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Tendon Avulsions in Children and Adolescents

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Introduction

During growth, the apophyses and insertion sites of tendons and muscles are weaker than the tendons and muscles themselves, and bones. At these growth areas, therefore, avulsions of tendons and muscles or avulsion fractures may occur [1], especially during physical activity, including school and competitive sports. These injuries may occur also as a result of direct contusion, fall, or twisting injury. Some of these injuries cause sudden severe symptoms with pain, swelling, disability, and loss of function [2–4]. In partial avulsions, the symptoms are minor, and the correct diagnosis is frequently delayed. In these cases, often ectopic calcification is observed at a later date, as a consequence of periosteal new bone formation in the hematoma at the site of the lesion [1,5]. This heterotopic bone growth may hamper the function of the limb, limiting range of motion, or by the friction of soft tissues rubbing over the prominence. Fibrotic nonhealed avulsions cause prolonged problems, prevent maximal performance, and prompt further examination in greater depth.

Principles of Diagnosis and Management

The diagnosis of a tendon avulsion is usually easy. A careful history and physical examination are usually complemented by plain radiographs. At times, only special projections show the avulsed fragment [6]. Further diagnostic procedures are seldom necessary in the acute phase. However, in patients with long-standing history, ultrasonography, bone scan, computed tomography (CT) scan, or magnetic resonance imaging are needed for a more precise diagnosis and to plan management [7].

In most patients with tendon or muscle insertion avulsion, management is conservative [8,9]. Immobilization in

a plaster cast, elastic bandage, crutches, modified rest from physical activity, cold packs, and oral analgesia are usually sufficient. Rarely, surgical evacuation of the hematoma and fixation of the avulsed fragment may become necessary [3,10]. After surgery, immobilization to allow soft tissue and bone healing is required. Rehabilitation to return to the preinjury level of performance is important. Follow-up of the patients is needed for long enough to detect possible complications and the rare growth disturbances that can follow avulsions, regardless of the management method [9,11]. Early recognition of the injuries and initiation of appropriate management can prevent prolonged disability and later deformity, and help to return the young athletes to sports.

Avulsion Site and Type

There are several reports of different avulsion lesions [1,4,8,10–13]. Almost all of the tendons of the human body have been reported having been avulsed, mostly in children, adolescents and young adults [1]. The most common avulsions are those of the finger extensors at the distal phalanges (mallet finger); patellar tendon avulsion at the tibial tuberosity; hamstring tendons at the ischial tuberosity; and avulsions at the anterior spines of the pelvis and at the peroneus brevis tendon insertion at the fifth metatarsal bone [1]. Probably, avulsions at the iliac crest apophysis [14] or the triceps tendon at the olecranon [7] are comparatively rare. Though most avulsions occur in children and adolescents, they are seen at all ages.

Upper Extremity

In young athletes in throwing and “overhead” sports (such as baseball, javelin, tennis, and volleyball), apophysitis may occur at the medial humeral epicondyle, the site of the common flexor muscle insertion [5]. Little League elbow encompasses medial epicondyle apophysi-

tis or partial tear, and/or a lateral radiohumeral chondral lesion from repeated compression injury during throwing [15]. The medial epicondyle may separate and remain nonunited until adolescence or adulthood. It may require later surgery with removal of the loose fragment.

Avulsion of the triceps tendon is uncommon, typically occurring in skeletally mature individuals. It can also occur in adolescents [7]. Magnetic resonance imaging is useful in confirming the diagnosis. Stress fractures of the tip of the olecranon and apophysitis of the olecranon have been described in young javelin throwers [16].

Distal biceps tendon avulsion in young individuals is very rare. The diagnosis is not always easy, and magnetic resonance imaging helps to evaluate the severity of the injury and to plan management. Surgical reinsertion gives the best results in managing this injury [13,17]. Proximal avulsions of the tendon of the long head of the biceps may occur intra-articularly as a superior labrum anterior-posterior (SLAP) lesion. This injury has to be considered in the differential diagnoses of shoulder sports injuries seen in adolescent athletes [18]. The management is arthroscopic metal or bioabsorbable anchor fixation.

Small partial avulsions in the wrist and hand of young athletes occur often [1], and are sometimes difficult to detect clinically and radiographically [15]. With total tendon avulsions, loss of function makes the diagnosis easier. In “mallet finger,” both avulsion fractures and tendon avulsions occur. They should be treated without delay with a finger extension orthosis or by surgery. Recognition of injury patterns in sports, with early activity modification, can prevent deformity and disability from all upper arm injuries [15].

Pelvis

Anterior iliac spine avulsions are classical injuries to adolescent athletes. They have been reported in the superior and, less frequently, in the inferior anterior iliac spine [2,9,11,19]. The involvement of the apophysis ranges from painful apophysitis to full avulsion fracture [12]. Most of the avulsions can be treated conservatively with rest and/or immobilization. Surgery may be required when there is major displacement or a large bony fragment [2,10]. In some patients, long-lasting functional disability remains due to a prominent bone fragment or new bone formation. Limitation of hip joint flexion may follow a displaced, malunited fragment of the anterior inferior iliac spine. We have performed surgical excision of large ectopic calcifications after avulsions of the inferior anterior iliac spine with limitation of hip joint flexion.

The ischial tuberosity can avulse by traction of the hamstring tendons. Apophysitis, partial avulsion, and large bony avulsion are different types of this avulsion injury [20,21]. Apophysitis usually occurs to 13- to 15-year-old athletes, and avulsion fractures to 14- to 16-year-

old athletes, but they are sometimes seen in older individuals [22]. Local pain, especially on stretching, is typical, and hampers active exercise. A large hematoma of the posterior thigh can occur after bony avulsions. Bony avulsions with a diastasis greater than 3cm are treated surgically. Other injuries usually heal with conservative management [9,10,21,22]. Sometimes there are problems in the differential diagnosis. Bahk et al. described neoplasm simulating avulsions in 11- and 15-year-old boys [23].

Avulsions of the iliac crest are rare, but can be seen in adolescent athletes [24,25]. These are usually partial and can be treated conservatively. Healing by ossification usually occurs, but may take several months.

Avulsions of muscle or tendon insertions of the pubis and the lesser trochanter are also rare [11], and normally heal with rest, seldom causing later problems.

Knee

In the adolescent knee, avulsion of the intercondylar eminence of the tibia is a type of ligament injury, and is beyond the scope of this chapter [26]. Avulsion of the adductor tubercle is seen associated with medial capsuloligamentous injuries [19].

Complete tears of the quadriceps tendon and patellar tendon usually occur in older individuals, but have been seen occasionally in high-power sports events, such as high jump, basketball, and weightlifting [13]. Total transverse fractures of the patella have been reported to occur with maximal jumping or landing injury mechanisms. Patellar avulsions through the proximal or distal apophysis have been described [4], both in patients with and without jumper's knee.

Avulsion fractures or apophyseal injuries of the anterior tibial tuberosity occur mainly during sport activities, and are due to high strains exerted on this region by the eccentric action of the knee extensor muscles [8,27,28], and have been reported in adolescent athletes both with and without Osgood-Schlatter lesions [27,29–31]. Usually, avulsion fractures are partial [8], but complete bony avulsion may also occur [28,32], as well as true distal patellar tendon avulsions [31]. Konsens and Seltz reported fractures and tendon ruptures through large patellar tendon ossicles following Osgood-Schlatter disease [33]. In mild displacement, following closed reduction of the fragments, immobilization in a cast for 3 to 4 weeks is recommended [8,30]. In some patients with partial avulsion, rest from physical activity with elastic bandage has been used successfully as the only management. Displaced fractures have been treated surgically by internal fixation with screws, Kirschner wires (with or without a metal wire tension band), and with sutures through drill holes, with postoperative immobilization in a plaster cast for 4 to 6 weeks [3,27,28,30].

Foot and Ankle

Avulsions of the Achilles tendon with a bony fragment are rare [19]. These injuries need a well-planned surgical repair. The insertion site should be reconstructed, and the bony prominence of the superior calcaneal corner should not cause any anterior irritation to the tendon (see Figures 10-1 and 10-2).

Avulsion fracture of the base of the fifth metatarsal is usually a relatively benign injury [34]. Sometimes, the diagnosis is delayed, and the fracture is not seen in conventional radiographs of the foot [6]. However, it will usually heal with rest from physical activity for one month. Elastic bandage can be used for the first week or two. Avulsion of the peroneal tendon from the base of the fifth metatarsal can be bony, periosteal, or a pure tendon insertion avulsion [1]. In avulsion fractures with large diastasis and in tendon avulsions, surgical management ensures the full force of eversion of the foot [35].

Avulsions of the tendon of the tibialis posterior from the navicular are rare, the diagnosis can be difficult, and surgical management can be required [34]. Avulsions of foot extensor or flexor tendons seldom occur in athletes. Loss of functions is usually detected right after the injury, and early surgical reinsertion gives good results [34].

Tibialis anterior tendon avulsion from its tarsal insertion may occur, but usually the tendon rupture occurs at



FIGURE 10-1. Avulsion of the superior corner of the calcaneus in a 19-year-old female dancer. (Courtesy of Prof. Nicola Maffulli.)



FIGURE 10-2. Avulsion of the superior corner of the calcaneus in a 19-year-old female dancer following percutaneous fixation with two partially threaded, cannulated cancellous screws inserted at either side of the Achilles tendon. (Courtesy of Prof. Nicola Maffulli.)

the anterior aspect of the ankle of middle-aged patients [34]. Extensor and flexor tendon avulsions at the insertion sites of toes are rare.

Conclusions

Tendon avulsions as a group are not rare. Although tendon avulsions occur in all age groups, adolescent athletes especially suffer from these injuries. The apophyses in children and adolescents are weaker than other supporting structures around them [1]. In the immature skeleton, other epiphyseal injuries are seen with the same injury mechanisms that cause ligamentous or bony lesions in adults [36]. Some of the osteochondroses in active young athletes, together with the strains of training, may weaken the apophyses, and increase the risk for avulsion fractures [5]. The diagnosis of a tendon avulsion or an avulsion fracture is usually easy. The management is planned according to the type, site, and degree of the injury. It is usually conservative, but surgery may be needed too. When a bony or cartilaginous avulsion occurs around the age of full ossification, conservative management usually is successful. Later, in instances of purely tendinous avulsions, surgery is more often indicated.

References

1. Josza L, Kannus P. (1997) *Human Tendons*. Champaign, IL: Human Kinetics.
2. Metzmaker JN, Pappas AM. (1985) Avulsion fractures of the pelvis. *Am J Sports Med.* 13:349–358.
3. Maffulli N, Grewal R. (1997) Avulsion of the tibial tuberosity: muscles too strong for a growth plate. *Clin J Sports Med.* 7:129–132.
4. Powell RS, Wilson JS, Shall LM. (1998) Bilateral bony avulsion at the inferior patellar pole in a patient with jumper's knee. *Am J Knee Surg.* 11:189–191.
5. Kannus P, Niittymäki S, Järvinen M. (1988) Athletic overuse injuries in children. *Clin Paediatr.* 27:333–337.
6. Pao DG, Keats TE, Dussault RG. (2000) Avulsion of the base of the fifth metatarsal not seen on conventional radiography of the foot: the need for an additional projection. *Am J Roentgenol.* 175:549–552.
7. Zionts LE, Vachon LA. (1997) Demonstration of avulsion of the triceps tendon in an adolescent by magnetic resonance imaging. *Am J Orthop.* 26:489–490.
8. Balmat P, Vichard P, Pem R. (1990) The treatment of avulsion fractures of the tibial tuberosity in adolescent athletes. *Sports Med.* 9:311–316.
9. Sundar M, Carty H. (1994) Avulsion fractures of the pelvis in children: a report of 32 fractures and their outcome. *Skeletal Radiol.* 23:85–90.
10. Ducloyer P, Filipe G. (1988) Apophyseal avulsion of the pelvis in children. *Chir Pediatr.* 29:91–92.
11. Jacobsen S. (1993) Apophyseal avulsions of the pelvis and proximal femur. *Ugeskr Laeger.* 155:2124–2125.
12. Grasshoff H, Franke H. (1988) Apophyseal avulsions of the pelvis. *Beltr Orthop Traumatol.* 35:112–117.
13. Kannus P, Natri A. (1997) Etiology and pathophysiology of tendon ruptures in sports. *Scand J Med Sci Sports.* 7:107–112.
14. Aksoy B, Öztürk K, Ensényel CZ, Kara AN. (1998) Avulsion of the iliac crest apophysis. *Int J Sports Med.* 19:76–78.
15. Kocher MS, Waters PM, Micheli LJ. (2000) Upper extremity injuries in the paediatric athlete. *Sports Med.* 30:117–135.
16. Hulkko A, Orava S. (1986) Stress fracture of olecranon in javelin throwers. *Int J Sports Med.* 7:210–213.
17. Rantanen J, Orava S. (1999) Rupture of the distal biceps tendon. A report of 19 patients treated with anatomic reinsertion, and a meta-analysis of 147 cases found in the literature. *Am J Sports Med.* 27:128–132.
18. Snyder JS. (1994) *Shoulder Arthroscopy*. New York: McGraw-Hill.
19. Orava S, Ala-Ketola L. (1977) Avulsion fractures in athletes. *Brit J Sports Med.* 11:65–71.
20. Kujala UM, Orava S. (1993) Ischial apophysis injuries in athletes. *Sports Med.* 16:290–294.
21. Kujala UM, Orava S, Järvinen M. (1997) Hamstring injuries. Current trends in treatment and prevention. *Sports Med.* 23:397–404.
22. Kujala UM, Orava S, Karpakka J, Leppävuori J, Mattila K. (1997) Ischial tuberosity apophysitis and avulsion among athletes. *Int J Sports Med.* 18:149–155.
23. Bahk W.J, Brien EW, Luck JV, Mirra JM. (2000) Avulsion of the ischial tuberosity simulating neoplasm—a report of two cases. *Acta Orthop Scand.* 71:211–214.
24. Lambert MJ, Fligner DJ. (1993) Avulsion of the iliac crest apophysis: a rare fracture in adolescent athletes. *Ann Emerg Med.* 22:1218–1220.
25. Valdes M, Molins J, Acebes O. (2000) Avulsion fracture of the iliac crest in a football player. *Scand J Med Sci Sports.* 10:187–190.
26. Horibe S, Shi K, Mitsuoka T, Hamada M, Matsumoto N, Toritsuka Y. (2000) Nonunited avulsion fractures of the intercondylar eminence of the tibia. *Arthroscopy.* 16:757–762.
27. Tomola G. (1968) Avulsion fracture of the tibial tuberosity. *Med Sport.* 8:157–158.
28. Vainionpää S, Böstman O, Pätäälä H, Rokkanen P. (1985) Fracture of the tibial tuberosity in adolescents. *Arch Orthop Trauma Surg.* 104:20–24.
29. Levi JH, Coleman CR. (1976) Fractures of the tibial tubercle. *Am J Sports Med.* 4:253–263.
30. Ogden JA, Tross RB, Murphy MJ. (1980) Fractures of the tibial tuberosity in adolescents. *J Bone Joint Surg.* 62-A:205–215.
31. Bowers KD. (1981) Patellar tendon avulsion as a complication of Osgood-Schlatter's disease. *Am J Sports Med.* 9:356–359.
32. Hand W, Hand C, Dunn W. (1971) Avulsion fractures of the tibial tubercle. *J Bone Joint Surg.* 53-A:1579–1583.
33. Konsens RM, Seitz WH Jr. (1988) Bilateral fractures through “giant” patellar tendon ossicles: a late sequela of Osgood-Schlatter disease. *Orthop Rev.* 17:797–800.
34. Lutter LD, Mizel MS, Pfeffer GB, eds. (1994) *Orthopaedic Knowledge Update: Foot and Ankle*. Rosemont, IL: AAOS.
35. Thompson FM, Patterson AH. (1989) Rupture of the peroneus longus tendon. Report of three cases. *J Bone Joint Surg.* 71-A:293–295.
36. Kannus P, Järvinen M. (1988) Knee ligament injuries in adolescents. *J Bone Joint Surg.* 70-B:772–776.