Review Article

Plantar Fasciitis: An Updated Review

CME Credits

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Abstract

Plantar fasciitis (PF) is a common musculoskeletal disease. Histologic findings of patients with PF showed mainly chronic degenerative processes rather than inflammation. In addition to mechanical factors, such as repetitive stress and reduced ankle dorsiflexion, PF is also linked to rheumatologic diseases and genetic factors. Ultrasound is becoming a standard imaging technique for assessing PF. Major sonographic findings included increased plantar fascia thickness and hypoechoic plantar fascia. In addition to traditional B-mode ultrasound, sonoelastography can also be utilized to diagnose PF. Ultrasound can also be used to guide therapeutic interventions. Over 80% of patients with PF improved under nonsurgical treatment. Treatment options for PF include physical therapy, modalities (laser, therapeutic ultrasound), extracorporeal shock wave therapy (ESWT), injections, transcatheter arterial embolization, and surgery. For injections, corticosteroid was mostly used in the past but has been replaced gradually by other techniques such as platelet-rich plasma or dextrose prolotherapy. There is also more and more evidence about ESWT in treating PF. Surgery serves as an option for recalcitrant PF cases, and endoscopic fasciotomy seemed to have good outcomes. Ultrasound plays an important role in diagnosing of PF and evaluating the treatment effect, and the use of sonoelastography in addition to traditional B-mode ultrasound may help in the early detection of PF and assessment of the treatment effect.

Keywords: Dextrose prolotherapy, extracorporeal shock wave therapy, plantar fasciitis, platelet-rich plasma, sonoelastography, ultrasound

Epidemiology

Plantar fasciitis (PF) is the most common cause of heel pain in adults. The incidence of PF was 3.83 cases per 1000 patient years, which was higher in females. The lifetime incidence was about 10%.[1,2] PF may present bilaterally in a third of the cases.[3] The prevalence of PF is estimated between 3.6% and 7% among runners.[4,5]

Pathophysiology

PF was originally thought to be an acute inflammatory disease, but histologic findings of samples from patients undergoing surgery showed myxoid degeneration with fragmentation and degeneration of the plantar fascia, reflecting a chronic degenerative process without inflammation.[6,7] Repetitive stress associated with standing upright and weight bearing may cause microtears in the plantar fascia, and the constant stretching of the fascia results in chronic degeneration, eventually leading to pain during sleep or at rest.[3] In addition, vascular and metabolic disturbances, excessive free radicals, hyperthermia, and genetic factors have also been linked to degenerative change in connective tissues.[8] Degenerative-atrophic changes of the heel fat pad were observed in patients with rheumatoid arthritis (RA) and spondyloarthropathies, which may also contribute to the chronic abnormalities of the plantar fascia.[9]

Risk Factor

A matched case-control study found that reduced ankle dorsiflexion, obesity, and work-related weight-bearing were independent risk factors for PF, and reduced range of ankle dorsiflexion appeared to be the most important one.[10] Others risk factors include pes planus, pes cavus, excessive running, and leg length discrepancy.[11] High prevalence of PF was also found in patients with autoimmune diseases, such as RA.[12]

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Diagnosis

History and physical examination

The typical clinical history of PF includes pain at the inferior and medial heel and is worst with the first few steps out of bed in the morning. Pain often decreases after activities begin, but can worsen at the end of the day. Tenderness may present at the medial calcaneal tubercle.[3] Most patients with PF are unilateral, but up to 30% of cases have a bilateral presentation.[13] The windlass test [Figure 1] have high specificity (100%) but low sensitivity (32%) for PF, which may be helpful in confirming the disease during physical examination.[14]

X-ray

Plain radiography is helpful in ruling out bony lesions. A calcaneal spur is frequently seen on lateral heel radiographs in PF patients. A study found that the prevalence is significantly higher compared with the control group (89% vs. 32%), but the causal relationship needed to be further examined.[15] People with chronic heel pain are more likely to have a calcaneal spur, but the spur remains *in situ* after symptoms resolve.[11]

Ultrasound

Ultrasound is considered a reliable imaging technique for assessing PF. Major sonographic findings included increased plantar fascia thickness and hypoechoic plantar fascia [Figure 2a and b].[16] A review incorporating six ultrasound studies concluded that ultrasound is an effective tool in diagnosing PF, and the mean thickness of PF patients ranged from 4.2 to 6.67 mm.[17] Ultrasound can also be used to rule out other pathology, such as plantar fibroma [Figure 2c]. Ultrasound can also be utilized to guide therapeutic interventions in patients with PF.[18] A review article concluded that ultrasound-guided injection had better therapeutic outcomes than palpation-guided injection, and could avoid damaging the plantar fascia or injecting it into surrounding soft tissue.[19] Ultrasound-guided injection could be done either by in-plane or out-of-plane approach [Figure 3a and b].

Magnetic resonance imaging

Magnetic resonance imaging (MRI) scan is not routinely indicated in diagnosing PF. It is usually reserved for patients with recalcitrant PF or if others pathology is suspected.[20] The major findings of MRI include increased thickness of the plantar fascia and increased signal intensity in the substance of the fascia.[21] In cases of atypical or recalcitrant heel pain, MRI may be helpful in ruling other pathology such as plantar fascia tear, calcaneal edema, or arteriovenous malformation.[22]

Figure 1: Windlass test. The patient stays in a weight-bearing position, and the examiner passively extends the first metatarsophalangeal joint of the great toe. The test is positive if pain is provoked

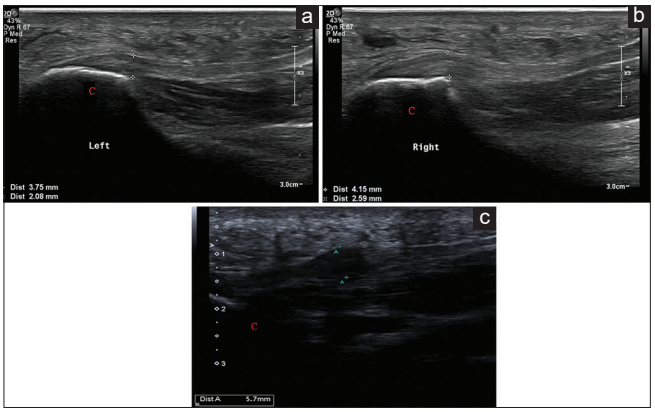

Figure 2: (a) Measurement of the plantar fascia thickness. The thickness is measured at the origin of the plantar fascia at the calcaneus (thickness = 3.75mm). (b) Thickened plantar fascia in a patient with plantar fasciitis (thickness = 4.15mm). (c) A hypoechoic mass was accidentally found in the plantar fascia, compatible with a plantar fibroma. C: Calcaneus

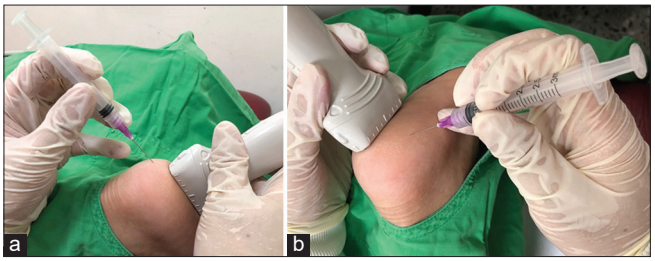

Figure 3: (a) In-plane approach of echo-guided injection to the plantar fascia (b) Out-of-plane approach of echo-guided injection to the plantar fascia

Treatment

Physical therapy

One randomized controlled trial (RCT) assigned 84 patients to stretching or strengthening program, and both groups significantly reduced pain and had improved gait pattern in patients with PF.[23] Another RCT compared plantar fascia–specific stretching protocol to a high-load strengthening program. Both groups improved but the high-load strength training group had a quicker pain reduction and better improvements in function.[24]

Medication

Nonsteroidal anti-inflammatory medications (NSAIDs) are commonly used in treating PF. One RCT randomly assigned patients to either a placebo group or an NSAID

group (celecoxib) in addition to conservative treatment, including heel-cord stretching, heel cups, and night splinting. The results showed that NSAID may increase pain relief and decrease disability.[25]

Night splint

The evidence of night splint in treating PF is conflicting. An RCT concluded that a tension night splint does not lead to significant additional benefits in either pain, function, or flexibility in addition to a structured home program.[26] Another RCT showed no significant improvement of symptoms when a night splint was added to nonsteroidal anti-inflammatory drugs plus Achilles tendon stretching.[27] However, a RCT showed that the application of foot orthoses with adjustable dorsiflexion night splints was more effective than the foot orthoses alone in relieving foot pain in patients with PF.[28] Further studies are needed to determine the role of night splints in the treatment of PF.

Extracorporeal shock wave therapy

Extracorporeal shock wave therapy (ESWT) serves as an option of noninvasive treatment for PF, and it can be divided into focused and radial types. A meta-analysis evaluated 9 RCTs showed that ESWT had higher improvement rates in treating PF than the placebo, and both focus-type and radial-type ESWT were effective.[29] A network meta-analysis in 2018 including 19 trials showed that ESWT induced significant pain reduction compared with placebo both in short term (<6 weeks) and intermediate-term (2–4 months).[30] An RCT showed that patients with thinner plantar fascia experienced less pain after ESWT, and the improvements in pain and function were similar in high-intensity (0.56 mJ/mm^2) and low-intensity (0.12 mJ/mm^2) groups.[31] However, due to high heterogeneity in relevant studies, the optimal regimen of ESWT (including total sessions, density, and intervals) in treating PF is still undetermined.

Low-level laser therapy

Low-level laser therapy (LLLT) utilized the absorption of laser light at the electronic level without the generation of heat. It had been applied in a wide range of treatments, including wound healing, inflammation, and pain reduction.[32] A meta-analysis in 2022 incorporating 14 studies showed that LLLT improved pain in the short term (<6 weeks) and can be considered as a component of care of patients with PF. However, when comparing with ESWT, LLLT did not show greater pain reduction.[33]

Therapeutic ultrasound

There was conflicting evidence about the effectiveness of therapeutic ultrasound in treating PF. An RCT compared therapeutic ultrasound to sham ultrasound and found that therapeutic ultrasound was no more effective than the sham group,[34] while another RCT showed the treated group had significant pain reduction compared to the sham group.[35] Another RCT found no additional benefit of therapeutic ultrasound when added to stretching exercise in treating PF.[36] When compared to ESWT, a meta-analysis incorporating 5 RCTs concluded that ESWT is superior to therapeutic ultrasound in pain reduction and functional improvement.[37] Thus, the role of therapeutic ultrasound is unclear, and further large-scaled trials are warranted.

Injections

Corticosteroids injection

Corticosteroids were thought to treat PF by reducing inflammation, but inflammation was not found in the tissue specimens from chronic PF patients.[6] Other studies found that corticosteroids may treat PF through the mechanism of inhibiting fibroblast proliferation and expression of ground substance proteins, which have been detected in histologic studies of chronic PF patients.[38,39] Abnormal thickening of the plantar fascia may be the result of increased secretion of ground substance proteins such as proteoglycans and subsequent tissue edema.[40]

A RCT published in *BMJ* recruited 82 patients with PF to ultrasound-guided injection of normal saline or dexamethasone. The results showed a single ultrasound-guided dexamethasone injection provided greater pain relief than placebo and reduced swelling of the plantar fascia for up to 3 months.[38] Another RCT comparing steroid injection to radial ESWT found that both interventions caused improvement in pain and functional ability 2 months after treatment, but the inter-group differences were not significant.[41] An RCT comparing foot orthoses and corticosteroid injection showed that corticosteroid injection is more effective than foot orthoses in short term (<4 weeks), but this effect disappeared afterward.[42] A 2018 meta-analysis comparing steroid injection to 4 types of noninvasive treatment concluded that steroid injection tends to be more effective for pain reduction than noninvasive treatments within 3 months.[43] As for the injection site, a trial found that injection deep to the fascia might result in greater reduction in plantar fascia thickness, pain, and disability and improved foot-related quality of life comparing to injection superficial to the fascia.[44] The potential complications of corticosteroid injections include fascia rupture and fat pad atrophy, which were revealed by retrospective studies.[45,46]

Dextrose prolotherapy

Dextrose prolotherapy is a type of regenerative injection and it is postulated that it may decrease pain through the down-regulation of TRPV1 receptor.[47] Dextrose prolotherapy was inexpensive and had been increasingly being used in musculoskeletal disorders.[48] A recent RCT showed that dextrose prolotherapy has comparable efficacy to radial ESWT in reducing pain, functional limitation, and plantar fascia thickness.[49] A meta-analysis in 2022 including 6 RCTs showed that dextrose prolotherapy is effective in reducing pain, improving foot functional score, and decreasing plantar fascia thickness at short-term and intermediate-term follow-up (<6 months) compared to placebo or exercise. However, the long-term effect (>6 months) was unclear.[50]

As for the regimen, the most frequently used concentration of dextrose was 15% and 20%, and the injectate volume ranged between 2 mL to 10 mL at a time. The number of injections ranged between 1 to 3 times at a 1-week to 3-week interval. Due to the highly heterogeneous protocols in previous studies, the optimal regimen of dextrose prolotherapy in treating PF was still undetermined.[50]

Platelet-rich plasma

Platelet-rich plasma (PRP) contains a high concentration of growth factors that promote proliferation, migration, cell differentiation, and angiogenesis, and it had been widely in sports medicine, dental medicine, wound repair, and alopecia with growing evidence of its efficacy in recent 30 years.[51] An RCT allocated patients into 3 groups: injections of PRP, corticosteroid, or normal saline. Both PRP and corticosteroids were more effective in treating chronic PF than normal saline, and there was no significant difference between PRP and corticosteroid groups.[52] A trial comparing dextrose prolotherapy and PRP concluded that both treatments were effective, and there was no statistically significant difference between the two groups.[53] A meta-analysis in 2021 concluded that PRP is superior to corticosteroid injections for pain control at 3 months and lasts up to 1 year.[54] Another recent meta-analysis included only RCTs found no significant difference between autologous blood-derived products and corticosteroids, as measured by pain or function, in short, intermediate, or long-term.[55]

As for PRP versus whole blood, an RCT in 2022 showed that patients with PF improved significantly after either PRP or whole blood injections, with no significant differences seen between two groups.[56] Since PRP has much higher cost than whole blood injections, the pairwise comparison needs further clarification.

Botulinum toxin A injection undetermined

Botulinum toxin A (BTX-A) had been used for the treatment of poststroke spasticity and many chronic conditions. There is emerging evidence that BTX-A also works in PF. A 2022 meta-analysis including only RCTs showed that BTX-A injections resulted in significant pain relief and functional improvement.[57] When comparing with other treatment, an RCT showed the combination of BTX-A and plantar fascia stretching exercises exhibited more rapid and sustained improvement than corticosteroids injection over 6 months.[58] However, BTX-A did not achieve better pain relief when compared with ESWT in another RCT.[59]

Radiofrequency nerve ablation

Radiofrequency nerve ablation (RFNA) of the calcaneal branches of the inferior calcaneal nerve serves as another treatment option in patients with chronic heel pain associated with PF. Several prospective interventional studies showed that RFNA was an effective treatment in treating heel pain associated with PF, especially for those patients who did not respond to other conservative treatment options.[60-62]

Transcatheter arterial embolization

Transcatheter arterial embolization serves as a new intervention for tendinopathy and enthesopathy that are refractory to traditional management. It is hypothesized that chronic pain may partially result from neovascularization and the accompanying neonerves, and embolization may block these pain generators. Okuno *et al*. published case series in various musculoskeletal diseases, and it seemed effective in a case with chronic PF.[63] Further studies are needed to confirm the therapeutic effect in patients with PF.

Surgery

Approximately 80% of patients with PF improve within 12 months with nonoperative therapy.[64] Surgery is usually considered when all nonoperative treatments have failed and the pain became chronic. Endoscopic fasciotomy has become the standard surgical treatment. Compared with the open approach, the patients who had undergone endoscopic plantar fasciotomy had less pain and greater satisfaction.[65] A systematic review and meta-analysis showed endoscopic fasciotomy seemed to have good outcomes, but the grade of recommendation was poor (Grade C) due to a lack of RCT.[66] Potential complications of surgery include plantar arch collapse and scarring of the incision site.[11]

Ultrasound in Evaluation of Treatment Effect in Plantar Fasciitis

Apart from aiding the diagnosis of PF, ultrasound also plays an important role in evaluating the treatment effect. Two studies showed that the reduction in fascia thickness correlated with improvement in pain, and changing the thickness of the plantar fascia is a valid objective measurement to evaluate the effectiveness of treatment protocols.[67,68] In addition to fascia thickness, fascia vascularity also provides substantial information in evaluating the treatment effect. A study revealed that fascia vascularity, as assessed by color Doppler ultrasound, was associated independently with self-perceived pain, and both fascia vascularity and thickness were associated with foot dysfunction in PF patients.[69] In addition, a study utilizing contrast-enhanced ultrasound found that 83.3% of PF patients showed a visible hyperperfusion at the plantar fascia in comparison to the surrounding tissue, which may offer a new diagnostic tool in assessing PF and provide quantitative parameters for monitoring therapeutic effect.[70] A systemic review concluded that ultrasound serves as an accurate, reliable and noninvasive imaging technique for monitoring the effects of different interventions and guiding therapeutic interventions in patients with PF.[18]

Sonoelastography in Plantar Fasciitis

In addition to traditional B-mode ultrasound, ultrasound elastography [Figure 4] can also be utilized to evaluate PF. Ultrasound elastography has been utilized widely in musculoskeletal diseases in the past two decades. The

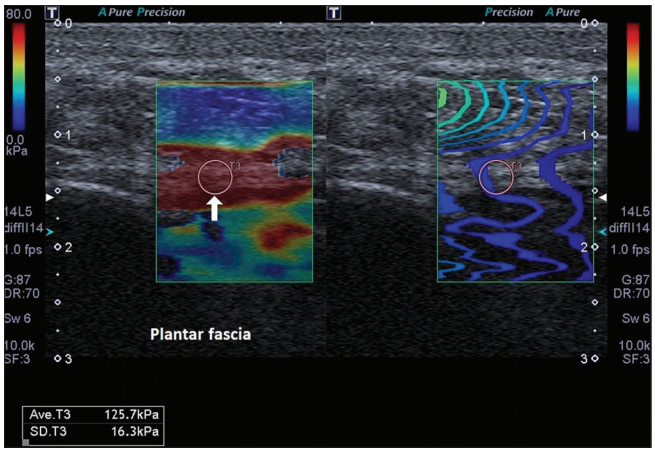

Figure 4: Elastography of the plantar fascia

mechanical property of tissues is evaluated by its response to stress.[71,72] Two major techniques are used in musculoskeletal elastography, including compression elastography and shear-wave elastography (SWE).[71] Sonoelastography provides important diagnostic information beyond B-mode, with typically lower tissue stiffness in symptomatic plantar fascia.[73]

There is emerging evidence that sonoelastography works in diagnosing PF. A study in 2021 using SWE showed that plantar fascia stiffness decreased in patients with PF and served as an independent factor in diagnosing PF.[74] Studies utilizing compression elastography also revealed that the plantar fascia softens with age and in subjects with PF, and elastography may detect PF earlier than traditional B-mode ultrasound[75,76] Another study in 2022 revealed that SWE improved the diagnostic accuracy of gray-scale ultrasound in PF and served as a good supplementary tool in diagnosing PF.[77] Besides, a 12-month longitudinal follow-up study of ESWT in treating PF showed that PF stiffness increased after treatment along with the reduction of pain, indicating the potential role of elastography in evaluating the treatment effect of PF.[78]

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patients have given their consent for their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal identity, but anonymity cannot be guaranteed.

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Conflicts of interest

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