

Achilles Tendinitis In Running Athletes

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Abstract: Achilles tendinitis is an injury that commonly affects athletes in the running and jumping sports. It results from repetitive eccentric load-induced microtrauma that stresses the peritendinous structures causing inflammation. Achilles tendinitis may be classified histologically as peritendinitis, tendinosis, or partial tendon rupture.

Training errors are frequently responsible for the onset of Achilles tendinitis. These include excessive running mileage and training intensity, hill running, running on hard or uneven surfaces, and wearing poorly designed running shoes. Biomechanical ab-

normalities that predispose to Achilles tendinitis include gastrocnemius-soleus muscle weakness or inflexibility and hindfoot malalignment with foot hyperpronation.

The initial treatment should be conservative with relative rest, gastrocnemius-soleus rehabilitation, cryotherapy, heel lifts, nonsteroidal anti-inflammatory drugs, and correction of biomechanical abnormalities. Surgery is recommended only for persons with chronic symptoms who wish to continue running and have not benefited from conservative therapy. (J Am Bd Fam Pract 1989; 2:196-203.)

In Homer's *Iliad*, the Greek chieftain Achilles was mortally wounded by an arrow that pierced his heel, which was his only unprotected area, because the remainder of his body had been made invulnerable by an immersion in the River Styx.¹ Today, the Achilles tendon is a common site of athletic injury because of the demanding training regimens of competitive athletes and the rising numbers of recreational athletes.

Achilles tendinitis commonly affects athletes involved in track and field, cross-country running, tennis, basketball, baseball, gymnastics, and ballet. James, et al. found Achilles tendinitis to be the third most common running injury (11 percent of all such injuries); only knee pain (29 percent) and the posterior tibial syndrome (13 percent) occurred more frequently.² Others have reported that Achilles tendinitis accounts for 6.5 and 18 percent of running injuries.^{3,4}

Achilles tendinitis is believed to result from repetitive, eccentric musculotendinous loading, which causes microtraumatic structural damage. Middle-aged men are most frequently afflicted, with the average age of onset being 39 years in one study.⁴ Increased susceptibility to injury in older persons may be due to loss of normal tendon elasticity, which predisposes the tendon to eccentric, load-induced microtears.

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Anatomy

The Achilles tendon (calcaneal tendon), which inserts on the calcaneus, is the common tendon of the gastrocnemius and soleus muscles. The gastrocnemius muscle arises from two heads originating on the femoral condyles and lies superficial to the soleus. The soleus arises from the posterior surfaces of the proximal tibia and fibula and does not cross the knee joint. This muscle pair primarily plantar flexes the foot and secondarily flexes the leg.⁵ The plantaris muscle, which completes the muscle triad referred to as the "triceps surae," has its own tendon, which contributes no fibers to the Achilles tendon. Two major bursae lie adjacent to the tendon; the subcutaneous bursa is situated between the skin and the insertion of the Achilles tendon, while the retrocalcaneal bursa lies deep to the tendon, adjacent to the posterior-superior calcaneal border (Figure 1).

The tendon is composed of primary bundles of dense connective tissue and collagen fibers that are packaged into individual tendon functional units known as fascicles or secondary bundles. Groups of fascicles constitute the true tendon, which is loosely held together by the surrounding blood vessels, nerves, and lymphatic-carrying endotendon. The peritendon covers the endotendon and is composed of a loose, inner connective tissue (epitenon) and an outer tissue (paratenon), which act as an elastic sleeve to allow free tendon movement. The Achilles tendon has no true synovial sheath.

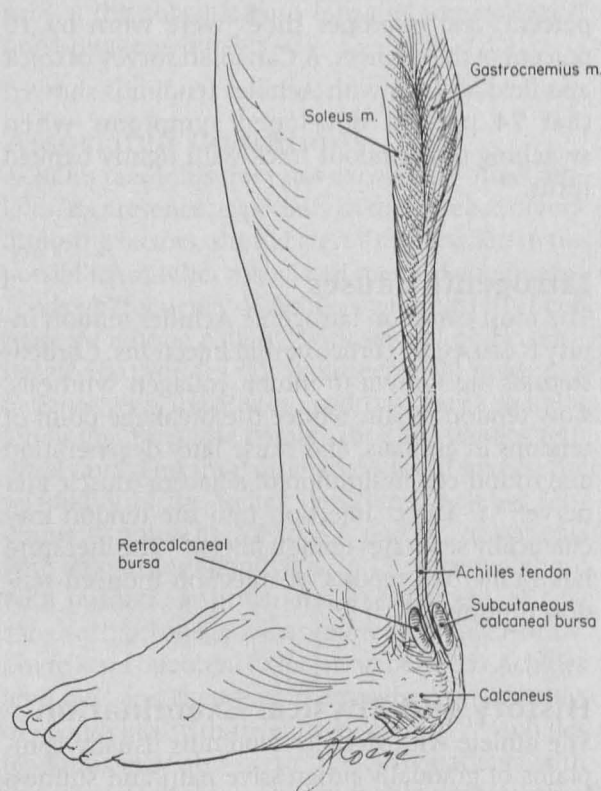


Figure 1. Anatomy of the Achilles tendon and adjacent structures.

Drawing by Gwynne M. Gloege

Three vascular sources supply the Achilles tendon. These include longitudinal vessels that cross the musculotendinous junction, small vessels that anastomose in the periosteum at the tendon-osseous junction, and most importantly, the vascular branches of the posterior tibial and peroneal arteries along the entire length of the tendon.⁶ A region of reduced vascularity exists in the distal tendon, 2 to 6 centimeters from its insertion.⁷⁻⁹ Lindholm and Arner found this to be the site of tendon rupture in 45 of 46 cases.¹⁰ This region also seems to be the most common site of tendon inflammation.¹¹⁻¹⁴ The twisting and the lateral rotation of Achilles tendon fibers as they descend produce additional stress and tendon hypovascularity.^{15,16}

Classification of Achilles Tendon Injuries

Achilles tendon injury is classified according to macroscopic and histologic examination. Although no true synovial membrane exists, the

term "tenosynovitis" has been used to describe inflammation of the tendon and adjacent structures.^{17,18} A more proper classification of injury types includes: (1) peritendinitis, (2) tendinosis, (3) peritendinitis with tendinosis, (4) partial tendon rupture, and (5) complete tendon rupture. Peritendinitis refers to inflammation of the peritendinous sheath, and tendinosis indicates tendon microstructural disruption. The first four types are the common, overuse Achilles tendon injuries seen in runners; complete tendon rupture is not discussed in this review.

Pathomechanics

During the push-off phase of running, up to 2000 pounds of force may be transmitted to the Achilles tendon. This tremendous force is absorbed through eccentric tendon loading when the rapidly dorsiflexing foot decelerates.^{19,20} Repetitive eccentric loading may produce focal or diffuse tendon degeneration and inflammation. As injured tissue heals, granulation tissue develops and frequently forms adhesions between the tendon and paratendon, resulting in recurrent inflammation.

Etiology

The etiology of Achilles tendinitis (peritendinitis or tendinosis) is multifactorial. The most important factors are poor gastrocnemius and soleus muscle flexibility, hyperpronation of the running foot, poor running shoe design, excessive eccentric muscle loading, and overtraining. A tight, poorly flexible Achilles tendon may be the most common predisposing factor, aggravated by wearing high-heeled shoes and by inadequate stretching. The Achilles tendon is long, compared with gastrocnemius and soleus muscle lengths, which helps absorb large forces. If flexibility is limited, the tendon loses some of its shock-absorbing elasticity, predisposing it to eccentric load-induced microtears and inflammation.

The typical sequence of foot biomechanics during running must be reviewed to discuss the effect of hyperpronation. The sequence consists of heel strike, rapid pronation, and supination.²¹ At heel strike, initial ground contact is made with the lateral aspect of the heel. Rapid pronation follows as the midtarsal joint unlocks, relieving tension on the plantar fascia and enabling the foot to adjust to uneven terrain and absorb impact. Supination

then occurs as the midtarsal joint locks to increase plantar fascia tension and convert the foot from a mobile adaptor to a rigid lever arm in preparation for the push-off. Many runners with Achilles tendon problems have a prolonged pronation phase (hyperpronation), causing increased medial tendon tension and a resultant whipping action or "bowstring" effect on the Achilles tendon. Thirty degrees of change in hindfoot position results in a 10 percent elongation of the fibers on the stressed aspect of the tendon.¹⁶ Poor gastrocnemius-soleus flexibility adds to hyperpronation by forcing a compensatory increase in knee flexion during running.²² These conflicting internal and external rotatory forces imparted to the tibia during simultaneous foot pronation and knee extension may "wring out" tendon vessels to produce avascularity.

Shoe design plays an important role in the development of Achilles tendon injury. Hyperpronation often results from wearing shoes with soft heel counters, narrow heels, or poor medial heel counter support. Running shoes with high, poorly padded heel counters place unnecessary pressure on the tendon. Shoes with inadequate heel elevation produce increased tendon stretch and, consequently, increased loading at heel strike. Rigid, inflexible soles add to tendon strain by lengthening the ankle-to-forefoot lever arm. Poorly cushioned shoes, particularly when worn by persons with rigid, cavus feet, lead to Achilles tendon strain through their reduced capacity to absorb impact and eccentric loading.

Training practices that increase eccentric tendon loading, particularly when associated with sudden changes in training, often lead to Achilles tendon injuries. Examples include increases in hill running and sprinting; changes to a harder running surface; running on uneven terrain; running on a high-traction, all-weather track; sudden mileage increases; resumption of training after a break; and changes in running shoes. Overtraining causes damage to immature, healing tendinous granulation tissue and depletes tendinous glycogen stores, which may diminish a muscle's capacity to generate sufficient protective contractile forces.⁴

Clement, et al. reviewed factors associated with Achilles tendinitis in 109 symptomatic runners.⁴ Training errors were apparent in 75 percent, moderate-to-severe hindfoot malalignment with hyperpronation was present in 56 percent, poor gastrocnemius-soleus flexibility was noted in 39

percent, and improper shoes were worn by 10 percent of the runners. A Canadian survey of track and field athletes with Achilles tendinitis showed that 74 percent developed symptoms when switching to an indoor track with tightly banked turns.¹⁸

Iatrogenic Causes

The most common iatrogenic Achilles tendon injury is caused by corticosteroid injections. Corticosteroids are known to inhibit collagen synthesis, slow tendon repair, reduce the breakage point of tendons in animals, and cause fatty degeneration and round-cell infiltration of adjacent muscle and nerve.²³⁻²⁷ Direct injection into the tendon mechanically separates tendon fibers.²⁸ The literature has numerous reports of injection-induced tendon rupture.^{10,13,20,28-31}

History and Physical Examination

The athlete with Achilles tendinitis usually complains of gradually progressive pain and stiffness in the distal 5 centimeters of the tendon, though pain may occur more proximally or distally. The onset of symptoms frequently coincides with a change in training intensity or quality. Initially, pain occurs only following activity, but with continued use, the tendon may also become painful during activity. Symptoms frequently decrease or temporarily disappear after a proper muscle warm-up, probably due to a loosening of inflammatory adhesions between the tendon and peritendinous sheath.¹⁷

The physical examination may show tendon tenderness and thickening, overlying soft tissue swelling, and crepitus. Pain is often reproduced by rapidly dorsiflexing the foot, or by asking the patient to hop on one foot. Limited ankle dorsiflexion due to a tight Achilles tendon is common. Flexibility can be measured by determining the angle between the tibia of the maximally dorsiflexed ankle with the knee flexed and a vertical line extended to the floor. This angle measures 25 to 45 degrees in the normally flexible person.¹⁷ A palpable tendon defect suggests partial or total tendon rupture. The Thompson squeeze test is useful to help diagnose complete tendon rupture. In this test, the examiner "squeezes" the calf muscles and observes for plantar flexion; an absence of plantar flexion indicates complete rupture. Localized tender-

ness at the subcutaneous bursa or retrocalcaneal bursa suggests bursitis.

Associated Conditions

Achilles tendinitis does not exclusively affect athletes. Its presence, especially in the absence of predisposing factors, should alert the physician to the possibility of other associated medical conditions.

A high frequency of Achilles tendinitis has been reported among patients with several of the seronegative arthritides.³²⁻²⁴ Fourteen to 31 percent of patients with the Reiter syndrome have Achilles tendinitis; thus, the combination of Achilles tendinitis and a urethral discharge should suggest the possibility of the Reiter syndrome. Achilles tendinitis is noted in 7.5 to 8.6 percent of patients with ankylosing spondylitis, in 17 percent of those with psoriatic arthritis, and in 9 percent of persons with seronegative asymmetric oligoarthritis. There is no apparent association between Achilles tendinitis and rheumatoid arthritis, osteoarthritis, or spondylitis with ulcerative colitis.³²⁻³⁴ Achilles tendinitis may also occur in elderly patients with chondrocalcinosis secondary to calcium pyrophosphate dihydrate crystal deposition within the tendon.³⁵

Recurrent bouts of Achilles tendinitis in children may represent an initial manifestation of familial type II hyperlipoproteinemia.³⁶ The inflammation is a result of xanthomas that form within the extensor tendon sheaths.³⁷ Pain may be so severe during tendinitis attacks that affected children may be unable to walk.

Diagnosis

The diagnosis of Achilles tendinitis is usually made on the basis of the patient's history and the physical examination. Radiographic examinations are most useful to rule out other causes of such pain. The lateral view radiograph should provide easy visualization of the anterior and posterior Achilles tendon margins.³⁸ Significant tendon thickening and calcification may be noted in chronic tendinitis. The lateral view radiograph of an acutely ruptured tendon may show retraction and interruption of musculotendinous tracts, soft tissue defects, tendon ossification, and fracture of the osteophyte at the junction of the Achilles tendon and calcaneus.³⁹ The configuration of the Kager triangle on the lateral radiograph, which is bordered posteriorly by the inner contour of the

Achilles tendon, anteriorly by the deep flexor tendons, and inferiorly by the calcaneus, changes relative to the normal ankle in tendon rupture.²⁰ The Toygar angle refers to an abnormal depression in the normal, smooth tissue contour overlying the Achilles tendon at the site of the ruptured tendon.¹⁰

Ultrasonography may help define the integrity of an injured Achilles tendon. Electromyograms have been used to detect the presence and location of partial tendon rupture.²⁰ Magnetic resonance imaging, with its outstanding soft tissue resolution, may help diagnose partial and total Achilles tendon ruptures.

Differential Diagnosis

Several clinical conditions may mimic Achilles tendinitis. The following is a differential diagnosis of heel and lower leg pain:

1. A *calcaneal contusion* is due to direct plantar surface trauma, resulting in periosteal inflammation. Clinically, it is characterized by point tenderness on the plantar surface of the calcaneus.
2. *Plantar fasciitis* refers to an inflammation of the plantar fascia, with resultant pain and tenderness at the calcaneal insertion and along the longitudinal arch.
3. *Retrocalcaneal bursitis* results from excessive pressure on the bursa from a poorly padded shoe heel counter. The "bursal squeeze test" is positive if pain is produced when the examiner uses the thumb and finger to exert pressure on the bursa.
4. *Subcutaneous bursitis* ("pump bump") is also due to excessive shoe heel counter pressure and often occurs in association with a prominent posterior calcaneal angle. The overlying skin may become erythematous, thickened, and tender.
5. *Calcaneal stress fractures* result from repetitive microtrauma, while *complete calcaneal fractures* occur only following severe trauma. The diagnosis of fractures is made with the use of radiographs, radionuclide bone scans, or computerized tomography.
6. *Rupture of the medial head of the gastrocnemius* commonly occurs in middle-aged athletes, presenting as a sudden stabbing pain in the proximal calf. The physical examination typically shows tenderness near the medial

gastrocnemius origin, a palpable muscle defect, and reduced plantar flexion strength (with an intact Thompson squeeze test).

7. *Posterior tibial tendinitis* (shin splints) results from inflammation of the posterior tibialis muscle and is characterized by pain and tenderness along the medial tibial border.
8. *Tibial and fibular stress fractures* are usually overuse fractures that exhibit bony point tenderness. The diagnosis is often confirmed with radiographs in chronic cases but typically requires radionuclide bone scans to diagnose acute injuries.
9. A *compartment syndrome* occurs when lower leg intracompartmental pressures increase, resulting in cramping, pain, swelling, muscle weakness, and sensory loss.
10. *Nerve entrapment* of the medial branch of the posterior tibial nerve may occur secondary to shoe pressure. Symptoms include numbness and pain in the distribution of the nerve. The diagnosis is made with neurologic examination or nerve conduction studies.

Treatment

Conservative

The initial management of Achilles tendinitis involves tendon rest. Weekly training mileage, sprint training, and hill training should be reduced to permit healing of inflamed structures. The recommended amount of rest depends on the severity and occurrence of pain experienced by the athlete. Type I pain is defined as pain that is experienced only following activity. These athletes should reduce their training by 25 percent. Type II pain occurs both during and after activity but does not restrict performance. Treatment involves reducing training mileage by 50 percent. Type III pain refers to pain during and after activity and does restrict performance. These persons should temporarily discontinue running. Type IV pain is chronic and unremitting and may require more aggressive therapy when conservative measures fail.⁴⁰ It is important during the rest phase of treatment that a nonweight-bearing form of exercise such as swimming, bicycling, or swimming-pool running be prescribed to help maintain aerobic conditioning.

In addition to changes in training, the gastrocnemius-soleus musculotendinous unit must be stretched to increase flexibility and strengthened to protect from future injury. Patients should be

shown the proper method of Achilles tendon stretching, which involves a constant, gentle stretch to the tendon with the ankle in dorsiflexion and the knee both fully extended and slightly flexed. Complete rest of the tendon should be avoided to prevent further weakening.

The injured athlete should warm the affected area before training and should apply ice afterwards, except in the acute phase of injury when heat should be avoided. Ultrasonic treatment often helps to reduce inflammation, but it may exacerbate inflammation by disturbing local leukocytes. Nonsteroidal anti-inflammatory drugs may help reduce inflammation acutely, but they are less helpful for chronic injuries.

Running shoes should be replaced when they show excessive wear. Heel lifts of one-fourth to three-eighths inch are added to both training and dress shoes to help reduce tendon stress. Medial heel wedges with firm heel counters and orthotic devices may help correct hyperpronation in persons with hindfoot malalignment.

Clement, et al. treated 109 runners with Achilles tendinitis using gastrocnemius-soleus rehabilitation, control of pain and inflammation, and correction of biomechanical variables with orthotic devices. After 5 weeks of treatment, excellent results were reported in 73 runners, good results in 12, and fair results in only 1. The remaining 23 athletes did not follow-up.⁴

A retrospective study of runners with Achilles tendinitis showed that 92 percent noted improvement when ice was applied after training, 64 percent reported benefits from ultrasonic treatments, and 10 percent were helped by anti-inflammatory medications. Fifty-six percent of the runners could not compete for at least 4 weeks, and 16 percent noted a permanent reduction in their competitive performance level.¹⁸

Heel pads reduce the stretch on the Achilles tendon, and the use of visco-elastic polymer heel wedges has been shown to reduce significantly the magnitude of heel strike force during walking and running.⁴¹ Other studies have conflicting results on the potential of such heel pads to treat Achilles tendinitis.^{42,43}

Rehabilitation of the injured Achilles tendon should focus on stretching to increase the resting length of the musculotendinous unit and on strengthening to increase tendon load-absorbing capabilities. As a guideline, the tendon should be exercised to the point of pain or discomfort in only the last few repetitions of each set. This will insure

that sufficient tendon loading occurs to produce strengthening, while protecting the tendon from further injury. Curwin and Stanish reported improvement in all 57 Achilles tendinitis patients who completed an eccentric strengthening and stretching rehabilitation program.⁴⁴ Fifty-four percent experienced a complete resolution of symptoms. Unfortunately, no control group was used.

Prolonged casting results in selective atrophy of type I muscle fibers, which limits its usefulness in treating Achilles tendinitis.^{45,46} Some authors, however, advocate its use for short periods when treating chronic tendinitis that has failed conservative therapy.¹⁷

Surgical

Surgery may be appropriate for certain patients with chronic Achilles tendinitis who wish to continue running but have not improved with extensive conservative therapy. The most common surgical procedure involves exploring the tendon, tendon sheath, and mesotendon through a medial longitudinal incision. Inflamed, degenerated tissues and calcifications are resected, adhesions are lysed, and the tendon is inspected for partial rupture. The retrocalcaneal bursa is examined and resected if degeneration is noted. If a prominent superior calcaneal tubercle is noted to cause chronic tendon irritation, an osteotomy may be performed.^{17,40,47,48} Postoperatively, the lower extremity is placed in a short leg cast for 3 to 6 weeks, after which progressive weight-bearing, stretching, and strengthening are prescribed. Leach and colleagues reported a series of 20 surgical procedures on athletes with chronic symptoms. Achilles tenolysis was performed in 11, removal of retrocalcaneal superior tuberosities in 6, resections of calcium in 3, and a combination of these procedures in the remaining athletes. All but one were eventually able to return to their desired levels of activity.¹⁷

Prevention

Clement postulated that an increased awareness of the importance of Achilles tendon stretching has reduced the frequency of Achilles tendinitis in runners today.⁴ Regular and proper heel cord stretching should be in the training regimen of every athlete participating in running sports. Orthotic shoe devices may be helpful in limiting

the pronation phase in persons with excessive pronation.⁴ Running shoes should be replaced regularly before showing signs of excessive wear.

Ideally designed running shoes have a wide, flared heel and a well-cushioned heel counter. A heel lift of 12 to 15 mm is recommended, and a medial heel wedge may help prevent hyperpronation. The sole should be cushioned to absorb impact and to permit adequate flexibility at the metatarsophalangeal joints. Waffled soles may reduce the torsional stress transmitted from the ground during the support phase.²

Running training mileage should be increased gradually, particularly after breaks in training. Sprint training, hill running, and track running must also be introduced into the runner's training program gradually. The majority of a runner's training should be done on level asphalt, dirt, or cinder surfaces, because concrete sidewalks, banked streets, and tracks with tight turns predispose to Achilles tendon injury. When an athlete begins to experience pain in the Achilles tendon, an early reduction in training intensity is advised.

Partial Achilles Tendon Rupture

Partial Achilles tendon rupture was thought to be rare until Ljungqvist described 24 cases in 1968.²⁰ Unlike total rupture, which tends to occur in middle-aged, deconditioned persons, partial rupture commonly affects young, fully grown, well-trained athletes. Partial rupture usually results from overtraining, but it may occur secondary to direct trauma. Pain is the most prominent symptom, occurring maximally during the push-off phase of running. The onset of symptoms may be gradual or sudden. Physical examination may show tendon tenderness, nodular tendon thickening, and a palpable tendon defect. The similarity of symptoms with those of tendinitis often makes the distinction difficult to make. Partial tendon rupture can be diagnosed with electromyographic studies or with ultrasonography.²⁰ Lateral ankle radiographs usually show soft tissue swelling.³⁰ Magnetic resonance imaging may prove to be a helpful diagnostic aid.

Conservative measures should be used initially in the management of a minimal rupture. Such treatment includes rest, tendon strapping, cryotherapy, and heel lifts. If conservative therapy fails or if rupture is extensive, surgery may be indicated. Denstad and Roaas repaired partially ruptured tendons for 58 patients, 81 percent of whom

were athletes.³⁰ Sixty-seven percent had noted a gradual onset of pain, 30 percent experienced sudden increases in pain associated with additional training, and 11 percent had a history of direct trauma to the tendon. Preoperatively, all patients had localized tendon tenderness, all but 3 had localized swelling, and only 2 had a palpable tendon defect. The procedure involved examination with splitting and excision of pathologic tissue and closure of defects side-to-side. Postoperatively, 86 percent of the patients were reportedly pleased with their results, and only 6.5 percent were unsatisfied.³⁰

Summary

Achilles tendinitis is a common injury that affects athletes involved in running and jumping sports. The injury results from repetitive micro-trauma caused by eccentric loading, which stresses the tendon and peritendinous structures. Histologically, Achilles tendinitis may be due to peritendinitis, tendinosis, peritendinitis with tendinosis, or partial tendon rupture. Achilles tendinitis most commonly results from training errors, including excessive running mileage, rapid increases in training intensity, uphill running, sudden changes in running surfaces, training on indoor tracks, and wearing poorly designed running shoes. Athletes with gastrocnemius-soleus inflexibility and weakness or with functional hyperpronation of the foot are biomechanically predisposed to injury. The initial treatment of Achilles tendinitis includes rest, gastrocnemius-soleus stretching and rehabilitation, cryotherapy, heel lifts, nonsteroidal anti-inflammatory medications, and, possibly, ultrasonics. If hyperpronation of the foot occurs, a medial heel wedge or motion-controlling orthotic may be helpful. Surgery is considered for athletes with partial tendon rupture or chronic tendinitis that is refractory to conservative therapy.

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