Current Concepts in Rehabilitation of Plantar Fasciitis

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Abstract

Plantar Fasciitis is the most common cause of heel pain treated mostly conservatively and physical therapy significantly contributes to alleviate the symptoms using both exercise therapy and electrotherapeutic modalities. attributes to 8% of all running related sports injuries, 15% of all reported foot complaints and 7% of all the reported complaints of tenderness of heel in patients above 65 years. An understanding of the fasciitis' pathomechanics and a comprehensive knowledge of these modalities, their mechanism of action, and the evidence of their efficacy can help in swift and accurate clinical decision making, helping the patients and the health-care system alike.

Keywords: Plantar Fasciitis; Heel Pain; Rehabilitation; Physical Therapy; Pathomechanics

Abbreviations

PF: Plantar Fasciitis; SI: Steroid Injection; ESWT: Extracorporeal Shock Wave Therapy; HILT: High Intensity LASER Therapy; LLLT: Low Level LASER Therapy; APTA: American Physical Therapy Association

Introduction

Plantar Fasciitis (PF) or Fasciosis or Fasciopathy is a chronic debilitating condition which adversely affects our basic activities of daily living [1]. The thick fibrous band of plantar aponeurosis that not only maintains the arch in quiet standing [2] but also provides proprioception [3] and acts like a spring and conserves energy for propulsion during walking [4]; sustains chronic repetitive injury due to mechanical overload. This excessive loading may be due to obesity/increased body mass index [5-10], occupations involving excessive walking or long hours of standing, running with poorly cushioned footwear [11] or biomechanical anomalies like pes planus or pes cavus [12]. The injury exceeds the body's capacity

to heal [13-16] and leads to the development of pain and inflammation of plantar fascia and perifascial structures [12].

This culminates into a chronic pain in the medial heel, pain during first steps in the morning with an underlying degenerative process characterized by the failed healing response and an absence of histopathological signs of inflammation [16,17]. The management of plantar fasciitis is mostly conservative [9] and physical therapy is most commonly recommended along with other rehabilitation interventions like orthotic support, and pharmacological management like NSAIDs and corticosteroid injections etc (Table 1). The field of physical therapy is dynamic and ever emerging and new interventions like Extracorporeal Shock Wave Therapy (ESWT), Dry Needling, Myofascial Release etc. backed with considerable research are being used to treat the plantar fasciitis. The aim of this paper was to present a comprehensive overview of the interventions and their mechanism of action and reported efficacy for the ease of clinical decision making and treatment planning.

Physical therapy	Orthotic Devices	Injections and other Alternate treatment strategies
Electrotherapy Extra Corporeal Shock wave Therapy Dry Needling LASER/Photobiomodulation Iontophoresis Ultrasound	Pre-Fabricated/over the counter	Corticosteroid injections
Exercise Therapy 1. Manual Therapy 2. Manipulation/ Strain Counter strain 3. Stretching	Custom-made orthoses	Autologous Whole Blood or Platelet Rich Plasma
Low Dye Taping and Kinesiotaping	Night splints	Botulinum toxin Injection
		Dehydrated amniotic membrane injection
		Low Dose radiotherapy

Table 1: Principal rehabilitation strategies for management of planter fasciitis.

Pathomechanics of plantar fasciitis

Biomechanically, it has been documented that, those persons with a hyper mobile foot or hyper pronated foot develop planter fasciitis [18]. The normal foot pronates maximally at foot flat phase of the gait but the hyper pronated feet, continue pronating and are unable to supinate during mid stance. The propulsion needs a rigid (supinated) foot and these overpronated feet do not achieve the rigid, locked position due to inadequate supination. This leads to abnormal force absorption and distribution. Adult foot deformities like Convex pes valgus (vertical talus), tarsal coalitions, and congenital metatarsus varus; developmental deformities like talipes calcaneovalgus, talipes calcaneovarus, postural metatarsus adductus and forefoot varus, ligament laxity, tight Achilles tendon, weak intrinsic foot musculature-all lead to a overpronated foot [19].

Pes cavus, pes cavovarus and pes equinovarus all have abnormal supination of the foot. These Individuals also tend to develop planter fasciitis. A neutral foot at heel strike pronates immediately to absorb shock of contact. The abnormally supinated feet either

stay supinated throughout stance or pronate late i.e. in the propulsive phase where supination is required. According to Root, *et al.* pronation during push off makes the heel unstable and causes trauma [19]. Forces generated during both pronation and supination increase the planter fascial tension, too much or too little of either motion at wrong time of gait cycle leads to inefficient foot function and potential dysfunction [12].

Chandler and Kibler [20] and Kwong, *et al.* [21] suggested that it's not merely from the abnormal motion; but the duration of motion is also a very significant factor in the development of planter fasciitis. Cornwall [22] suggested that when the joints of foot function continuously beyond a normal end range, medial joint capsule and ligamentous structures experience greater stress and, posterior tibialis get excessively fatigued to control abnormal motion [23]. This leads to pain, discomfort and inflammation of the fascia. An increase in weight-bearing activities like running, jogging cause micro trauma to the fascia and, repetitive micro trauma without allowing the body to recover also leads to planter fasciitis. The other causes may be neurological, arthritic, due to tumor etc [24].

Treatment options

The understanding of biomechanics and pathomechanics helps in determining treatment options for the condition. The medical treatment comprises of use of non-steroidal anti-inflammatory drugs, Corticosteroid Injections, Botulinum toxin or Platelet Rich Plasma, Extracorporeal Shock Wave therapy. Surgical management includes sectioning of planter Fascia, Release of lateral planter nerve, Endoscopic planter release. The rehabilitation interventions aim at restoring normal muscle strength, improving muscle flexibility, and normalizing biomechanical influences by use of modalities and techniques to increase and maintain extensibility, reduce pain and maintain the foot in proper position. Manual therapy, stretching, strengthening, taping, orthosis, osteopathic manipulation, dry needling Laser, phonophoresis etc. are most commonly recommended.

Rehabilitation-Current concepts

Extra corporeal shockwave therapy: ESWT is a non-invasive short duration, high- pressure amplitude, pulsed Sound wave that produces controlled micro trauma to stimulate a healing response and microneovascularisation [25]. The American College of Foot and Ankle Surgeons in 2010, have recommended ESWT as a treatment of choice for plantar fasciitis with or without a plantar spur when nonoperative treatment has failed [24].

Mechanism of action: The efficacy of ESWT is being widely reported yet the mechanism of action remains unclear. It is speculated, that the effect comes from reflexive analgesic effect by destroying the unmyelinated sensory fibers and inducing excitability of the axon or suppression of inflammatory process by inducing production of nitric oxide [25]. The probable effects of ESWT have been summarized into 4 phases-Physical, Physiochemical, Chemical and Biological which take place through cavitation, mechanotransduction, increasing the permeability of the cell membrane and causing the release of biomolecules through stimulation. ESWT can induce neovascularization at the junction of the tendon-bone; it stimulates collagen synthesis and release of growth factors such as VEGF (vascular endothelial growth factor), PCNA (proliferating cell nuclear antigen) and eNOS (endothelial nitric oxide synthase). Subsequently, these factors lead to the improvement of the blood supply and to an increase in cell proliferation and ultimately to the tissue regeneration of tendons and bones for tissue repair [26]. The functional proteins released due to the procedure not only promote wound and bone healing, they are Anti-Inflammatory, chondroprotective and stimulate nerve regeneration [27].

Efficacy: A meta-analysis [25] of 9 RCTs involving 658 cases was conducted to ascertain the efficacy of ESWT and it was reported that within 3 months, the success rates and pain relief in the high intensity ESWT group were higher as compared to Corticosteroid injection treatment. The lowest was noted in the low intensity ESWT group [25]. A recent meta-analysis [28] compared the efficacy of shock wave and corticosteroid injections and found that both were successful in causing pain relief and improving self-reported function at 3 months post treatment. They recommended Shock wave to be a better treatment option as the VAS scores showed larger improvement in that group compared to the corticosteroid group.

Recent studies [29-32] have found ESWT to be an effective modality in alleviating pain in plantar Fasciitis patients. Akinogulu, *et al.* [33] found additional benefits of increased proprioception and improvement in Static and Dynamic Balance by means of Single leg Standing and Functional Reach test. Takla MKN, *et al.* [34], Cinar E., *et al.* [35] compared ESWT to laser and found significant improvement in both groups and while Takla MKN [34] found ESWT to be better, Cinar E., *et al.*'s [35] recommendations were opposite. A recent study by Ulusoy, *et al.* [36] found comparable evidence for both. Several authors [27-44] have also compared ESWT to Steroid injections, Botox A, Autologous CP and Surgical release. The

results show that ESWT is equally effective and has longer, lasting treatment effects than injections. On comparing ESWT with plantar release, Radwan, *et al.* [42] and Saxena, *et al.* [44] produce contrasting evidence. Radwan, *et al.* [42] found both to be equally effective and Saxena, *et al.*'s [44] results favor surgical release; yet he states that ESWT should be preferred over surgical release as it allows the athlete to stay active between treatments. Overall, it seems safe to say that the ESWT can be opted for before proceeding for invasive interventions.

Figure 1: Extra corporeal shock wave therapy.

Photobiomodulation or laser: The low-level laser therapy (LLLT) is the application of light to promote tissue metabolism, healing and regeneration. APTA [45] recommends the use of low-level laser therapy (LLLT) to reduce pain and improve the level of activity in individuals with heel pain/plantar fasciitis.

Mechanism of action: LLLT is applied between the low power range of 1 to 500 mW and the spectral width falls near the red or near infra-red spectrum (600 nm - 1000 nm) which helps in better penetration of the Laser into the skin. It is said to affect cellular metabolism, protein synthesis and wound healing and helps in reducing pain [2,46]. The photochemical effect of the Laser causes stimulation of mitochondria, increases the ATP, RNA and protein synthesis, which causes increased cellular metabolism, accelerates the inflammatory response and facilitates healing [47,48].

Efficacy: LLLT has been studied by various authors [34,36,49-52] and they have all claimed the treatment to be effective in reduction of pain and improvement of function in plantar fasciitis. Kiritsi, *et al.* [51], Macias, *et al.* [52], Akinogulu, *et al.* [33] have reported reduction of Plantar Fascia thickness by Ultrasonographic measurement and Takla, *et al.* [34] have reported improved pressure point threshold following LASER in PF. Oradhan [49] compared High Intensity Laser Therapy (HILT) with LLLT and found greater effectiveness of HILT. LLLT also shows greater effectiveness when used in conjunction with ESWT than either alone. A recent systematic review by Wang, *et al.* [53] concluded that the LLLT was not only significantly effective in relieving the heel pain in PF patients, it was also effective up to 3 months post treatment.

Figure 2: Photobiomodulation or LASER.

Dry needling: Though the earlier evidence is speckled with negative recommendations as by The APTA [9] guidelines (based on publications before 2013); the recent RCTs point towards its efficacy.

Mechanism of action: Dry needling is said to reduce pain by affecting the concentration of neuropeptides- substance P and Calcitonin Gene Related Peptide and increasing endorphin levels in local tissue and serum [54]. The increased blood flow may also be responsible in removing substances responsible for nociception.

The dry needling is said to affect the areas of brain responsible for sensory, cognitive and affective dimensions of pain [54].

Efficacy: Rastegar, *et al.* [55] compared dry needling with steroid injections (SI) concluded that the steroid injections give faster pain relief but dry needling can provide more satisfactory results in the long term. Uygur, *et al.* [56] reported comparable efficacy of dry needling as compared to corticosteroid injection at 3m and while the SI lost its efficacy at 6m, the dry needling did not. Cochetti, *et al.* [54] compared dry needling with sham needling and found lesser pain and improved function in the treatment. Eftekharsadat, *et al.* [57] performed dry needling on trigger points in gastrocnemius and the reduced pain was reported even 4 weeks. after withdrawing intervention. They concluded that Dry needling is effective in improving the pain and may be used as a treatment option before using any invasive treatment options. Despite some reports of adverse effects of pain and bleeding from site post intervention, Uygur, *et al.* [56] state that none of the patients discontinued their sessions.

Manual therapy, stretching and strengthening

Manual therapy: Manual therapy in conjunction with exercises has been found to be effective in significantly improving the symptoms of planter fasciitis not only in the short term but also at 6 month follow up. The manual techniques for mobilizing the soft tissue are recommended by APTA [9].

Mechanism of action: Joint mobilization techniques can improve first ray and subtalar joint mobility in a cavus foot. Increased extensibility of soft tissues and improved mobility of joints can improve the biomechanics of foot [11]. Improved mobility, joint play and flexibility of ankle following a week of Strain- Counter strain technique of manual therapy have been reported [58].

Efficacy: Ajimsha, *et al.* [59] studied the effects of Myofascial release and provided sham ultrasound to the control group. There was improvement in foot function index scores and pain pressure threshold. Renan-Ordine, *et al.* [60] have found that the trigger point manual therapy is effective and when combined with self-stretching outcomes are even better. Celik, *et al.* [61] and Johannsen, *et al.* [62] have compared manual therapy with steroid injections (SI). Their reports show that the effectiveness of manual therapy is comparable to SI and though, these deliver a quicker relief, the joint mobilization and strengthening group maintains the

effects of treatment for longer [61]. Johannsen, *et al.* [62] suggest that a combination of SI and manual therapy will be most effective than either alone. Saban, *et al.* [63] and Shashua, *et al.* [64] compared manual therapy with Ultrasound and found similar effects in both groups. Kamoneski, *et al.* [65] and Rathleff, *et al.* [66] provided rigorous strength training to their patients and reported improvement in pain and function.

Figure 3: Stretching of a. Great toe b. plantar fascia c. and d. Gastrosoleus stretching.

Strengthening: Strengthening should incorporate all muscles that are involved with controlling pronation and facilitating the windlass mechanism. The program should strengthen the posterior tibialis, ankle plantar flexors, and peroneus longus muscles as well as the proximal hip and knee musculature [11].

An impairment- specific approach should be used to target the muscle groups for strengthening. In case of overpronation due to

decreased intrinsic ankle pronation control, Bolgla, *et al.* [67] suggest strengthening of posterior tibial musculature. The pronated foot may be due to decreased intrinsic ankle supination control and ankle plantar-flexor strengthening and intrinsic foot musculature strengthening is recommended. Improvement in proximal hip and knee muscle strength is recommended if there is decreased extrinsic pronation control [67].

Stretching: Gastrocnemius and soleus muscle stretching to improve the dorsiflexion range of motion should be included in the exercise prescription for both the high and low arched feet [68]. Pfeffer, *et al.* [69] reported a 72% improvement in subjects participating in an 8-week stretching program. This study showed that improved Achilles' tendon flexibility decreases the tension applied directly to the plantar fascia. According to a systematic review [70] regarding the efficacy of stretching, evidence points towards plantar fascia stretching being more effective than Achilles' tendon stretching alone. The exercise progression can be from a non-weight-bearing position to a weight-bearing position. Use of contract - relax method of proprioceptive neuromuscular facilitation technique is found to be effective [71].

Orthosis and taping

Orthosis: The orthosis support and cushion the foot. They absorb the shock at heel strike and stabilize/support the foot during propulsion, hence minimizing the pain and discomfort that accompanies every step of a biomechanically compromised foot. These are available as over-the-counter prescriptions or pre-fabricated devices and comprise of insoles, heel pads, heel cups, medial arch supports [72]. Turlik, *et al.* [73] studied the role of prefabricated and custom-made orthosis and found both to give significant relief though the custom-made orthosis were superior to pre-fabricated orthosis. Custom made orthosis are a better option than the pre-fabricated ones [74-76] and Total Contact insoles are an effective first line of treatment [77,78]. Yucel, *et al.* [78] have found the improvements in foot function and pain and reduction of thickness of planter fascia, post use of total contact insoles to be comparable to ultrasound guided corticosteroid injections.

The customized orthoses have a more patient specific approach and comprise of rigid or semi rigid devices like as supramalleolar orthosis or University of California and Biomechanics Laboratory (UCBL) foot insert [11]. Chethan, *et al.* [79] compared the effectiveness of various foot orthosis and found that the UCBL insert

provided significant pain relief. The effects lasted up to 6 months. A combination of custom orthosis with stretching exercises have reported more effectiveness than either alone [80,81].

Wedging: Wedging in a shoe tends to take the strain off the planter aponeurosis. The medial wedging has been widely documented as a possible shoe modification that reduces the excessive pronation and relieves the person of pain [21,73] though evidence for lateral wedging also exists. Kogler, *et al.* [82] support lateral wedging as they reported greatest (planter aponeurosis) strain reduction, when a 6° wedge was placed under the lateral aspect of the forefoot.

Night splints: Plantarflexion is the resting position of the foot and is also the position not conducive for a patient with inflamed planter fascia. When the foot stays in this position over night, it causes stretching of the inflamed tissue thus producing pain with the first morning steps. Night splinting in dorsiflexed position has been recommended to improve flexibility [83,84]. Wheeler, *et al.* [85], in contrast, report no added benefit of a tension night splint when given in conjunction with a home exercise program.

Taping: The taping of the arch during the waking hours helps support the foot, reduces strain on the planter fascia and optimizes ligament and muscle function [11]. Low-dye taping helps support the foot to optimize ligament and muscle function that can help decrease the tensile forces placed on the planter fascia [86]. According to the clinical practice guidelines issued by APTA in 2014 [45], the use of anti-pronation taping for immediate (up to 3 weeks) pain reduction and improved function for individuals with heel pain/planter fasciitis is recommended. Elastic therapeutic taping of gastrocnemius muscle and planter fascia is recommended for short term pain relief. Podolsky, *et al.* [87] and Radford, *et al.* [88] have reported reduction in pain following low-dye taping. Abd el salam, *et al.* [89] and Tsai CT, *et al.* [90] have also found taping to be effective for alleviating pain due to planter fasciitis, the latter more so, as their study also reported reduction in planter fascia thickness post Kinesiotaping.

Others

- **Iontophoresis:** According to the guidelines by APTA [45], Clinicians may or may not use iontophoresis with dexamethasone or acetic acid to provide short-term (2 - 4 weeks) pain relief and improved function. Iontophoresis following Icing and ultrasound was found to be beneficial in a study by Cleland, *et al* [91].

- **Phonophoresis:** The use phonophoresis with ketoprofen gel is recommended [45] to reduce pain in individuals with heel pain/planter fasciitis. In a study by Jasiak-Tyrkalska, *et al.* [92], a three weeks treatment with phonophoresis with ketoprofen gel (along with strengthening, stretching and orthosis) showed significant improvement in pain.
- **Ultrasound:** The effectiveness of ultrasound in planter fasciitis has been questioned by the APTA guidelines [9]. There were no high-quality studies assessing the efficacy of Ultrasound as a primary modality, yet, studies by Shashua, *et al.* [35], Saban, *et al.* [39] and Dunning, *et al.* [93] reported improvement in patient related outcomes post application of Ultrasound. The effects were significant though lesser than the modality being examined.

Figure 4: Ultrasound therapy.

Conclusion

There is a positive body of evidence for the efficacy of ESWT, Dry Needling, and LASER and the use of these modalities before trying invasive therapies has been recommended. Manual therapy Taping have been found effective in combination with other modalities or alone and the effects have been reported to be comparable with Steroid Injections. More high-quality studies with rigorous methodology may establish their efficacy further. Night Splinting and Ultrasound may be beneficial when used in conjunction with other modalities or exercises. The study has culminated last 10 years of evidence regarding the rehabilitation options for treatment of planter fasciitis and the evidence has weighed heavily in favor of using non-invasive modalities before going for the more invasive options.

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