any fragment more than 3 cm is treated surgically (see surgical treatment).

A study by Fernbarch and Wilkonson⁴ on 20 male adolescents engaged in competitive sports show that operative treatment is rarely indicated. Results were as good in those treated conservatively as in those treated with open reduction and internal fixation of the fragment, regardless of the amount of displacement.^{2, 8, 13}

Surgical treatment

Surgical reattachment or excision of the fragment is indicated if a bony block to hip flexion occurs with distal migration especially in avulsion fractures of the AIIIS (Fig. 11).¹⁵

If the ischial tuberosity is displaced more than 3 cm after avulsion by the hamstring muscles, it should be surgically reattached to prevent complications.^{3, 12, 15, 25} If it was left to heal in this position, the strength of the hamstring muscle may be decreased. It must, however, be remembered that a surgically reattached muscle may likewise have decreased strength. The lesion should be repaired within two weeks following the injury.

Various studies, for example by Fernbarch and Wilkonson⁴ and Metzmaker and Pappas,¹⁰ reported that open reduction and internal fixation should be used for symptomatic non-unions only.^{3, 6, 22} Motion at this inadequate bony or fibrous lesion causes chronic pain, and surgical intervention may alleviate the symptoms.^{4, 7, 16, 19}

In competitive athletes, the period of recuperation may be shortened by open reduction and internal fixation. In cases reported,²² active exercises of the hip joint were begun two days after surgery. Patients were able to resume active training three to four weeks after trauma, with no significant decrease in strength of their thigh muscles.²²

The treatment of avulsion fractures depends on the degree of displacement of the avulsed fragment. If not displaced, non-operative treatment is recommended. If displaced more than 3 cm, surgical reattachment or excision of the fragment is indicated.

Complications of avulsion fractures of the pelvis

A bony block to hip flexion may occur in avulsion fractures of the anterior inferior iliac spine if distal migration has occurred. It can be treated surgically.¹⁵

Decreased muscle strength owing to poor reattachment or displacement of a fragment, or after surgical intervention, may occur.¹⁵ A decrease in posterior thigh muscle strength and a decrease in thigh girth are sometimes found post-injury.²¹

Rarely, excessive callus formation or myositis ossificans will occur after a displaced ischial tuberosity fracture.^{2, 13} This may sometimes need excision (Fig. 12).

A rare delayed complication of avulsion fractures of the ischial tuberosity is overgrowth of the tuberosity. Associated knee pain with significant bone and muscle atrophy in the thigh is noted.²¹ This causes persistent disability even years after the injury.^{3, 21} Leivseth and Reikeas⁹ suggested that the changes in muscle tension, owing to shortening of the muscles, are the main factors producing atrophy.

Another common complication of avulsion fractures of the ischium is sciatica induced by the dislocated fragment impinging on and piercing the sciatic nerve.^{8, 21}

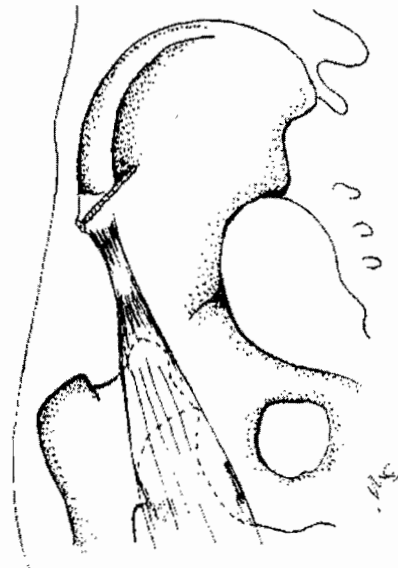


Fig. 11. Surgical technique for fixation of the anterior superior iliac spine.⁵

Prognosis for the outcome of avulsion fractures of the pelvis

Studies have reported good results with conservative treatment and a progressive rehabilitation programme.¹⁰ Open reduction and internal fixation of significantly displaced fragments do not seem to improve results.¹³

In a study done by Sudar and Carly,¹⁹ only 10 of the 32 adolescents participating in the study had disability persisting into adulthood and limitation of sports activity. They suggested that surgical treatment would not guarantee the return of the athlete to the same standard of activity as before the injury.¹⁹

With avulsion fractures of the ASIS (sartorius muscle attachment), as well as in avulsion of the AIIS (rectus femoral part of the quadriceps muscle),¹⁵ bony union is not necessary for good functioning. A fibrous union will produce good results.

Excessive callus formation after healing, especially of ischial avulsions, may be painful and impair sports activities, and may be surgically excised.^{2, 13} In a study done by Rockwood *et al.*,¹³ patients returned to athletic competition after excision, and were pain free at 5-year follow-up.

It seems that most cases of disability persisting into adult life, with limitation of sport participation and persisting symptoms, occur with avulsing injuries of the ischial tuberosity.

In avulsion of the lesser trochanter of the femur, the degree of displacement of the fragment from the femoral shaft did not correlate with the symptoms or the length of



Fig. 12. Excessive callus formation and ossification of the obturator externus muscle after a displaced ischial tuberosity fracture.⁵

time required for recovery.¹⁷

It seems that more complications and prolonged symptoms are seen in patients with a delayed diagnosis, or athletes who ignore the advice to rest after injury.⁹ Metzmaker and Pappas¹⁰ emphasised that full strength and integration of the involved muscles must be obtained before returning to competition, to prevent re-injury.

Conclusion

- Avulsion fractures of the pelvis are important to recognise owing to the greater number of young athletes participating in sport nowadays.
- The most common avulsion fractures of the pelvis are: (i) sartorius muscle that avulses the anterior superior iliac spine; (ii) direct head of rectus femoris that avulses the anterior inferior iliac spine; and (iii) hamstring muscle that avulses the ischial tuberosity.
- Treatment consists of rest, application of ice, and early mobilisation within pain limits, especially to stretch and mobilise from the outset.
- Most athletes return to their athletic activities without complications.

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