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Treating In-Season Athletes With Mid-Portion Achilles Tendinosis

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Clinical Vignette

AW is a 42-year-old male ultramarathon runner without significant past medical history who reports 8 months of unresolving left heel pain.

His primary care physician (PCP) had diagnosed him with Achilles tendinitis and instructed him to maintain relative rest and start physical therapy. He underwent 6 weeks of physical therapy without definitive improvement. He was subsequently sent to a sports medicine expert who performed sonographically guided needle fenestrations and platelet-rich plasma injections for Achilles tendinosis without improvement. When he presented to the physical medicine and rehabilitation sports medicine clinic, he requested a treatment that required minimal downtime, as he wanted to begin training for an upcoming 100-mile race that was taking place in 8 weeks.

Defining the Problem

Achilles tendon injury is the most common musculoskeletal condition in ultramarathon runners (defined as athletes who compete in distance races longer than 26.2 miles), and it ranks second in the general non-ultramarathon running population.[1] The annual incidence of Achilles tendon injuries is 9% to 11%, and an estimated lifetime risk of 52% has been reported.[1,2] The majority of Achilles tendon injuries are managed conservatively with success.[3] However, recalcitrant cases have been reported in 29% of cases, and a prolonged time to return to activities may not be acceptable to avid runners.[4] Physicians traditionally classified Achilles tendon injuries based on the location of the pathology, separating the most distal 2 cm segment as "insertional" and more proximal segment as "mid-portion or non-insertional."[5] Tendonitis is a common term used to describe all painful tendon conditions, but it is important to understand that Achilles tendonitis or paratenonitis infers an acute injury. Tendonitis is characterized by an inflammatory process that involves granulocytic infiltration of the tendon, whereas tendinosis is characterized by a degenerative process marked by disorganized tendon fibers with occasional local necrosis, calcification, or neovascular ingrowth on histologic examination.[6] Clinical distinction between these two conditions is important, as treatment for tendonitis/peritendinitis may be ineffective in individuals suffering from painful tendinosis.

Achilles Tendon Anatomy and Injury

Achilles Tendon as an Anatomical Structure at Risk for Injuries

The Achilles tendon fibers arise from the rostral end of both gastrocnemius and soleus muscles, receiving an equal contribution from both muscles. While the Achilles tendon is the thickest and strongest tendon in the human body, it is believed to be at risk for injuries because 1) the muscle-tendon construct traverses the knee, ankle, and subtalar joints, and 2) because it receives up to 12.5 times the body weight during high-impact activities, such as running, jumping, or landing.[6,7]

Paratenon

The Achilles tendon lacks a true tendon sheath. Instead, the tendon is surrounded by an areolar tissue called paratenon.[8] Paratenon normally functions to lubricate tendon tissue to allow smooth gliding of the tendon with respect to surrounding tissues. However, the paratenon can occasionally become inflamed, resulting in a painful Achilles condition termed paratenonitis. While clinically similar to painful tendinosis, paratenonitis is a distinct condition that can co-exist with tendinosis.

Retrocalcaneal Bursa

Both retrocalcaneal bursa and retroachilles bursa exist at the insertion of the Achilles tendon, with the retrocalcaneal bursa deep to the tendon and retroachilles bursa superficial to it. Both bursae can be a source of heel pain, but retrocalcaneal bursal hypertrophy, inflammation, and/or adhesion has been observed in cases of insertional Achilles tendon injuries.[9]

Plantaris Tendon

Recent studies have implicated the plantaris tendon in the pathogenesis of mid-portion Achilles tendinosis.[10] As the plantaris tendon is located along the medial portion of the Achilles tendon, movement of these tendons against one another can result in traction forces and adhesions. This places an increased stress on the Achilles tendon, most commonly at the mid-portion area.

Table 1. **Intrinsic and Extrinsic Risk Factors for Achilles Tendinosis**

Intrinsic	1) Male sex 2) Advanced age 3) Biomechanical malalignments i. Forefoot hyperpronation ii. Cavus foot iii. Immobility of the subtalar joint
Extrinsic	1) Training errors i. Sudden increase in running mileage or intensity ii. Change in terrain iii. Running on hard or sloped surfaces 2) Improper footwear i. Insufficient heel height ii. Rigid soles iii. Inadequate shock absorption iv. Wedging from uneven wear

Vascular and Nerve Supply

The vascular supply to the Achilles tendon arises from branches of both the posterior tibial artery and the peroneal artery. The mid-portion area receives less blood supply compared to the distal portion of the tendon, and this might explain why mid-portion tendinosis is five times more likely compared to insertional tendinosis.[3] Sensation to the tendon is mainly supplied from the sural nerve, with smaller contributions from the tibial nerve. However, there is recent evidence that chronic Achilles tendon pain is associated with neovascular ingrowth that creates neo-nerve ingrowth from Kager's fat pad, sensitizing the Achilles tendon further. This phenomenon has been termed neurogenic inflammation and offers a new intervention to treat Achilles tendinosis.[8,11]

Risk Factors of Achilles Tendinosis

Intrinsic and extrinsic risk factors have been identified in Achilles tendinosis (Table 1).[12] In one study, males comprised 89% of reported cases of Achilles tendon disorders out of 476 cases reported. This is believed to be caused by stronger forces generated by larger calf muscles on the tendon.[4] Advancing age, especially above 60, has been associated with increasing risks of Achilles tendon disorders.[13] Age-related decrease in vascularity of the tendon is felt to play a role in causing injury.[8] Biomechanical

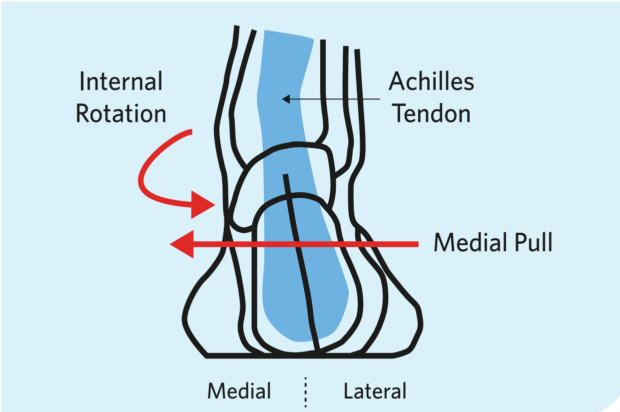

Figure 1. Forefoot hyperpronation of the right leg. In forefoot hyperpronation, there is internal rotation of the tibia that draws the Achilles tendon medially. This can lead to a "whipping" action of the Achilles tendon when the knee extends during the stance phase of gait/running.

malalignments have been implicated in the pathogenesis of Achilles tendon diseases.[14] Forefoot hyperpronation, for example, generates an internal rotation of the tibia that draws the Achilles tendon medially. In this setting, when the knee extends during the stance phase of gait/running, this can lead to a "whipping" action of the Achilles tendon (Figure 1). This can result in micro-tears along the medial portion of the tendon that can precipitate tendinopathy.[8] Cavus foot is the term used to describe a high arched foot. This deformity is thought to lead to lateral Achilles tendinopathy by placing excessive stress on the lateral side of the Achilles tendon during loading.[15] Subtalar joint immobility results in decreased inversion and eversion of the foot, which causes increased tension of the Achilles tendon during movement.[4]

Clinical Presentation of Mid-Portion Achilles Tendinosis

Patients most often complain of pain in the Achilles tendon area that is worse with loading of the tendon. Inspection may reveal thickening in focal areas. On palpation, an area of focal tenderness is most often present. Swelling, warmth, or erythema along the tendon is more consistent with an inflammatory process seen in Achilles tendonitis/paratenonitis. During range of motion testing, subjective pain of the tendon may be elicited with dorsiflexion of the ankle.[16] If crepitus is noted with passive range of motion of the ankle, this is suggestive of paratenonitis. A specific exam maneuver that should be performed is the Thompson test, which has a 96% to 98% positive predictive value in detecting an Achilles tendon rupture.[17] This test is performed by placing the patient in a prone position and squeezing the middle one third of the calf muscle. Passive plantar movement should be seen as a normal response when the calf muscle is squeezed. However, if there is an Achilles tendon rupture, there will be no plantar movement. Tendon loading tests, such as a single heel leg raise or a hop test on the affected tendon may be performed.[18]

Differential diagnosis for Achilles tendinosis is broad, and the following imaging modalities can be used to rule out these differential diagnosis (Table 2).

Diagnostic Studies

Plain Films and CT Scan

X-rays and computed tomography (CT) scans have low utility in the diagnosis of Achilles tendinosis given the limited detail of soft tissue and ligamentous structures.[19,21] However, these imaging techniques may reveal other etiologies of posterior heel pain that mimic Achilles tendon pathologies, such as Haglund's deformity, which is a posterosuperior bony outgrowth arising from the lateral aspect of the calcaneal tuberosity in adults or calcaneal apophysitis, also known as Sever's disease, which involves painful inflammation of the calcaneal growth plate in children.[19] Additionally, calcification or ossification of the tendon identified on x-rays or CT may require surgical removal.[19]

Table 2. **Differential Diagnosis of Achilles Tendinosis**

Pathologic Process	Condition
Bone	Haglund's deformity Os trigonum Ankle joint osteoarthritis Osteochondritis of the talus Stress fracture of the distal tibia or calcaneus Sever's disease
Muscle/Tendon	Complete or partial rupture of the Achilles tendon Accessory soleus muscle Posterior tibialis tendon rupture Plantar fasciitis Tenosynovitis of the flexor hallucis longus Plantaris tendon tear
Nerve	Tarsal tunnel syndrome Sural neuropathy
Inflammatory	Retrocalcaneal bursitis Infection

MRI

Magnetic resonance imaging (MRI) provides excellent soft tissue detail, and is a superior imaging technique compared to x-rays or CT scans in the workup of Achilles tendinosis.[19] A healthy Achilles tendon will display low signal on conventional MRI, reflecting compact tendon structure and minimal water content. Conversely, tendinosis results in high signal within the tendon, as well as tendon thickening and fusiform tendon shape.[19]

MRI is the preferred imaging technique when tendon rupture is suspected and if high-quality ultrasound is not readily available.[19] MRI can also be utilized to clarify the diagnosis of tendinosis versus tendon tear when the presentation is uncertain. Tendinosis will be displayed on MRI images with increased T2 signal in tendon or increased tendon diameter, but intact tendon fibers, while disruption of tendon fibers will be identified in partial and full thickness tears.[19] Increased signal on MRI in cases of tendinosis may also help predict chronicity of symptoms and clinical outcomes.[20]

Ultrasound

Ultrasound (US) represents a cost-effective, readily available diagnostic imaging modality that has gained popularity in musculoskeletal medicine to evaluate a variety of clinical conditions, including Achilles tendon pathologies. Normal Achilles tendon appears as echogenic fibrillary lines in long axis view and appears homogeneous in thickness.[19] Normal tendon thickness is 4 mm to 7 mm.[19,20] Tendinosis will appear darker (termed hypoechoic) with loss of fibrillar architecture and fusiform thickening of the tendon.[21] With careful examination, both partial and full thickness tears can be visualized.[19,21]

Additional ultrasound findings of tendinosis include neovascularization, which is the development of new blood vessels within the tendon.[19,21,22] Color Doppler is used to visualize this phenomenon. A healthy tendon will be largely devoid of blood vessels, while neovascularization can be a sign of chronic tendon irritation and is associated with greater pain and worse functional outcomes, as well as longer duration of symptoms when identified in cases of tendinosis.[19,21,22]

Management

Conservative Treatment Options for Mid-Portion Achilles Tendinosis

Conservative measures in the management of Achilles tendinosis are successful in the majority of cases. However, over a quarter of cases can become recalcitrant.[23] Conservative measures are usually employed for 3 to 6 months before advancing to alternative and more invasive treatments (Table 3).[19] However, as detailed below, newer treatments may be employed earlier depending on the clinical situation and specific type of pathology identified on imaging.

Relative rest with avoidance of tendon loading, shoe wear modifications, heel lifts, and taping, as well as stretching, are all recognized first steps in cases of Achilles tendinosis.[23] Short courses of nonsteroidal anti-inflammatories (NSAIDs) with any combination of these treatments may also be beneficial in the acute stages of tendinosis.[24]

Eccentric muscle training is thought to encourage healing by improving tendon collagen fiber orientation and by restoring leg muscle strength.[11] This program was originally described in 2003 and boasted a success rate of 90% for mid-portion Achilles tendinosis.[25,26] Though insertional Achilles tendinopathy is outside of the scope of this article, it is worth mentioning that this original protocol had a very low success rate of 32% when used in cases of insertional tendinopathy. Therefore, this protocol was modified by Jonsson et al. in 2008 by eliminating the dorsiflexion component.[27] In this modified program, patients with insertional tendinopathy performed ankle eccentric exercises by slowly lowering the foot from a plantar-flexed position to a flat surface, rather than on a raised box or platform as per the program for mid-portion tendinosis.[27] Elimination of dorsiflexion was proposed to reduce the compression forces between the pathologic tendon, bursae, and bone from impingement in full dorsiflexion that may be aggravating.[27]

Extracorporeal shock wave therapy (ESWT) can be used in the treatment of Achilles tendinosis.[28] ESWT involves the delivery of acoustic energy waves to pathologic tendon beds, such as in lateral epicondylosis, plantar fasciosis, rotator cuff tendinosis, and Achilles tendinosis.[29,30] The mechanism of action is poorly understood, but ESWT is thought to trigger an inflammatory response around pathologic tissue, triggering collagen remodeling within the damaged tendon.[29]

Topical glyceryl trinitrate (GTN) patches can be considered as an adjunct for mid-portion Achilles tendinosis. Daily 1.25 mg per 24 hours GTN patches, combined with conservative modalities can reduce pain and increase activity levels in patients with mid-portion Achilles tendinosis. This is based on a study that showed 78% of patients treated with a combination of GTN patches and eccentric exercise were asymptomatic with activities of daily living at 6-month follow-up, compared to 49% of patients treated with rehabilitation alone.[31] GTN is a prodrug of endogenous nitric oxide and stimulates collagen synthesis by wound fibroblasts, thus promoting healing and/or improving blood supply. In prescribing GTN patches, common side effects should be discussed, including headaches and orthostasis.[31]

Corticosteroid injections are not recommended in the treatment of Achilles tendinosis, as steroids do not address the underlying pathology of degeneration and may increase risk of tendon rupture.[11] Steroids may further alter appropriate healing mechanisms in an already damaged tendon by promoting stem cells within the tendon to form adipose, cartilage, and bony tissue while inhibiting formation of favorable, tendon-healing collagen cells.[32]

Interventional Treatment Options

Sonographically guided interventions for Achilles tendinosis have emerged within the last decade that may serve as alternatives to surgery when traditional measures fail (Table 3). For example, platelet-rich plasma (PRP) therapy has been studied as a possible treatment for mid-portion Achilles tendinosis with mixed results. Platelets derived from whole blood via cell separation techniques are injected into the area of tendinopathy, triggering a release of growth factors with established functions in tendon cell proliferation, collagen synthesis, and vascularity.[33] Despite promising results in pilot studies, a double-blind, randomized, placebo-controlled clinical trial showed no differences in functional outcomes, return-to-play, or patient satisfaction when PRP plus eccentric exercise was compared to placebo plus eccentric exercise.[34] Additionally, there were no differences in ultrasonographic tendon structure nor degree of neovascularization at follow-up between the PRP and placebo groups.[35] However, studies of PRP with repeated injections, different concentrations, and variable activation techniques for Achilles tendinosis are still being conducted.[36]

Dextrose hyperosmolar injections, or prolotherapy injections, have been shown to be beneficial in cases of Achilles tendinosis in terms of reduction in pain, improved function, patient satisfaction, and sonographic appearance of the tendon. However, there has not been a controlled study to investigate relative efficacy of this intervention.[37-39] Synergy between prolotherapy and eccentric exercise programs also has been documented.[40] Although the exact mechanism is unknown, prolotherapy involves injection of an irritant, usually dextrose, to elicit an immune-mediated healing cascade with proliferation of tendon tissue.[37,38] Multiple prolotherapy injections, each spaced out by 4 to 6 weeks, must be used before achieving acceptable improvement.[37-39]

Table 3. **Management of Mid-Portion Achilles Tendinopathy**

CONSERVATIVE	
Activity/Footwear Modifications	— Relative rest — Stretching — Heel lifts/tape
Medications	— NSAIDs — Topical GTN patches
Physical Therapy	— 12 weeks eccentric/heavy load training
Modalities	— ESWT

INTERVENTIONAL
— PRP — Prolotherapy — Chemical ablation (polidocanol injections) — Percutaneous sonographically guided tendon scraping — HVIGI — Percutaneous ultrasonic tenotomy

SURGICAL
— Open intratendineous debridements — Minimally invasive paratenon debridements — Gastrocnemius lengthening or recession — Tendoscopy: tenotomies, paratenon debridements, division of plantaris tendon

Conservative measures are typically utilized for 3 to 6 months. Choice of treatment modality is patient specific. Interventional treatments may serve as alternatives to surgery with less recovery time and more rapid return to sport/activity. ESWT=Extracorporeal shock wave therapy; GTN=Glyceryl Trinitrate; PRP=platelet-rich plasma; HVIGI=high-volume image-guided injections.

There are specific injections that target neovascularization. The first of these procedures is termed chemical ablation, which involves an injection of a sclerosing agent called polidocanol. Polidocanol injections target the intimal layer of the vascular wall, leading to vessel micro-thrombosis.[22] The nerves around the ventral tendon that act as pain generators are proposed to be affected as well, either through depletion of blood supply from elimination of neovascularization or direct action of the sclerosing agent. Polidocanol was shown to be superior to an injection of anesthetic alone in terms of decreasing pain and increasing patient satisfaction with treatment for Achilles tendinosis.[22] Maximum benefit was achieved with 2 to 3 injections, spaced out by 6 to 8 weeks between injections for a total of 16 to 24 weeks of treatment.[41] Of note, these injections are not U.S. Food and Drug Administration (FDA)-approved, despite the lack of adverse events in previous treatment groups.[22,41]

Tendon scraping, which involves direct separation of neovessels with a scalpel or needle, has shown early success with low rates of recurrence.[42,43] Open tendon scraping technique with a scalpel compared to percutaneous scraping with a needle performed under sonographic guidance was shown to be equivalent in improvement of pain and complication rate. Patient satisfaction was 89% for each procedure.[43] Additionally, tendon scraping allowed early tendon loading with full weight bearing in 1 to 2 days, with progressive return to full tendon loading activities as tolerated within 4 to 6 weeks.[43] This recovery time contrasts with the 24 to 30 weeks required for prolotherapy, and the 16 to 24 weeks required with polidocanol injections.[44]

High-volume image-guided injections (HVIGI) also target neovascularization associated with Achilles tendinosis.[45] Large volumes, approximately 20 mL to 50 mL, that combine local anesthetic and normal saline injected adjacent to the damaged tendon are thought to generate local mechanical effects leading to stretching and breaking of neovessels and thereby attenuating neurogenic inflammation.[46,47] These injections were shown to be effective in decreasing pain and improving function after 3 weeks, with sustained benefits at 1-year follow-up, although no comparison of this procedure exists versus tendon scraping.[45,46]

Finally, sonographically guided percutaneous tenotomy and debridement, or simply, percutaneous ultrasonic tenotomy (PUT), is an emerging technology for treatment of refractory mid-portion Achilles tendinosis. This technology is based on the concept of phacoemulsification, in which ultrasonic energy is utilized to emulsify and remove pathologic tissue.[29] The device utilized for this technique has a working tip that emulsifies tissues within a 1 mm vicinity and is placed within pathologic tissue via ultrasound guidance. This technique has shown positive results in animal models and soon may be studied in clinical trials of refractory Achilles tendinosis.[48]

These office-based techniques may serve as an alternative to surgery and a means for a quicker return to functional activities. However, many of the studies are limited by small sample sizes, lack of control groups, lack of head-to-head comparisons, and inconsistent study outcome variables. As a result, consensus on efficacy and applicability has not been reached. Selection of a particular technique is patient- and physician-dependent. Insurance coverage and cost must also be factored. Tendon scraping and PUT are usually covered by insurance, but the other procedures, in most cases, are not.

Surgical Treatment Options

An estimated 25% of cases of Achilles tendinosis fail treatment and require surgical intervention, although this percentage may be decreasing with newer treatments (see Table 3 on Page 5).[23]

Minimally invasive techniques, such as paratenon debridements, focus on paratendinous tissues and elimination of neovascularization. Open techniques, such as intratendineous debridements, address the diseased area of the tendon itself and may involve augmentation of the tendon, including flexor hallucis longus tendon transfer, in severe cases.[49,50] Gastrocnemius lengthening or recession to offload the Achilles tendon, which can be done open or in a minimally invasive approach, is another recognized technique.[49] There is no significant difference between open vs. minimally invasive surgery for Achilles tendinopathy in terms of success rates or patient satisfaction, with both surgical techniques achieving average patient satisfaction rates of over 80%.[49] Return to full tendon loading activities required 3 to 6 months of recovery with both techniques.[51] Tenotomies, paratenon debridements, and division of the plantaris tendon when indicated can all be performed endoscopically as well.[52-54] Tendoscopy may lower rates of surgical complications, but recovery time still remains approximately 3 months before a return to full, previous level of activity.[53]

Clinical Vignette Outcome

After a careful discussion with AW, he opted for mechanical tendon scraping as his treatment of choice. His goal was to safely return to running to prepare for his ultramarathon in 8 weeks. Diagnostic ultrasound was performed, which showed a loss of homogenous thickness of the mid-portion Achilles tendon with presence of neovascularization over the area of tenderness (Figure 2a). Sonographically guided left mid-portion Achilles tendon scraping was performed with the patient prone and his left foot hanging off the examination table. The approach used was lateral to medial approach. The area of neovascularization, sural nerve, and vascular structures were marked under sonographic visualization. A 27-gauge, 1.25 inch needle was used to anesthetize the area first under continuous sonographic guidance. A stab incision using a #11 blade followed, which was then followed by an insertion of an 18-gauge, 1.5 inch needle attached to 15cc of normal saline to the ventral aspect of the mid-portion Achilles tendon (Figure 2b, 2c). The needle tip was moved in a cephalocaudal direction to perform scraping movements while injecting saline until neovascularization in the area was terminated as evidenced by obliteration of vascular flow on sonography (Figure 2d). The patient was instructed to bear weight as tolerated.

On day 2 following the procedure, AW was able to return to light running as his left heel pain had resolved. By day 7, he was able to run, although his cardiovascular fitness had limited his ability to maintain the same exercise intensity as prior to the onset of pain. He was ultimately able to complete his race without recurrence of left heel pain.

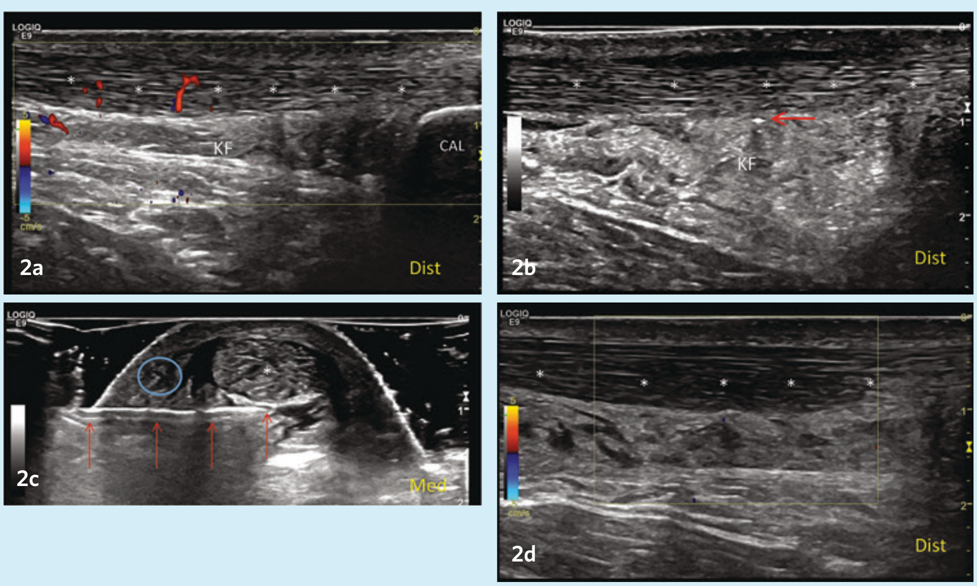

Figure 2a. Pre-procedural Color Doppler with a long-axis view of the Achilles tendon. Note the thickening of the mid-portion tendon with associated hyperemia (red color). This area corresponded with sonopalpation tenderness. Left side is proximal by radiological convention while the right side of the screen is distal. Cal: Calcaneus. KF: Kager's fat pad. Asterisk: Achilles tendon.

Figure 2b. Out-of-plane view of the needle, long-axis to Achilles tendon. The needle is shown slightly to the right of the center of the image as an echogenic white dot ventral to the Achilles tendon (red arrow). The orientation is the same as in Figure 2a.

Figure 2c. In-plane view of the needle, short-axis to the Achilles tendon. Left side is lateral while the right side is medial. Red arrow points to the needle. Blue circle denotes short-axis view of sural nerve.

Figure 2d. Post-procedural Color Doppler with a long-axis view of the tendon. Note hyperemia is no longer present. The orientation is the same as Figure 2a.

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