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Evidence-based orthotic management of PTTD

The medical literature supports the use of orthotic devices in patients with posterior tibial tendon dysfunction, especially those in the early stages. Demonstrated benefits include improvements in foot and ankle alignment, clinical symptoms, and functional outcomes.

By Holly Olszewski, CPO

Posterior tibial tendon dysfunction (PTTD) is a common disorder seen in adults; it is also often referred to as adult acquired flatfoot deformity.[1] PTTD is a musculoskeletal condition characterized by a dysfunction of the tendon of the tibialis posterior (TP) muscle. Suggested etiologies of PTTD include chronic tenosynovitis, exacerbation of congenital pes planus with degenerative tendinosis, and trauma or previous injury to the tendon.[2-7] Risk factors include pre-existing flatfoot, obesity, age, female gender, sedentary lifestyle, diabetes, hypertension, previous trauma, and inflammatory diseases.[8-11] PTTD is described clinically in stages based on symptom presentation (Table 1).[7,9]

The TP is the primary stabilizer of the medial longitudinal arch (MLA); the TP muscle inverts and plantar flexes the foot, stabilizing the hindfoot by locking the midtarsal joints and inverting the subtalar joint. This rigid foot position and MLA elevation allow the triceps surae to plantar flex the ankle efficiently in a normal foot/ankle complex during gait.[1]

Dysfunction of the posterior tibial tendon (PTT) permits the hindfoot to remain in eversion and the midfoot to be more flexible throughout stance. The flexible midfoot is then subjected to mechanical overloading, both from body weight and the force of the triceps surae acting laterally relative to the axis of rotation of the subtalar joint, which causes a powerful pronation moment.[1] As a result of these abnormal stresses, ligamentous and soft tissue structures in the foot can stretch and deform over time.[8,12,13] In particular, the calcaneonavicular and plantar ligaments, which provide static support for the posterior tibial tendon, can become attenuated, increasing the eccentric load on the PTT.[1] Subsequent characteristic PTTD foot deformities include collapse of the MLA, hindfoot eversion, forefoot abduction, and often an Achilles tendon contracture.[5,7,14,15]
These foot/ankle deformities have been shown to affect the function of the TP. The PTT has a short excursion length of approximately 2 cm.[16,17] A small elongation (as little as 10 mm) can affect the tendonôs contractile efficiency and impair muscle function.[1,7,17] In a laboratory study, researchers found that the TP was less effective at raising the MLA after a flatfoot deformity was induced.[18] Researchers have also found that during ambulation, PTTD patients have significantly lengthened posterior tibial tendons compared to controls.[19]Poorer functional outcomes were reported in those patients with extreme tendon lengths.[19] Additionally, ankle weakness is common in PTTD patients.[20,21] However, researchers have found that even stage II PTTD patients with good TP strength still have abnormal kinematics compared to control groups, suggesting loss of ligamentous integrity and need for external support.[21]

Figure 1. Examples of AFOs used for PTTD in the medical literature: double upright AFO (left), gauntlet style AFO (center) and low articulated AFO (right).

Orthotic management of PTTD

Orthotic treatments for PTTD aim to decrease the patientôs pain, allow for increased activity and function, maintain a neutral foot and ankle position, and prevent or postpone progression of deformity.[8,20,22-38] The literature suggests that orthotic intervention can be successful for a majority of PTTD patients.[20,31-38]

PTTD Classification by Stages

Stage I	Stage II	Stage III	Stage IV
Tenosynovitis or degeneration of the tendon	Elongation and degeneration of the tendon	Elongation and degeneration of the tendon	Same presentation as stage 3 with inclusion of:
Pain	Pain	Pain	Valgus deformity of the talocrural joint
No deformity	Flexible pes planovalgus deformity	Fixed pes planovalgus deformity	Arthritis of the ankle
Mild weakness (able to complete single heel rise with inversion of hindfoot)	Forefoot abduction when weightbearing	Forefoot abduction when weightbearing	
	Significant weakness (no or limited inversion of hindfoot in single heel rise)	Inability to perform a single-leg heel rise	

Table 1. PTTD is classified by stages by Johnson and Strom7 and later by Myerson.9

Orthotic treatment choices for PTTD vary based on the clinical presentation, symptoms and patient activity level. Patients can be grouped into two categories: those with an acute presentation and those with chronic symptoms.

Orthosis use is often paired with physical therapy to address underlying musculoskeletal issues. However, care should be taken to maintain a corrected foot position when exercising to reduce strain on the PTT.[32] Nielsen et al proposed that symptom resolution and functional improvement associated with posterior tibial tendon bracing allows physical therapy to be more effective.[32]

Acute PTTD/stages I-II

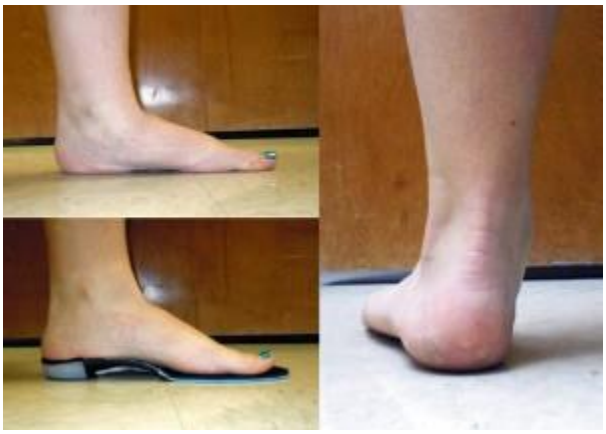

Figure 2. A subject with Stage I PTTD. Photos show posterior view (right), medial view (top), and the subject standing on a custom foot orthosis (bottom).

Tome et al suggested that the goal of orthotic intervention in patients with stage I PTTD is to prevent the development of abnormal kinematics associated with stage II PTTD.[15] Immobilization for three to six weeks in a walking cast or controlled ankle motion (CAM) boot is often recommended for acute/stage I disease to restrict soft tissue movement, protect ligamentous structures, and allow for healing and reduction in inflammation.[8,22,25,34] A foot orthosis or support inside the CAM boot may be applied to help control hindfoot eversion.[22] After the period of immobilization, foot orthoses are frequently used for continued support of the MLA. Pomeroy et al recommends initial use of foot orthoses if the patient presents with mild stage I symptoms.[8]

Chronic PTTD/stages II-IV

Orthoses used in the literature for stage II-III include foot orthoses, UCBL (University of California Berkeley Laboratory foot orthosis) devices, supramalleolar orthoses, solid and articulating ankle foot orthoses (AFOs), gauntlet style AFOs, and double upright AFOs.[31-38]

A small number of clinical studies have documented specific criteria used to choose between different orthoses. Chao and colleagues used a molded AFO if a patient had a fixed deformity, forefoot varus greater than 10° when the calcaneus was in a neutral position, and obesity defined as 35 lbs over ideal body weight.[35] If the deformity was flexible, varus was less than 10°, and no obesity was present, a UCBL device was used.[35] Alvarez et al used short articulated AFOs if patients had PTTD symptoms for more than three months, could not ambulate more than one block, or could not perform a single side heel rise.[20] A foot orthosis with high trimlines was used for patients who could complete the heel rise and walking distance and whose symptom duration did not exceed three months.[20]

It is important for orthosis design to take into account the flexibility of the deformity and control of abnormal kinematics. Tome and colleagues suggest that orthosis selection should be based on a deviceôs ability to control rearfoot eversion, MLA angle, and forefoot abduction across the entire stance period.[15] This matching of the PTTD deformity and flexibility to the fabrication of the orthotic device is an important concept that has been discussed in the literature.[23,28,33,35] For a flexible deformity, fabricating an orthosis in a subtalar joint neutral position is designed to promote corrected foot position during weightbearing and slow or stop the progression of the calcaneal valgus deformity.[28] For a rigid deformity, the orthoses should be fabricated in an in situ position with accommodations for bony prominences to support existing deformity and prevent worsening.[28]

Biomechanical studies

PTTD patient models or simulated PTTD feet are used in biomechanical studies to investigate the kinematic effects of orthotic interventions in a laboratory environment. These studies are important for validating the ability of orthotic devices to influence foot and ankle biomechanics, and to help explain the mechanisms underlying symptomatic relief associated with device use.

Custom-made foot orthoses have been shown to significantly improve the biomechanical position (in terms of talocalcaneal angles and talar pitch measured by radiograph) of the foot and ankle in persons with flexible flat feet.[39] This is supported by similar studies.[25,40] Corrected alignment with foot orthoses and shoes has also been shown to increase TP muscle activation in patients with flatfoot deformities.[41]

Diamond et al found that an articulated AFO with UCBL-style foot plate was effective for controlling hindfoot motion in a simulated stage II PTTD foot.[42] Neville and Houck looked at foot and ankle alignment in three different AFOs (off the shelf, custom solid AFO, custom articulated AFO) on a patient with stage II PTTD. They found that all AFOs were associated with changes in hindfoot correction and increase in the MLA. However, the articulated AFO corrected forefoot abduction to the greatest extent. The authors proposed that the articulated AFO allowed the extrinsic muscles of the foot and ankle to improve foot kinematics.[43]

In a previous study, the same group found that greater posterior tibial tendon length during ambulation in PTTD patients relative to controls could be primarily attributed to changes in hindfoot eversion and forefoot abduction.[19] First metatarsal dorsiflexion and ankle dorsiflexion were less likely to be associated with posterior tibial tendon lengthening.[19] These results may suggest allowing dorsiflexion in stage II PTTD may provide patients with improved gait kinematics while having a limited effect on PTT length.

Retrospective clinical studies

Clinical studies give information on how orthotic interventions affect average PTTD patient outcomes over a longer term. Improvement in pain levels, functional outcomes (such as activity level or ability to ambulate distances), and avoidance of surgery are often used to describe ñsuccessfulò treatment of PTTD. Retrospective, prospective, and controlled trials have reported success rates ranging from 67% to 90%.[20,31-35,37,38]

A number of clinical researchers have retrospectively reviewed the outcomes of their routine treatment regimens for PTTD.[31,32,34] Jari et al reviewed their institutionôs standard treatment and found that 82% of patients were satisfied with the nonsurgical results (average follow-up time of two years) and ñdid not wish to consider surgery.ò[31] Patients in early stages were treated with physical therapy and orthoses (stage I=foot

orthoses; stage II=foot orthoses, UCBLs, or custom-built shoes); patients in stage III/IV used foot orthoses, AFOs and-or custom built shoes.

Nielsen et al reviewed consecutive symptomatic PTTD patients in their clinic and found successful conservative outcomes (resolution of symptoms without surgery) in 87.5% of patients over a 27 month period. Treatment included orthotic intervention (CAM walker and/or low profile articulating AFO or LAFO) and physical therapy; the authors stated that outcomes improved when patients performed their physical therapy exercises while wearing their AFOs.[32] Successful nonsurgical treatment appeared to be associated with the use of any type of brace, and in particular the LAFO, according to the authors. They suggested that use of a LAFO may be particularly helpful because it combines the benefits of a foot orthosis with additional ankle support, while allowing full weightbearing during ambulation.[32]

Lin et al completed perhaps the longest-term (seven to 10 years) retrospective follow-up study on orthotic intervention for stage II PTTD patients.[34] Patients were first treated for six weeks in a walking cast, then transitioned to a double upright AFO with a medial T-strap and rocker bottom shoes. The AFO was used until the patientsô symptoms were resolved (average 14.9 months). At an average 8.6 year follow up, 69.7% of patients, were orthosis-free, had avoided surgery, and reported quality of life scores that were similar to national norms. An additional 15.2% of the patients had symptom improvement and avoided surgery, but continued to wear the orthosis full or part time. The authors also reported no clinical progression of deformity from stage II to III during the follow-up period. However, in the patients who did not have surgery, follow up indicated that TP weakness remained (19.2% had a weak heel raise and 38.5% could not complete a heel raise).

Prospective clinical studies

Prospective studies follow patients throughout the treatment regimen, so parameters can be measured before and after treatment. Orthotic treatment choice may be based on study criteria (as discussed above in the cases of Chao et al and Alvarez et al).[20,35] Chao et al found that the majority (67%) of stage II or III patients treated with an AFO or UCBL orthosis had good to excellent results, based on pain, function, and patient satisfaction.[35]Approximately half of the patients continued to wear their orthoses at 20 month follow up; those who discontinued use did so because of resolution of symptoms (12%), medical issues (6%), discomfort (18%), or surgery (8%).[35]

In Augustin et alôs investigation of patients with PTTD (stages I-III) who used an AFO, 90% of patients had a statistically significant improvement in symptoms and quality of life after an average of one year follow up.[37]The majority of patients (86%) continued to wear the orthosis at follow up; one patient discontinued use due to symptom resolution, and two stopped because of other medical issues. A considerable percentage of patients (28.5%) had bilateral involvement; all bilateral patients had improvement.

Alvarez et al prospectively treated stage I or II PTTD patients with orthotic devices and an aggressive exercise program over a three-year period.[20] At the initial evaluation, most patients presented with global ankle weakness. The criteria described previously were used to determine if the patients were given AFOs or foot orthoses. Most patients (70%) met the criteria for AFOs. The authors allowed patients to switch from an AFO to a foot orthosis during treatment when their pain had subsided and TP strength on the affected side was comparable to the contralateral side.

The majority of patients (89%) responded positively to the rehabilitation program. Alvarezôs outcome parameters for success were very rigorous ï requiring the ability to perform 50 heel raises with minimal or no pain and to toe walk 100 feet and conversion from an AFO to foot orthoses. Most patients (83%) successfully reached these goals. Another 6% of patients were satisfied with their treatments, but continued to wear their AFOs for pain control or as a personal choice despite minimal or no pain.

Krause et al completed a prospective study on patients with flexible stage II PTTD and a history of symptoms averaging 29 months duration.[33] Previous treatment included foot orthoses and therapy. The authors used a supramalleolar type ñshellò brace in an effort to provide a medium-profile orthosis. Patients were casted in a corrected position. After an average of 61 months, 83% of patients had a high level of satisfaction with the brace, with no onset/progression of arthritis or radiographic progression of deformity. At the end of follow up, more than half the patients were able to perform a single-leg heel rise without pain; no patients were able to

complete this before the orthosis intervention. Two patients (11%) had improved enough to discontinue use of their orthosis.

Controlled clinical studies

Randomized controlled studies provide the most valuable information for analysis; because these trials include control groups, each treatment variable can be analyzed. In 2009, Kulig et al performed a randomized controlled trial of conservative treatment with foot orthoses only, foot orthoses with concentric exercises, and foot orthoses with eccentric exercises. In patients with stages I and II PTTD, they found significant increases in function and reductions of pain in all groups after three months of custom foot orthosis use and stretching. The addition of concentric or eccentric progressive resistance exercises that focused on the TP muscle improved results.[38]

Summary

Overall, the literature is supportive of orthotic device use for patients with PTTD, especially in the early stages. Orthoses can improve foot and ankle alignment, clinical symptoms, and functional outcomes in PTTD patients, with success rates up to 90%.[20,31-35,37,38] Studies that measured deformity found that most patients (83% to 85%) had no progression during the course of their treatment.[33,34] After an initial regimen of orthotic treatment, up to 89% of patients in some studies eventually used a more minimal orthosis or even discontinued use of their orthosis due to symptom resolution.[20,34,35] Additionally, pairing orthosis use with appropriate physical therapy in early stages of PTTD may improve outcomes and TP muscle strength.[20,38] More randomized, controlled clinical studies are needed to help define clinical treatment protocols for PTTD and orthotic intervention.

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Acknowledgments: Special thanks to Brad Conner, Eric Burns, and Steve Whiteside.

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