Nonsurgical Management of Midsubstance Achilles Tendinopathy

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INTRODUCTION

The Achilles tendon is one of the most commonly injured tendons that results in significant pain and loss of function. The incidence of Achilles tendinopathy (AT) is 2.35 per 1000 in the adult population and is frequently associated with sporting activities or a change in activity level.1 Men and women between the ages of 20 and 60 are affected equally and commonly present to a health care provider 11 to 12 weeks after the onset of symptoms.1 A variety of etiologic factors contribute to AT and a thorough

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KEYPOINTS

- Achilles tendinopathy is commonly due to a change in activity level, but may also be related to pathoanatomic, biomechanical, and pain-related impairments.
- Reactive tendon states require acute symptom management strategies in contrast to treatment for a tendon in disrepair or degeneration.
- Tendon loading exercise is the mainstay of initial management, but may be supported by medication, ice, shoe inserts, manual therapy, stretching, taping, or low-level laser.
- If unresponsive to initial management, shockwave therapy and injections are options before considering surgery.
- The Victorian Institute of Sports Assessment-Achilles, pain scales, heel raise and jump tests, and ultrasound can be used to assess treatment outcome and recovery.

INTRODUCTION

The Achilles tendon is one of the most commonly injured tendons that results in significant pain and loss of function. The incidence of Achilles tendinopathy (AT) is 2.35 per 1000 in the adult population and is frequently associated with sporting activities or a change in activity level.1 Men and women between the ages of 20 and 60 are affected equally and commonly present to a health care provider 11 to 12 weeks after the onset of symptoms.1 A variety of etiologic factors contribute to AT and a thorough
evaluation combined with evidence of treatment effectiveness and the patient’s preferences are important to identify the most appropriate treatment plan. Treatment is often successful with nonsurgical intervention, and some unresponsive cases may be candidates for surgery. The purpose of this article is to describe the nonsurgical management of midsubstance AT.

PATIENT EVALUATION OVERVIEW

The etiology of midsubstance AT is variable and often multifactorial. Evidence-informed evaluation will help to identify relevant factors in each patient with AT and devise appropriate treatment. Etiologic factors include overuse, training errors, altered lower limb biomechanics, footwear, postural or leg length imbalances, impaired muscle performance, and direct trauma. In addition to etiologic factors, the status of the tendon is important in treatment decisions and prognosis. The continuum model of tendinopathy provides a simple way of estimating tendon status and can be used in parallel with examination findings and treatment (Fig. 1). Of particular importance is dissociating tendon reactivity from disrepair or degeneration. Clinically, a reactive tendon is acutely painful even to minimal load, has homogenous swelling (no lumps or bumps), and the patient reports a substantial change in activity that overloaded the tendon. Other considerations important to diagnosis, treatment, and prognosis include biomechanical, pathoanatomic, and pain characteristics identified using clinical measures and imaging (Table 1).

History and Comorbidities

- Frequently associated with sporting activities, but can occur in nonathletes.
- Tendon reaction induced by change in activity level, including increased training volume, intensity, or terrain (eg, hill training). Reactivity may be induced after a period of immobilization (eg, recovering from injury), decreased activity (eg, off-season), initiating an exercise program from a relatively sedentary lifestyle, or a direct trauma to the Achilles.3,6
- Individuals with diabetes, obesity, dyslipidemia, inflammatory or autoimmune disorders, hypertension, and prior use of oral or injected steroids are at increased risk.1,24–26

Fig. 1. Continuum model of load-induced tendinopathy. Clinically, a reactive tendon results in pain and acute reaction in the tendon cell and extracellular matrix after a burst of unaccustomed physical activity (including after immobilization) or a direct blow. Reactivity can present on a previously normal tendon or on a tendon in disrepair or degenerated. In tendon disrepair, failed or incomplete attempts to heal from the reactive stage results in further, but reversible, changes in the tendon matrix with or without vascular and neural ingrowth. The degenerative tendon demonstrates additional cellular and matrix changes (see pathoanatomic characteristics in Table 1) some of which are irreversible. Treatment for Achilles tendinopathy attempts to manage reactive episodes with a long-term goal of shifting the tendon state toward normal.
Palpation

- Palpatory tenderness is a hallmark sign of AT. The tendon is palpated by squeezing the Achilles tendon between the thumb and index finger with the patient prone.
- Pain and tenderness 2 to 6 cm from the distal attachment (Sp 0.73, +LR 3.11) that decreases with palpation in maximum dorsiflexion (aka, Royal London test; Sp 0.93, +LR 7.29) helps to confirm the diagnosis.

<table>
<thead>
<tr>
<th>Characteristics of Individuals with AT</th>
<th>Method of Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pathoanatomic</td>
<td></td>
</tr>
<tr>
<td>Increased tendon echogenicity</td>
<td>Ultrasound</td>
</tr>
<tr>
<td>heterogeneity</td>
<td></td>
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<tr>
<td>Increased tendon CSA and thickness</td>
<td>Ultrasound and MRI</td>
</tr>
<tr>
<td>Tendon softening</td>
<td>Ultrasound elastography</td>
</tr>
<tr>
<td>Partial tearing</td>
<td>Ultrasound and MRI</td>
</tr>
<tr>
<td>Neovascularization</td>
<td>Doppler ultrasound</td>
</tr>
<tr>
<td>Biomechanical</td>
<td></td>
</tr>
<tr>
<td>Decreased (&lt;11.5°)13 or increased</td>
<td>Goniometer</td>
</tr>
<tr>
<td>(&gt;9°)13 ankle dorsiflexion measured</td>
<td></td>
</tr>
<tr>
<td>with knee extended</td>
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<tr>
<td>Increased rearfoot inversion measured</td>
<td>Goniometer and 3D</td>
</tr>
<tr>
<td>in non–weight-bearing,13 and at initial</td>
<td>motion analysis</td>
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<tr>
<td>contact of running15</td>
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</tr>
<tr>
<td>Increased rearfoot inversion,15,16</td>
<td>3D motion analysis</td>
</tr>
<tr>
<td>inversion–eversion total range of</td>
<td></td>
</tr>
<tr>
<td>motion16 and rate of eversion15 during</td>
<td></td>
</tr>
<tr>
<td>running</td>
<td></td>
</tr>
<tr>
<td>Subtalar varus ≥4° or forefoot varus of</td>
<td>Goniometer</td>
</tr>
<tr>
<td>≥3° measured in non–weight-bearing17</td>
<td></td>
</tr>
<tr>
<td>Decreased ankle plantar flexion</td>
<td>Isokinetic dynamometer</td>
</tr>
<tr>
<td>strength14,15,16</td>
<td></td>
</tr>
<tr>
<td>Decreased ankle plantar flexion power</td>
<td>Spring loaded string/linear encoder</td>
</tr>
<tr>
<td>19</td>
<td></td>
</tr>
<tr>
<td>Decreased jump height and increased</td>
<td>Force mat</td>
</tr>
<tr>
<td>jump contact time19</td>
<td></td>
</tr>
<tr>
<td>Decreased tendon stiffness20</td>
<td>Dynamic ultrasound and isometric dynamometer</td>
</tr>
<tr>
<td>Increased tendon strain21</td>
<td>Dynamic ultrasound and isometric dynamometer</td>
</tr>
<tr>
<td>Pain-related mechanisms</td>
<td></td>
</tr>
<tr>
<td>Decreased tactile acuity22</td>
<td>2-point discrimination using asthesiometer</td>
</tr>
<tr>
<td>Increased local and nonlocal mechanical hyperalgesia23</td>
<td>Pain-pressure threshold using algometer</td>
</tr>
</tbody>
</table>

**Abbreviations:** 3D, 3-dimensional; AT, Achilles tendinopathy; CSA, cross-sectional area.
In chronic tendinopathy, there is a region of tendon thickening (Sp 0.90, +LR 5.90).27 Swelling that moves distally during dorsiflexion and proximally during plantar flexion may be observed (aka, arc sign; Sp 1.0, +LR infinity).27 Pain increases with activity and stiffness is reported during initial steps after being at rest.3 Increased stiffness perceived by patient is different from biomechanical stiffness, which is reduced in tendinopathy.20 Lack of pain with palpation (Sn 0.84, -LR 0.22) and no morning stiffness (Sn 0.89, -LR 0.19) are the 2 best single-item tests to rule out AT.

**Ankle Plantar Flexor Muscle Performance**
- Ankle plantar flexor muscle performance may be impaired owing to altered tendon structure or compensatory movement.
- Limited plantar flexion strength and power has been associated with AT using isokinetic dynamometry,14,15,18,19 but repeated single leg heel raises are the simplest method to assess plantar flexor muscle performance in the clinic.
- Standardized heel raise height by touching the dorsum of the foot to a crossbar (see Fig. 3F) improves the ability to identify plantar flexor impairments, including side-to-side differences.19
- Athletes less than 40 years of age perform 20 to 25 single-leg heel raises on average,19 but fewer repetitions are expected for nonathletes and older individuals.28
- Pain during single leg heel raise testing is specific for AT (SP 0.93, +LR 3.14).27

**Ankle and Foot Posture and Mobility**
- There is conflicting evidence of ankle dorsiflexion impairments (see Table 1),13,14 and therefore side-to-side differences may be more important in decision making. In the late stages of disrepair or degeneration, there may be increased dorsiflexion owing to increased tendon compliance. Dorsiflexion can be measured reliably in the supine or prone position with the foot off the plinth and the knee extended and then flexed at least 45°.29
- Static foot posture can be assessed and compared with the uninvolved side using the foot posture or arch height indices.30–32 Although tendinopathy may be present with any foot type, the Achilles may be susceptible to injury with increased foot pronation owing to its orientation medial to the subtalar joint axis and decreased tolerance to frontal and transverse plane motion.33
- Impaired mobility of the rearfoot (inversion or eversion) and ankle (dorsiflexion) may alter tendon loading during activity and has been identified primarily in runners and military trainees (see Table 1).13–16
- Video analysis may help to identify rearfoot and ankle movement impairments (eg, eversion and toe-out angle). A standardized analysis includes the use of a treadmill for gait analysis, capture rate of at least 120 frames/s for running or jumping (30 frames/s for walking), and camera placed perpendicular to the patient from posterior and lateral perspectives. During jumping, special attention is paid to side-to-side differences in heel height.
- Foot posture and mobility may be affected by function of proximal regions and considered in the evaluation. Dynamic knee and rearfoot valgus may be owing to altered neuromotor function of the gluteal muscles (ie, hip abductors and external rotators) and can be assessed by performance of single leg squat/step down or manual muscle tests.4,5,34
Imaging

- Tendon heterogeneity, thickening, softening, tearing, and neovascularization have been identified using ultrasound imaging or MRI and may help to indicate the degree of tendon disrepair or degeneration (see Table 1).8–12
- Although imaging results may indicate the degree of pathoanatomic changes, this does not always correlate with symptom severity or improvement.35 Therefore, careful use of imaging and discussion of results are important to avoid negative impacts on fear–avoidance behaviors and treatment expectations.

PHARMACOLOGIC TREATMENT OPTIONS

Pharmacologic treatment including oral, topical, and injected interventions can modulate symptoms and tissue healing to manage reactive tendon states (see Fig. 1) and complement a tendon loading program in nonacute tendinopathy (Fig. 2). Various pharmacologic treatments have been used in AT and no pharmacologic treatment, when used in isolation, has proven superior to a tendon loading exercise program.36

With the exception of an acute, reactive tendinopathy in an otherwise healthy tendon, pharmacologic treatment of AT is more effective when combined with a tendon loading exercise program.36 Fluoroquinolone antibiotics, oral corticosteroids, low-molecular-weight heparin, and the use of cyclosporine, cortisone, and rapamycin after organ transplant have been linked to AT and should be considered when taking the patient history or used with caution if indicated.37–40

Nonsteroidal Antiinflammatory Drugs: Oral and Topical

- Although AT generally lacks inflammatory cells, NSAIDs have both antiinflammatory and analgesic effects and may be used in acute or reactive tendon states.42 Laboratory studies indicate that NSAIDs may improve tensile strength of tendons via increasing cross-linkages between collagen fibers but the effect of NSAIDS on fibroblasts could potentially cause inflammatory and degenerative changes.43
- Oral NSAIDs are not recommended for chronic tendinopathy,44–46 but may be effective for short-term (7–14 days) pain relief44,45
- Numerous NSAID options are available (Table 2), and none have superior effectiveness for AT. Although ibuprofen has a lesser risk of gastrointestinal side effects, naproxen or celecoxib may be preferred for those with cardiovascular risk factors.53
- The side effects of NSAIDs include gastrointestinal and cardiovascular distress and should be used as briefly as possible.45,46,53
- Topical NSAIDs, such as diclofenac gel, are an effective and safe alternative to oral NSAIDs to reduce pain associated with acute tendinopathy.54,55

Injections

- Injected agents can modulate symptoms and/or facilitate tissue healing, but there is insufficient evidence to support routine use as the sole intervention.49
- Recent systematic reviews have concluded that platelet-rich plasma is not supported for AT56,57
- Local injection of corticosteroids may be useful in acute reactive AT to reduce pain and enable tendon loading exercise,41 but has little evidence for benefit in midsubstance AT and increases risk of rupture, especially in degenerated tendons.45,58,59
- Injected vascular sclerosing agents are used in chronic tendinopathy to address neovascularization and corresponding nerves to reduce pain.41,60 Because of
conflicting evidence of effectiveness,60–63 the need for several injections, and procedures that are technically demanding, sclerosing agents are considered after unsuccessful treatment with a tendon loading exercise program (see Fig 2).41,64

When warranted, specific procedures for injection intervention in the management of AT are described by Smith and colleagues. (See W. Bret Smith and colleagues’ article, “Midsubstance Tendinopathy, Percutaneous Techniques

Fig. 2. Treatment pathway for the management of midportion Achilles tendinopathy adapted from recommendations by Alfredson and Cook.41 Timeframes and intervention may be adjusted to consider the patient’s preferences, presentation, and response to initial treatment. If patient responds satisfactorily to any phase of treatment, loading exercises should be maintained for 6 to 12 months and symptom modulation strategies as needed. ESWT, extracorporeal shock wave therapy.
### Table 2
**Pharmacologic treatment options**

<table>
<thead>
<tr>
<th>Medication</th>
<th>Application</th>
<th>Usual Dosing</th>
<th>Frequency</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Nitrates</strong></td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Glyceryl trinitrate</td>
<td>Topical patch</td>
<td>1.25 mg/24 h</td>
<td>Replace patch daily</td>
<td>12–24 wk</td>
</tr>
<tr>
<td><strong>Sclerosing agent</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Polidocanol</td>
<td>Ultrasound + Doppler-guided injections</td>
<td>5–10 mg/mL</td>
<td>1–5 injections</td>
<td>3–6 wk apart</td>
</tr>
<tr>
<td><strong>Steroids</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dexamethasone</td>
<td>Iontophoresis</td>
<td>3 mL/80 mA-min</td>
<td>4 treatments</td>
<td>Every 3–4 d over 2 wk</td>
</tr>
<tr>
<td>Triamcinalone</td>
<td>Ultrasound-guided peritendinous injection</td>
<td>20 mg with 3.5 mL of 1% lidocaine or 3.5 mL 0.5% bupivacaine</td>
<td>1 time</td>
<td>-</td>
</tr>
<tr>
<td>Methylprednisolone</td>
<td>Peritendinous Injection</td>
<td>40 mg in 1 mL of 0.25% marcaine</td>
<td>1 time</td>
<td>-</td>
</tr>
<tr>
<td><strong>NSAIDs</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aspirin</td>
<td>Oral</td>
<td>325–650 mg</td>
<td>QID</td>
<td>7–14 d</td>
</tr>
<tr>
<td>Diclofenac</td>
<td>Oral</td>
<td>50–75 mg</td>
<td>BID</td>
<td>7–14 d</td>
</tr>
<tr>
<td>Etodolac</td>
<td>Oral</td>
<td>200–400 mg</td>
<td>TID-QID</td>
<td>7–14 d</td>
</tr>
<tr>
<td>Ibuprofen</td>
<td>Oral</td>
<td>200–800 mg</td>
<td>TID-QID</td>
<td>7–14 d</td>
</tr>
<tr>
<td>Indomethacin</td>
<td>Oral</td>
<td>20–50 mg</td>
<td>TID</td>
<td>7–14 d</td>
</tr>
<tr>
<td>Meloxicam</td>
<td>Oral</td>
<td>7.5–15 mg</td>
<td>Daily</td>
<td>7–14 d</td>
</tr>
<tr>
<td>Nabumetone</td>
<td>Oral</td>
<td>1000 mg</td>
<td>Daily</td>
<td>7–14 d</td>
</tr>
<tr>
<td>Naproxen</td>
<td>Oral</td>
<td>250–500 mg</td>
<td>BID</td>
<td>7–14 d</td>
</tr>
<tr>
<td>Piroxicam</td>
<td>Oral</td>
<td>20 mg/d</td>
<td>Daily</td>
<td>7–14 d</td>
</tr>
<tr>
<td>Sulindac</td>
<td>Oral</td>
<td>150–200 mg</td>
<td>BID</td>
<td>7–14 d</td>
</tr>
<tr>
<td>Celecoxib</td>
<td>Oral</td>
<td>100–200 mg</td>
<td>BID</td>
<td>7–14 d</td>
</tr>
<tr>
<td>Diclofenac sodium 1% gel</td>
<td>Topical</td>
<td>2–4 g</td>
<td>QID, Maximum of 32 g/d over affected areas</td>
<td>7–14 d</td>
</tr>
</tbody>
</table>

*Abbreviations: BID, twice daily; NSAIDs, nonsteroidal antiinflammatory drugs; QID, 4 times a day; TID, 3 times a day.*

* A 5-mg patch cut into fourths.
Topical Agents

- Agents administered topically such as glyceryl trinitrate patch and iontophoresis with dexamethasone may be effective in acute or reactive tendinopathy, but have not been studied as isolated interventions.
- Topical agents are coupled with a tendon loading exercise program, especially in reactive tendon states with suspected dysrepair or degeneration.

NONPHARMACOLOGIC TREATMENT OPTIONS

The most extensively studied and effective nonpharmacologic treatment for midsubstance AT is tendon loading exercise. Several other interventions have been investigated when combined with a tendon loading program, but few have been studied in isolation and none have demonstrated superior effects to a tendon loading program. Therefore, tendon loading exercises such as eccentric and concentric–eccentric heel raises form the core of midsubstance AT management (see Fig. 2) and the majority of patients can have a successful long-term outcome.65 Several different training programs have been proposed that vary in the type and speed of exercise in addition to the dosage and magnitude of loading (Table 3). There is limited evidence directly comparing the different tendon loading programs and no program has proven superior to the others. Therefore, consideration of the literature and patient preferences can help to identify the most appropriate loading program that the patient will adhere to for the time necessary to complete the program. To manage symptoms and facilitate adherence to the tendon loading program, there are several symptom-modulating interventions (see Fig. 2) discussed in the Combination Therapies Section that can be used, depending on patient preference and response. In addition, etiologic factors identified from the history and examination is important to address in the overall treatment plan. A physical therapist may assist in identifying the most appropriate tendon loading program, appropriate progression of loading, etiologic factors to address, and implementing symptom and physiologic modulating interventions if needed.

Correction of Etiologic Factors

- In acute reactive states in an otherwise healthy tendon, rest from activity that originally overloaded the tendon or reduced tendon load is warranted. The most common training factors in midsubstance AT include a rapid increase in activity/training such as initiating or progressing an exercise program, introducing sprint/interval training, or adding hill training.
- Other biomechanical factors associated with midsubstance AT are listed in Table 1. With the exception of trauma, most biomechanical factors arise gradually and are addressed with combined intervention, including taping, foot orthoses, and specific exercise interventions.

Tendon Loading Exercise

- The most common tendon loading exercises for the Achilles include heel raises using eccentric and concentric–eccentric muscle contractions (Fig. 3). Loading exercises are progressed by increasing load and speed depending on recreational and functional demands.
- Isolated eccentric exercises have been used in multiple clinical trials and significantly improved pain and function,66 although evidence is limited that eccentrics are superior to other loading programs.73,74 Other loading programs include...
Table 3
Parameters of tendon loading programs using heel raises (see Fig. 3)

<table>
<thead>
<tr>
<th>Tendon Loading Program</th>
<th>Exercise Description</th>
<th>Load/Progression</th>
<th>Sets × Repetitions</th>
<th>Frequency</th>
</tr>
</thead>
</table>
| Isolated eccentric\(^{18,66}\) | Standing with heels off the edge of a step, raise heels up using both feet (see Fig. 3C) and slowly lower using only 1 leg (see Fig 3D). Perform with knees straight and flexed approximately 45°. | Body weight at first, add weight using a backpack or by holding dumbbells when exercise becomes pain free (stop if disabling) | Knee straight: 3 × 15  
Knee flexed: 3 × 15  
Week 1: Knee straight only.  
Day 1–2: 1 × 10–15, day 3–4: 2 × 15, day 5–7: 3 × 15.  
Weeks 2–12: 3 × 15 with knee straight and 3 × 15 with knee flexed  
Goal of 3 × 15 with knee straight and 3 × 15 with knee bent, but patient can perform a repetition volume that is tolerable | 2 times/d, 7 d/wk for 12 wk |
| First week transition variation\(^{67,68}\) | | | | |
| Do as tolerated variation\(^{69}\) | | | | |

(continued on next page)
<table>
<thead>
<tr>
<th>Exercise Description</th>
<th>Load/Progression</th>
<th>Frequency</th>
<th>Sets x Repetitions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combined eccentric, concentric, and plyometric</td>
<td>Standing with heels on floor or off the edge of a step, raise heel(s) up and slowly lower. For eccentric heel raises, raise up with both feet and slowly lower.</td>
<td>Phase 1: 1 time/d for Weeks 1–2</td>
<td>1</td>
</tr>
<tr>
<td>Standing heel raises</td>
<td>Body weight at first, add weight using a backpack, weight machine, or by holding dumbbells.</td>
<td>Phase 2: 1 time/d for Weeks 2–5</td>
<td>1</td>
</tr>
<tr>
<td>Seated heel raises</td>
<td>Quick rebounding heel raises</td>
<td>Phase 2: 1 time/d for Weeks 2–5</td>
<td>1</td>
</tr>
<tr>
<td>Quick rebounding heel raises</td>
<td>Standing with heels on floor, raise and lower heels quickly as if you are jumping without the toes leaving the floor. Turn back up when the heel is approximately 1 cm from the floor.</td>
<td>Phase 3: 2–3 times/wk</td>
<td>1</td>
</tr>
<tr>
<td>Body weight at first, add weight using a backpack, weight machine, or by holding dumbbells.</td>
<td></td>
<td>Phase 3: 2–3 times/wk</td>
<td>1</td>
</tr>
<tr>
<td>Seated heel raises</td>
<td>Quick rebounding heel raises</td>
<td>Phase 4: 2–3 times/wk</td>
<td>1</td>
</tr>
<tr>
<td>Combined eccentric, concentric, and plyometric</td>
<td>Standing with heels on floor or off the edge of a step, raise heel(s) up and slowly lower. For eccentric heel raises, raise up with both feet and slowly lower.</td>
<td>Phase 4: 2–3 times/wk</td>
<td>1</td>
</tr>
</tbody>
</table>

*Body weight at first, add weight using a backpack, weight machine, or by holding dumbbells.*

*Quick rebounding heel raises: Standing with heels on floor, raise and lower heels quickly as if you are jumping without the toes leaving the floor. Turn back up when the heel is approximately 1 cm from the floor.*

*Combined eccentric, concentric, and plyometric: Standing with heels on floor or off the edge of a step, raise heel(s) up and slowly lower. For eccentric heel raises, raise up with both feet and slowly lower.*

*Standing heel raises: Body weight at first, add weight using a backpack, weight machine, or by holding dumbbells.*

*Seated heel raises: In the seated position raise 1 heel up and slowly lower. Adjust load or do not advance to the step if more than 5/10 pain during, or in the 24 hours after exercise.*

*Quick rebounding heel raises: Standing with heels on floor, raise and lower heels quickly as if you are jumping without the toes leaving the floor. Turn back up when the heel is approximately 1 cm from the floor.*

*Combined eccentric, concentric, and plyometric: Standing with heels on floor or off the edge of a step, raise heel(s) up and slowly lower. For eccentric heel raises, raise up with both feet and slowly lower.*

*Standing heel raises: Body weight at first, add weight using a backpack, weight machine, or by holding dumbbells.*

*Seated heel raises: In the seated position raise 1 heel up and slowly lower.*

*Quick rebounding heel raises: Standing with heels on floor, raise and lower heels quickly as if you are jumping without the toes leaving the floor. Turn back up when the heel is approximately 1 cm from the floor.*
Heavy slow resistance: 72 Heel raises performed with a 3-s concentric and 3-s eccentric phase (6 s total): (1) on a seated calf raise machine with knees flexed 90°, (2) on a leg press machine with knees straight, and (3) standing with heels off of a 1.5-inch object, barbell on shoulders and knees straight.

Progressed based on 15, 12, 10, 8, and 6 RM in respective training weeks. Pain rated at 4–5/10 allowable during training if subsided before the next session.

3–4 sets with a 2–3 min rest between sets and 5 min rest between exercise.


Abbreviation: RM, repetition maximum.

Achilles Tendinopathy Management

Speed is not described in most studies, but 3 seconds per repetition has been suggested.

Achilles Tendinopathy Management

3–4 sets with a 2–3 min rest between sets and 5 min rest between exercise.

3 times/wk for 12 wk

Abbreviation: RM, repetition maximum.

Achilles Tendinopathy Management

Speed is not described in most studies, but 3 seconds per repetition has been suggested.

Achilles Tendinopathy Management
heavy slow resistance training, a do-as-tolerated eccentric loading, and a combined program including isolated eccentric, concentric–eccentric, and plyometric exercise (see Table 3).

- If evidence of hip (contralateral pelvic drop, dynamic knee valgus) or foot weakness (pronation) is observed, specific exercise advised by a physical therapist may be warranted. Impaired gluteal muscle performance has been identified in runners with AT and may be related to the cause or persistence of symptoms.4,5

- Education about expected pain responses and recovery time is essential to the tendon loading program. Increased fear of movement may have a negative effect on exercise effectiveness,65 although this can be mitigated through appropriate education. Patients should be informed that muscle soreness is expected during the first few weeks,18 although the program can be adapted by reduced volume and a gradual transition in the first week.67,68

- Pain in the tendon is normal and an expected part of the loading program. A pain monitoring model can be used to guide intensity of training.3,70 In this model, pain of less than 5 on a scale of 0 (no pain) to 10 (worst imaginable pain) is acceptable during or within the 24 hours after training. If pain is greater than 5 out of 10 or pain and perceived stiffness is progressing from 1 week to the next, then the magnitude, volume, or dosage of loading should be modified.

- Soreness may be mitigated through use of symptom modulating interventions, such as medication, manual therapy, ice, stretching, taping, or shoe inserts.

Shoe Inserts
- Foot orthoses may be effective to alter the biomechanical and pain-related characteristics, but evidence is limited to runners.75,76 Although foot orthoses are intended typically to reduce pain through control of pronation, actual kinematic changes may not be necessary to achieve symptomatic improvement.76 Neuro-motor changes in the foot and calf muscles associated with foot orthoses use may also contribute to symptomatic improvement.77

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Fig. 3. Heel raise exercise performed (A) bilaterally on the floor, (B) unilaterally on the floor, (C) bilaterally on a step, (D) unilaterally on a step, and (E) seated. Isolated eccentric exercise is performed by performing the concentric phase bilaterally (A or C) and the eccentric phase unilaterally (B or E). Weight can be added to a backpack to increase load. Standardization of heel raise height during testing is achieved by the dorsum of the foot touching a bar at the peak of each repetition (F).
• There is conflicting evidence on the use of heel lifts, but recent evidence indicates that heel lifts may decrease compressive strain associated with AT and may be helpful during a reactive episode.

COMBINATION THERAPIES

Tendon loading exercise is the foundation of nonsurgical treatment for midsubstance AT, but can be combined with other symptom and physiologic modifying interventions to facilitate recovery (see Fig. 2). Several pharmacologic and nonpharmacologic interventions have been used with varying degrees of effectiveness to produce short-term changes in pain, perceived stiffness, and healing. Choosing between the various interventions to couple with tendon loading exercise should consider the clinical presentation that estimates the state of the tendon (see Fig. 1), including reactivity, availability of equipment, the patient’s preferences, and prior response to treatment.

**Tendon Loading Exercise and Laser Therapy**

The addition of low-level laser therapy to an isolated eccentric tendon loading program has demonstrated conflicting results, in part, owing to varying methodology. Parameters for laser therapy include irradiation of 6 points 1 cm apart on each side of the painful tendon with 0.91 J/point using an 820 nm wavelength probe that results in a power density of 60 mW/cm² for 12 total sessions over 6 weeks. The use of low-level laser therapy may be restricted owing to limited access to laser devices in most clinics. If used, effectiveness may be reduced if the patient has previously been treated with a steroid injection or if higher power densities greater than 100 mW/cm² are used.

**Tendon Loading Exercise and Iontophoresis**

In individuals with less than 3 months of pain, evidence from 1 small study indicates that dexamethasone delivered via iontophoresis may improve pain at 6 months and 1 year when coupled with a concentric-eccentric tendon loading and stretching program. A dose of 80 mA/min (20 minutes at 4 mA if tolerated) can be delivered using 3 mL of dexamethasone 4 times during a 2-week period.

**Tendon Loading Exercise and Shoe Inserts**

No studies were found that analyzed foot orthoses or heel lifts in addition to tendon loading exercises, but they may be beneficial for short-term use in the patient who has biomechanical deficits or who demonstrates improvement in pain with a trial of foot orthoses or a heel lift. Particularly, a heel lift may be effective if the tendon is reactive, but should be weaned as the tendon state improves (see Fig. 1). In addition, antipronation taping may be an effective strategy to predict symptomatic response to the use of foot orthoses.

**Tendon Loading Exercise and Taping**

In addition to the use of antipronation tape, there is limited and conflicting evidence that kinesiology tape can reduce symptoms in individuals with midsubstance AT. Considering the low cost and low risk of this intervention, kinesiology tape may be used to modulate symptoms when used in conjunction with a tendon loading program. Tape is applied parallel to the Achilles from the posterior calcaneus to the proximal lower leg using 1 or 2 strips. Tape can be left on for a few hours up to 1 week depending on patient tolerance and initial treatment response.
**Tendon Loading Exercise and Manual therapy**

Manual therapy based on joint and soft tissue impairments may help to improve function and adherence to tendon loading exercises by managing the musculotendon soreness associated with repeated tendon loading.\(^{33}\) Soft tissue mobilization is commonly performed parallel to the calf musculotendon fiber direction with or without a mobilization tool, or perpendicular to the tendon during dorsiflexion and plantar flexion.\(^{33,86–88}\) When indicated, direct mobilization of the tendon should be performed with caution to avoid a reactive response and should not be performed if the tendon is in a reactive state. Specific attention to tender and taut bands (trigger points) in the calf muscles can help to address sources of referred pain to the Achilles tendon.\(^{88,89}\) Trigger or tender points can be treated in a variety of ways including ischemic pressure, transverse friction, longitudinal strokes along the trigger band with 1 end “pinned,” or trigger point dry needling, depending on clinician experience and the patient’s preference. In addition to the calf, impairments in the posterior thigh, quadriceps, and gluteal area may be considered in select cases if associated with the AT.\(^{4,5,88}\)

**Tendon Loading Exercise and Stretching**

Calf stretches may help to reduce soreness and calf tightness associated with mid-substance AT, especially in individuals with limited dorsiflexion.\(^{33}\) Stretches are performed with the knee straight and with the knee bent for 30-second holds.\(^{90}\)

**Tendon Loading Exercise and Cryotherapy**

Cold or ice packs applied before and/or after activity, including tendon loading exercises, can help to reduce symptoms, particularly when the tendon is in a reactive state.\(^{75,91}\)

**Tendon Loading Exercise and Topical Glyceryl Trinitrate**

Topical glyceryl trinitrate (TGTN) is purported to promote tendon healing via the influence of nitric oxide on blood flow, collagen synthesis, and cellular adhesion, in addition to its analgesic effects.\(^{45,47,53}\) Studies demonstrate conflicting results when TGTN is combined with an eccentric loading program in individuals with chronic AT, with some reporting improved symptoms and function and another showing no benefit.\(^{47,48,92}\) Studies included application of a TGTN patch every 24 hours for 6 months to the most painful area. The effectiveness of intermittent use of the TGTN patch is unknown and side effects include skin rash at the patch site and headache, which may limit adherence to treatment.\(^{2}\)

**Tendon Loading Exercise and Shockwave Therapy**

Low-energy shockwave therapy can provide additional benefit when added to eccentric exercises.\(^{67,93}\) If the equipment is available, shockwave therapy may be considered if the patient is slow to respond to tendon loading exercise.\(^{94}\) Specific procedures for Shockwave therapy are described by Smith and colleagues. (See W. Bret Smith and colleagues’ article, “Midsubstance Tendinopathy, Percutaneous Techniques (Platelet-Rich Plasma, Extracorporeal Shock Wave Therapy, Prolotherapy, Radiofrequency Ablation),” in this issue.)

**Tendon Loading Exercise and Injections**

Despite limited evidence to support injection therapy for midsubstance AT,\(^{49}\) injections may be worthwhile when coupled with tendon loading exercises. Commonly used agents include corticosteroids, hypertonic glucose (prolotherapy), platelet-rich plasma, and polidocanol (a sclerosing agent).\(^{49}\) Because of limited evidence of effectiveness over non-pharmacologic treatment, injections are reserved for cases not responsive to initial
management. Specific procedures for injection therapies are described by Smith and colleagues. (See W. Bret Smith and colleagues’ article, “Midsubstance Tendinopathy, Percutaneous Techniques (Platelet-Rich Plasma, Extracorporeal Shock Wave Therapy, Prolotherapy, Radiofrequency Ablation),” in this issue.)

**Tendon Loading Exercise and Bracing**

Daily use of the DonJoy AirHeel brace (DonJoy Performance, Vista, CA) did not provide any additional benefit to eccentric exercises. Bracing may be considered in a very reactive tendon state where walking is affected severely. The duration of bracing should be limited to avoid decline in strength and stiffness properties of the tendon, and early loading after bracing used to promote tendon remodeling.

**Tendon Loading Exercise and Night Splints**

Night splints provide inferior improvements in pain and function when compared with an eccentric tendon loading program and do not provide any additional benefit when added to an eccentric program.

**TREATMENT RESISTANCE AND COMPLICATIONS**

The majority of patients will recover with treatment that includes tendon loading exercise, but 10% to 30% will continue to have symptoms. Resistance to treatment may be owing to nonadherence to treatment recommendations, severity of tendon degeneration, or sensitization. Although tendon properties change with age, patients of older age, and longer duration or higher intensity of symptoms are successful with nonsurgical treatment.

**Adherence**

Tendon loading exercise programs require frequent bouts of exercise for at least 3 months and adherence rates range from 72% to 100%. Other treatments such as shoe inserts, medication, and TGNT also require daily adherence for effective results. The treatment plan should be discussed thoroughly with patients to optimize adherence. Particularly if tendon loading exercises are recommended, patients should be educated about expected pain responses and address their fears related to movement, which has been shown to affect treatment outcomes.

**Tendon Structure**

Patients with greater severity of tendon pathoanatomic changes (see Table 1) may take longer to recover. In addition, Achilles pathoanatomy may be impacted by compression along the medial aspect by a thickened plantaris tendon.

**Sensitization**

Patients with AT commonly have symptoms for several months before seeking treatment. Persistence of symptoms may result in central and peripheral sensitization, including secondary hyperalgesia that has been demonstrated in several tendinopathic conditions. Recently, individuals with AT were found to have decreased 2-point discrimination, a sign of cortical reorganization, that may contribute to delayed or failed recovery. Consideration of psychosocial and behavioral factors may be important in these patients, but further research is needed to elucidate effective management of sensitization.
<table>
<thead>
<tr>
<th>Outcome Measure</th>
<th>Description</th>
<th>Reliability</th>
<th>MCID (Scale Points)</th>
<th>Cutoff Scores</th>
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| VISA-A<sup>107-109</sup> | Specific PROM for Achilles tendon dysfunction. Includes 8 (6 visual analog and 2 categorical) response items that assesses pain, functional status, and activity domains. Scores range from 0 to 100 and higher scores indicate higher function. | Test–retest: r = 0.93  
Intrarater: r = 0.90  
Intrarater: r = 0.90 | 6.5–12 | 90 points = full recovery |
| LEFS<sup>107,110</sup> | Designed for a range of hip, knee, ankle, or foot conditions. Includes 20 Likert response items with a range between 0 and 80. Higher scores indicate higher function. Condition specific questionnaire for those with lower extremity musculoskeletal conditions. Each item scored on a 0–4 Likert type scale. | Test–retest: ICC = 0.86 | 9–12 | — |
| FAAM<sup>110</sup> | Designed to assess a range of lower leg, foot, and ankle conditions. Includes a Likert response 21-item ADL and an 8-item sports subscales each scored from 0 to 100. Higher scores indicate higher function. | Test–retest: ICC = 0.87 (ADL subscale) and ICC = 0.89 (sports subscale) | ADL subscale: 8  
Sports subscale: 9 | — |

Abbreviations: ADL, activities of daily living; ICC, intraclass correlation coefficient; FAAM, Foot and Ankle Ability Measure; LEFS, Lower Extremity Functional Scale; MCID, minimum clinically important difference; PROM, patient-reported outcome measures; VISA-A, Victorian Institute of Sport Assessment-Achilles.
EVALUATION OF OUTCOME AND LONG-TERM RECOMMENDATIONS

Recovery from AT is indicated by reduced pain and recovery of function, including a return to usual and/or recreational activities. Pain is assessed using a numeric pain rating (0–10) or visual analog scale (0–100 mm) with a 30% change indicating meaningful improvement.106 The most widely used and valid measure of function specific to Achilles injury is the Victorian Institute of Sports Assessment-Achilles (VISA-A).107,108 The VISA-A is a self-administered questionnaire that assesses the impact of the Achilles problem on 3 domains: (a) pain, (b) functional status, and (c) activity (Table 4). In addition to the VISA-A, the Foot and Ankle Ability Measure and the Lower Extremity Functional Scale are valid and reliable function scales used clinically owing to their generalizability to all foot and ankle or lower extremity conditions (see Table 4).

In addition to pain and function measures, biomechanical and pathoanatomic characteristics are important factors in assessing outcome and predicting long-term recovery. Musculotendon strength, endurance, and stretch-shortening cycle function were still impaired at 1 year in 75% of individuals who completed a tendon loading program despite full symptomatic and functional recovery determined by the VISA-A.111 Therefore, heel raise or jump performance measures can be used to monitor treatment outcomes and recovery.

A lack of recovery of musculotendon function may be consistent with persistent tendon pathoanatomy. Greater tendon heterogeneity on ultrasound examination has been associated with a longer recovery time and poor outcome at 6 months of tendon loading exercise and corticosteroid injections.8,104 Continued improvement in AT can be observed up to 1 year after starting treatment,70 and ultrasound imaging may be useful during this time to monitor structural changes and encourage long-term adherence to tendon loading exercise. Because recovery of musculotendon function and integrity may take up to 1 year, nonsurgical management is recommended for at least 1 year (see Fig. 2).65 Patients are encouraged to adhere to tendon loading exercises 2 to 3 times per week after the typical 3-month program regardless of symptomatic improvement to avoid recurrent problems related to residual biomechanical and pathoanatomic impairments.

SUMMARY

Successful management of midsubstance AT can be accomplished with nonsurgical treatment, including isolated or combined pharmacologic and nonpharmacologic treatments. Current literature supports the use of tendon loading exercise as the mainstay of chronic AT management and long-term studies (2–8 years) indicate that 80% to 90% of patients will be able to return to desired activity levels with little to no symptoms.65,101 A variety of treatment options are used concurrently with the tendon loading program to help symptom modulation and tissue healing (see Fig. 2). To reduce symptoms in a reactive tendon, including acute AT, topical pharmaceuticals (iontophoresis with dexamethasone or diclofenac gel) are safe and effective solutions that avoid the risks associated with oral NSAIDs or corticosteroid injections. Other regenerative injectables (platelet-rich plasma, hypertonic glucose) have yet to demonstrate convincing evidence of effectiveness for routine use49 A small percentage of patients may not respond or adhere to a tendon loading program and may be candidates for shockwave or sclerosing treatment, and possibly surgery.

In addition to evidence of treatment effectiveness, intervention selection depends on clinical resources and patient preferences. Treatments such as shockwave therapy and laser may not be available in clinics near the patient.2 Other treatments such as TGTN and sclerosing injections may require extensive and repeated application that are not...
conducive to the patient’s circumstances. Although tendon loading exercises do not require any equipment, adherence over several months is important to achieve results and patients need to understand this fully at the outset of treatment. Patients prefer treatments with lower costs, greater chance of success, shorter time to return to their prior level of activity, and lower risks of side effects. In addition, patients prefer exercises over stand-alone injections, but treatment options should be discussed with each patient to identify the preferred treatment with greatest likelihood of success.

REFERENCES


85. Lim ECW, Tay MGX. Kinesio taping in musculoskeletal pain and disability that lasts for more than 4 weeks: is it time to peel off the tape and throw it out with the sweat? A systematic review with meta-analysis focused on pain and also methods of tape application. Br J Sports Med 2015;49(24):1558–66.


