

# Physical Therapy Interventions for Plantar Fasciitis: A Review Article

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**Abstract**— *The most common cause of non – traumatic pain in ankle –foot complex is plantar fasciitis. It has been shown that various invasive and non invasive treatment methods are successful as biomechanically considered treatment procedures. Furthermore, noninvasive treatment procedures which are aiming muscle restoration, bony and articular structures, optimal alignment, enhancing vascularization, and improvement of proprioceptive parameters have been reported in the literature. This article presents a review of physiotherapy interventions in conservative management of plantar fasciitis together with the results from the literature.*

**Keywords**— *Plantar Fasciitis, Physical Therapy, Conservative Management.*

## I. INTRODUCTION

Plantar fascia comprises of three bands of dense connective tissue [1]. The posterior tuberosity of calcaneum has two processes as medial and lateral. Medial process has attachments to the Flexor digitorum brevis, Abductor hallucis, and the medial head of Quadratus plantae, and the central band of plantar fascia. The plantar fascia has a fibro cartilaginous attachment to the calcaneum and the central band is constant along with lateral and medial bands. Abductor hallucis has an attachment to the medial part of plantar fascia while the musculus abductor digiti quinti pedis is attached to the lateral part of the plantar fascia. The central band is divided into five separate strands at the mid tarsal level. These five strands are inserted to the each proximal phalanges [2, 3]. Metatarsophalangeal joints dorsiflexion can be seen during walking. The plantar fascia is getting tighten according to the windlass mechanism [4]. All five strands help to raise the foot arch. The plantar fascia and osseous longitudinal arch of the foot together form a triangular truss. Plantar fascia prevents collapse and separation of foot arches during weight bearing [3].

Plantar fasciitis is a result of a chronic degenerative process in the plantar aponeurosis of the foot and one leading cause of the heel pain [5, 1]. It can be referred as heel spur syndrome, plantar heel pain and painful heel syndrome [6]. Plantar fasciitis prevalence rate is approximately 11%-15% among adults while it accounts 8% -10% of all injuries among athletes who engaged in running related sports events [7, 8, 9, 10]. Plantar fasciitis can be seen among both sedentary and athletic populations. People aged between 45 to 65 years are the most vulnerable group to develop the condition while women are more prone to suffer this condition compare to men [11, 12]. It is an enthesopathy of the plantar fascia origin at the medial tubercle of the calcaneus due to overuse or

repeated trauma [13, 14, 15]. Foot and arch problems like high arch, flat foot, limited dorsi flexion range of motion and foot wears with poor arch support like flip flops or soft soles can cause mechanical imbalance in foot [16,17]. Prolonged standing, walking running, heel spurs, tight achilles tendon, leg length discrepancy and sudden changes in activities like start a new running programme and changing foot wear can cause repeated micro trauma to the plantar fascia [18, 19, 20, 21, 22]. There is twofold increased risk to develop plantar fasciitis among people with body mass index more than 25 kg/m<sup>2</sup> compare to people with lower body mass index. Pregnancy, sudden weight gain, over weight and obesity are major risk factors to develop plantar fasciitis [23]. Diabetes mellitus, inflammatory arthritis conditions, osteoarthritis, and hypothyroidism are other risk factors which can cause plantar fasciitis [24, 25, 26].

Plantar fasciitis can diagnose clinically based on patients complaints and physical examination. Commonest symptom is pain and discomfort in the inferomedial heel area of the heel which can be aggravated by weight bearing after a period of non weight bearing or inactivity [27, 28]. Pain on first step in the morning is prominent diagnostic feature. Pain is aggravated following the dorsiflexion of the patient's pedal phalanges [29]. Pain is getting resolved with increasing activity but tend to increase again at the end of the day [30]. Limited dorsiflexion of the great toe and ankle [13, 31] and tenderness in palpation [32] are other common symptoms. According to the histological findings there are marked thickening and fibrosis of the plantar fascia along with collagen necrosis, chondroid metaplasia and calcification [33, 34]. Plantar fasciitis is a usually unilateral, but bilateral presentation can be seen up to 30% of the cases [13].

Usually, this condition resolves itself and most of the cases need only conservative management [35, 36]. But this self limiting period is varied up to 3 to 18 months or longer which can affect the patient quality of life adversely [37]. 10% to 20% of patients may develop chronic heel pain and require surgical treatments [5]. Surgery should be performed only for patients who have not responded to conservative management over 6 to 12 months [38]. Common surgeries are open plantar fasciotomy, resection of the heel spur if present and release of the abductor hallucis fascia [32, 33].

Physiotherapy interventions are considered as main stream conservative treatment approaches for the plantar fasciitis. It includes stretching exercises, strengthening exercises, night splints, orthoses, taping, dry needling, extracorporeal

shockwave therapy and manual techniques like joint mobilization, massage and myofascial trigger point release.

## II. STRETCHING

Conservative treatment methods are cornerstone in the management of plantar fasciitis. Among those conservative methods stretching of the plantar fascia and calf muscles are reported as an effective treatment method in literature [30, 39]. Both sustained and intermittent stretching exercises are proven to be effective in improving ankle and foot function as well as to reduce the pain sensation [40]. Some studies demonstrated that plantar fascia specific stretching methods may provide better improvements compare to achilles tendon stretching [41]. Positive outcomes can be seen with both plantar and achilles tendon stretching exercises together [30]. Achilles tendon and plantar fascia are structures which connected together by myofascial meridian of the superficial back line [42] and there may be a greater effect on pain relief and ankle and foot function improvements in plantar fasciitis patients when there plantar fascia and achilles tendon stretching applied together.

Digiovanni et al., (2003) conducted a research study to evaluate whether plantar fascia specific stretching exercises can improve the outcomes of chronic plantar fasciitis patients. 101 patients enrolled in the first phase of the research and all participants were given prefabricated full-length soft insoles, three weeks treatment with celecoxib and showed an educational video about plantar fasciitis. They were divided into two groups as plantar fascia tissue stretching group and achilles tendon stretching group. They were advised to use their regular shoe wears and maintain the normal activity level during the treatment period. Plantar fascia stretching exercises were done in seated position. They were instructed to cross the affected leg over the unaffected leg and applied the force distal to the metatarsal joints to pull the toes towards the tibia until patient felt the stretch over the sole of the foot. Free hand used to palpate the tension in the plantar fascia. They were asked to stretch plantar fascia before taking the first step in the morning. achilles tendon stretching group were instructed to do exercises in standing position and leaning towards the wall with placing the affected leg behind the unaffected leg. They were asked to keep the shoe insole under the affected leg to control the excessive midfoot pronation with stretching exercises. Then to bend the unaffected leg while keeping the knee of the affected leg straight and sole of the foot on the ground. They were instructed to do their first stretch as soon as they got down from the bed in the morning. Both groups had to perform exercises 3 times per day while maintaining the stretching force for 10 seconds with 10 repetitions at once for 8 weeks period. Before and after the treatments they filled the pain subscale of the Foot Function Index and activity level questionnaire. After the analysis of data they found the pain subscale of the Foot Function Index showed significantly superior improvements in group which were treated with plantar fascia stretching protocol. Also there were significant improvement in activity level and patient satisfaction in plantar fascia stretching group compare to the other group. According to the findings they concluded non weight bearing

plantar fascia stretching protocol has better improvement compare to weight bearing achilles tendon stretching protocol in patients with proximal plantar fasciitis [41].

Radford et al., (2007) conducted a research study to evaluate short term effectiveness of calf muscle stretching on plantar heel pain. Total 92 participants assigned into interventional group who received calf stretching and 3 minutes sham ultrasound while control group only received 3 minutes sham ultrasound. Interventional group was provided with a wooden stretching wedge. Participants had to perform the stretching exercises in standing position. They were asked to move their forefoot up the wedge until they felt a stretch in the calf muscles while they kept their heel on the ground. They performed stretching exercises 5 minutes each day for 14 days. They assessed outcomes at base line and after 14 days. They measured first step pain in the morning using the 100mm visual analogue scale and the Foot Health Status Questionnaire as primary outcome measures. Secondary outcome measures which they used were lunge test - measure the weight bearing ankle dorsiflexion range and the Foot Posture Index – measure the foot posture. According to the results both treatment and control groups were improved but there was no any statistically significant difference between groups in regard to the measured outcomes. They concluded that the two weeks calf muscle stretching protocol was not provided any statistically significant improvement in plantar heel pain sensation, foot function and general foot health [43].

Engkananuwat, Kanlayanaphotporn and Purepong, (2017) have assessed the effectiveness of stretching of plantar fascia together with achilles tendon as a treatment option for plantar fasciitis. 50 patients with unilateral plantar fasciitis were included in their study. Participants were divided into two groups as group 1: achilles tendon stretching group and group 2: simultaneously stretch both achilles tendon and plantar fascia. Group 1 instructed to do achilles tendon stretching as described in Digiovanni et al., (2003) [44]. Group 2 instructed to stand on a specially designed instrument to stretch the plantar fascia and achilles tendon simultaneously. Instrument was consisted with two wooden bases covered with a Bene feet mat. It contained short flexible spikes in the front and back and long flexible spikes at the middle. It was equipped with a motor and goniometer. This technique facilitated the stretching of plantar fascia and achilles tendon. Both groups were asked to perform five repetitions of stretching of each repetition with a holding time of a 20 seconds followed by a 20 seconds rest time. They performed stretching exercises twice a day and continued 5 days for week up to 4 consecutive weeks. Group 2 exhibited a greater improvement in pressure pain threshold compared to group 1 following a 4 weeks of treatments. Both groups displayed a significant improvement of the pain perception of the first step in the morning and pain around the medial plantar calcaneus within 24 hours. Improvements were reported with visual analogue scale, foot and ankle score and dorsiflexion range in ankle. Most of the patients in group 2 informed that their symptoms were greatly improved compared to group 1. They suggested simultaneous stretching of plantar fascia and achilles tendon is much more effective than only achilles tendon stretching [44].

Özer et al., (2015) has done a research study to evaluate effectiveness of plantar fascia specific stretching exercises in plantar fasciitis. 29 patients without any history of previous heel surgery were asked to perform non weight bearing plantar fascia specific stretching exercises with 10 repetitions, two times a day. Silicon heel pads and non steroidal anti inflammatory drugs were given to the patients. Patients were asked to follow the exercise regime regularly for 8 weeks time. Visual analogue scale was used as the outcome measure. According to the results, there was a significant difference between pre and post visual analogue scale scores and they concluded that the plantar fascia specific stretching exercises are effective in management of plantar fasciitis [45].

Sweeting et al., (2011) has done a systematic review on the effectiveness of manual stretching in the treatment of plantar heel pain. Six studies were used to review process. According to their review, limited numbers of studies are available, which evaluate the effectiveness of stretching exercises compared to other treatment options or to a control group. Some evidences advocate that the plantar fascia stretching is far superior to the achilles tendon stretching in short term. More randomized trials are needed to confirm the findings and to assess the effectiveness of stretching as a treatment method of plantar heel pain [46].

### III. HIGH LOAD STRENGTH TRAINING

Eccentric muscle loading has become highly effective conservative treatment strategy for the achilles and patellar tendinopathy with promising results [47, 48, 49, 50]. Also High-load strength training is able to cause high tensile loads across the tendon and cause positive effects on the degenerative tendon disorders like patellar and achilles tendinopathy [51].

Plantar Fascia is a structure consisted with collagen type 1 fibers. High load strength training is able to increase the collagen type 1 synthesis and it is helpful to normalize the structure of the tendon and improve the signs and symptoms of plantar fasciitis [52]. Decreased ankle dorsiflexors strength is one common symptom in plantar fasciitis. High load strength training can improve the ankle dorsiflexors strength [53, 54].

It is difficult to create high-load tensile forces on plantar fascia alone. In research studies, most of the time achilles tendon loading was used along with the windlass mechanism to create high load tensile forces on plantar fascia. There is a close anatomical inter connection between achilles tendon, paratendon, and the plantar fascia [55]. Because of this the high loading of the achilles tendon with activation of windlass mechanism can transfer the high load tensile forces to the plantar fascia [56, 57].

A research study had done by the Rathleff et al., (2014) used unilateral heel raises exercise with a towel under the toes to enhance the windlass mechanism. Participants were instructed to do the exercise on the stair case or a similar location. Each participant had individualized towel with the purpose of that the participants had their toes maximally dorsal flexed at the top of the each heel rise. There were three phases in the heel rise as 3 seconds concentric phase, 2

seconds isometric phase and finally 3 seconds eccentric phase. 12 repetitions maximum (RM) for three sets was the starting load and they slowly progressed the load by using a back pack filled with books. 10 RM with four sets was the exercise protocol after 2 weeks and it was progressed to 8 RM with 5 sets after 4 weeks. If participant was unable to perform desired protocol they were instructed to use both legs to perform exercise until they were strong enough to do the unilateral heel rise with desired load. They have followed the protocol for three months. The main purpose of the research study was to evaluate the effectiveness of shoe inserts and plantar fascia-specific stretching vs. shoe inserts and high-load strength training. They used foot function index (FFI) as an outcome measure. Participants who had undergone high load strength training showed more satisfaction towards the treatment and greater improvement in FFI at the end of the 3 months [58].

Another research study has done by Caratun et al., (2018) by modifying the high load strength training protocol which was originally did in the Rathleff et al., (2014). They recommended doing all exercises daily with a rolled-up cotton T-shirt rather than a towel for three months period or until the cessation of the pain sensation. There were 3 phases which included 5 seconds concentric phase, 3 seconds isometric phase and finally 5 seconds eccentric phase. Participants were instructed to perform 10 repetitions of heel raises against their own body weight for first 4 weeks. Then the participants were instructed to progress the heel raises with 10 RM load daily until they complete 3 months period. They concluded that the modified exercise regime was highly effective to relieve signs and symptoms of the plantar fasciitis [59].

### IV. NIGHT SPLINTS

Night splint is one of the common conservative treatment methods for plantar fasciitis [60]. Thermoplastic is the common manufacturing material of the night splints. It can maintain the foot in neutral or slightly dorsiflexed position at night. It can enhance the flexibility of plantar muscles and calf muscles. It can reduce the tension stress over plantar fascia which can feel first few steps in the morning [61, 62, 63]. It helps to reduce the heel pain due to plantar fasciitis. Some studies found treatment effect of the night splints were similar to customized and off-the-shelf foot orthoses [64]. But some studies suggest night splint application could cause additional pressure over the malleolus area and posterior aspect of the heel and it can lead to reduce the quality of sleep [65] and ultimately it can adversely affect over the treatment outcomes [66].

Lee et al., (2012) conducted a research study to assess the effectiveness of adjustable dorsiflexion night splint in combination with accommodative foot orthosis with 28 patients who were having plantar fasciitis. They were divided into two groups as A and B. Group A received only foot orthosis and group B received foot orthosis and dorsiflexion night splint. Orthosis was made from Poron material. Dorsiflexion night splint was able to maintain ankle in 5 degrees dorsiflexed position. Foot Function Index was used as an outcome measure and it was filled by the patient just prior to the first treatment and again at the 2nd and 8th weeks of the

treatment. According to the results pain was significantly reduced in group B compared to group A in 8 weeks time. Also total score of the Foot Function Index is significantly lower compare to group A within the same time period. Researchers suggested that there is an additional benefit when both dorsiflexion night splints and foot orthosis used together compared to orthosis alone for plantar fasciitis [67].

Wheeler, (2017) has conducted a single blinded randomized controlled trial to assess any improvements in pain or function after the usage of tension night splint with 40 chronic plantar fasciitis patients. Patients were divided into 2 groups as interventional and control group. Interventional group received both tension night splint and home exercise programme while control group only received home exercise programme. Home exercise programme was consisted of gastrocnemius, soleus, flexor hallucis longus, hamstring stretching exercises, and plantar fascia static stretch techniques, calf and intrinsic foot muscles strengthening exercises, and balance training exercises. They were taught to do exercise in optimal manner and how to progress based on their improvements. In addition to that interventional group received LA brace, plantar fasciitis night splint with instruction of proper usage. Data were collected using structured questionnaires before the treatments, and 6 weeks and 3 months after the treatments. They collected data about pain sensation, local function, anxiety and depression symptoms, and sleep quality. They used short form version of the International Physical Activity Questionnaire and two vital signs physical activity questions to data collecting purpose. In addition to that they measured passive ankle dorsi flexion range while patient was in prone position using a hand held goniometer and knee to wall distance was measured to assess flexibility in a more functional position. Plantar fascia thickness was recorded using musculoskeletal ultrasound. According to the results there was an improvement in pain and local function after 3 months follow up but interventional group responded quicker than the control group to the treatments and show improvements even in 6 weeks follow up. However, patients were complaining about ongoing pain symptoms. Researchers concluded that the usage of tension night splint can assist to relieve the symptoms of plantar fasciitis and there is a need of further studies to clarify the findings [68].

Probe et al., (1999) has performed a prospective randomized study to assess the effectiveness of adjuvant night splint therapy to relieve acute symptoms of 116 patients with plantar fasciitis. Interventional group received a dorsiflexion night splint for 3 months period with 1 month of oral anti inflammatory medication, achilles stretching exercises, and shoe recommendations. Control group received other same treatments except dorsiflexion night splint. Health status data Short Form 36 used to collect data. According to the results, there is a significant improvement of Short Form 36 scores with treatments for 3 months in both groups. They concluded there was no any difference in outcomes of treatment between interventional and control groups [69].

Wapner and Sharkey, (1991) have conducted a case series with 14 patients. They provided custom-molded

polypropylene ankle foot orthoses in 5 degrees of dorsiflexion to be used as a night splint and suggested night splint usage can be a useful and cost-effective treatment method for plantar fasciitis [70].

Landorf K, (2015) conducted a systematic review on plantar heel pain and plantar fasciitis. They evaluated 12 interventions related to plantar fasciitis. They assessed the short and long term effectiveness and safety of corticosteroid injection alone, short and long term effects of corticosteroid injections with local anesthetic injection, customized foot orthoses, extracorporeal shock wave therapy, heel pads and cups, local anesthetic injection alone, night splints, stretching exercises, surgery, and taping. They concluded that there was uncertain evidence regarding effectiveness of the night splint usage in plantar fasciitis [71].

## V. LOW DYE TAPING

Low dye taping is a common conservative treatment method for plantar fasciitis. It has an ability to change the mechanical function of the foot and relief the signs and symptoms of plantar fasciitis by reducing the stress over the plantar fascia [72]. Usually low dye taping is applied from first metatarsal head to fifth metatarsal head transversely. Second tape is applied from lateral side of the fifth metatarsal head to medial side of the first metatarsal head in U shape. Another U shape tape is applied covering 2/3 of the first U shaped tape. Finally another tape is applied to along the metatarsal heads transversely [73].

Landorf et al., (2005) has done a research study to evaluate effectiveness of low dye taping for the short term management of plantar fasciitis. 105 patients were divided into experimental group (65) and control group (40). Both groups were advised to perform calf stretches and to wear proper footwear. Experimental group received their low dye taping treatment using 3.8cm wide Leuko sports tape at the first appointment and advised to keep it for 3 to 5 days. Both groups were asked to mark their pain perception prior to the treatments and 3 to 5 days after the initial assessment. A 100 mm visual analog pain scale was used as the primary outcome measurement and a verbal response question with four definitive responses was used as the secondary outcome measurement. According to the results, visual analog pain scale scores were improved by mean 20 mm in experimental group while they were worsened by mean 6mm in control group. 63.1% of the experimental group responded as taping and stretching was very much useful to relieve their pain. They concluded low dye taping is highly effective to relieve pain in plantar fasciitis in short term [77].

Chae et al., (2018) has done a research study to measure the clinical and biomechanical effects of low dye taping and to assess the figure 8 modification of low dye taping in patients with heel pad atrophy. They found low dye taping was a clinically effective method to reduce pain perception and peak plantar pressure in hind foot in patients with heel pad atrophy, while the figure 8 modification of low dye taping was superior to the original low dye taping method to relieve pain and peak plantar pressure [73].

Radford et al., (2006) has conducted a randomized trial to

evaluate effectiveness of low dye taping for the short term treatment of plantar heel pain. 92 patients were recruited for the study and first group receive low dye taping with sham ultrasound while second group received only sham ultrasound as a treatment. They follow up the patients for one week period and measured first step pain using visual analogue scale. Foot pain, foot function and general foot health estimated using Foot Health Status questionnaire. According to the results there was a slight improvement in first step pain of the taping group, but it was not statistically significant compare to control group [75].

Park et al., (2015) has done a study to investigate the effects of the application of low dye taping on the pain and stability of patients with plantar fasciitis. 30 participants were divided into two groups as low dye taping (15) and conservative treatment group (15). Experimental group received 30 minutes Transcutaneous Electrical Stimulation (TENS), 5 minutes infra red treatment and modified low dye taping application. Conservative group only received TENS and infrared treatments. Patients underwent these treatments for 3 times per week for 6 weeks. Visual analogue scale used to assess pain sensation and a BioRescue device was used to assess the stability by measuring the transfer area of the center of gravity (TAOCOG). There was a significant improvement of pain perception in both the groups. They observed pain improvement was better in taping group compared to conservative group. As well as TAOCOG value improvements were higher in taping group compared to conservative group. They concluded low dye taping as an effective method to decrease the pain and to improve the stability in patients with plantar fasciitis [76].

Ranjan et al., (2016) has conducted a study to find the role of low dye taping as a short term treatment of plantar fasciitis. 56 patients included to the study and low dye taping was applied for one week time. First step pain was measured using visual analogue scale and Foot Health Status questionnaire used to evaluate foot pain, foot function and general foot health. After one week follow up, there was a significant reduction in pain and improvements in Foot Health Status. Few patients developed adverse events like allergic reaction to tape and too tight tape application. Their final conclusion was low dye taping is an effective short term treatment method for plantar fasciitis [77].

## VI. DRY NEEDLING

Dry needling is a novel and common treatment method used by physiotherapists [78, 79] mostly for musculoskeletal disorders like knee pain [80], lower back pain [81], neck pain [82] and shoulder pain [83]. It is a less invasive treatment method which targets myofascial trigger points [84]. Exact etiology is unclear for the plantar fasciitis and one suspected cause is occurrence of myofascial trigger points in the intrinsic muscles in the foot and proximal muscles to the foot [85]. Myofascial trigger point can be defined as a hyperirritable spot in the skeletal muscle and is associated with a hypersensitive palpable nodule in a taut band and may result in characteristic referred pain, tenderness, motor dysfunction, and autonomic phenomena [86]. A fine filament needle is inserted into the

trigger point [87] and it has an ability to change the biochemical environment around the trigger points and reduces spontaneous electrical activity within the trigger points of the skeletal muscles [88]. He and Ma, (2017) have done a meta analysis which analyzed seven randomized control trials to evaluate effectiveness of the dry needling for plantar fasciitis and they concluded dry needling as an effective method to reduce pain which arise due to plantar fasciitis [89].

Rahbar et al., (2018) has conducted a randomized control trial to compare the efficacy of dry needling and extracorporeal shockwave therapy for plantar fasciitis. They evaluated 72 patients with plantar fasciitis. All participants were instructed to do stretching exercises and stop the usage of nonsteroidal anti-inflammatory medications during the treatment period. Patients were positioned in supine position to facilitate needle entering. 18-gauge needle was used and it was taken out a little and re entered to get the desired response. When this procedure was failed to make the desired response they were stopped the procedure and kept the needle in place until it produced appropriate response. The movement of the needle continued until the muscle twitch stopped and when it stopped they kept the needle still for five minutes before removing it. Usually moving point located on the medial side of the foot and it was found by an experienced physicians and physiotherapists. 30 minutes treatment session was given and in case of failure, three sessions were performed. In shock wave they were given 3 sessions once a week and for treatment they used radial shock wave machine with impulse intensity of 2000, energy flux of 0.25 and frequency of 10 Hz. They evaluate the outcomes of the treatment in three times using visual analogue scale and foot function scale. There were significant pain intensity reduction and improvement in the foot function scale in the dry needling group compared to shock wave therapy group at the end of the eight week follow-up [90].

Eftekhar-Sadat, Babaei-Ghazani and Zeinolabedinzadeh, (2012) have done a single-blinded randomized clinical trial on dry needling treatment for chronic heel pain due to plantar fasciitis. There were 20 patients involved in the study and they were divided into two groups as interventional group and control group. All patients were instructed to follow stretching exercises, plantar cold massage and calf muscle massage at home. Also patients were given 50 mg diclofenac sodium to be used once in a 12 hours and an orthostatic plantar pad. Interventional group received dry needling treatment one session for four weeks continuously. They used a dry needle with the length of 30-50mm and diameter of 0.6mm to needle the four myofascial trigger point in the gastrocnemius muscle [91]. During the treatment session patient was lying flat and followed the same procedure described in Rahbar et al., (2018) [90]. One treatment session was lasted up to 30 minutes. They assessed the outcomes of the treatment in three times. Pain intensity was measured using visual analogue scale. Range of motion of the ankle plantar flexion and dorsi flexion was measured. Foot function index was evaluated using a validated questionnaire. The questionnaire consisted was with 7 and 5 scores respectively for minimal detectable changes (MDC7)

and standard error measurement (SEM5). There was a significant improvement in the pain intensity in interventional group compared to control group after 4 weeks. There was no any significant difference in ankle dorsi-flexion and plantar flexion among two groups. After four weeks scores of the (MDC7) and (SEM5) were significantly lower in interventional group compared to control group [91].

Cotchett et al., (2011) conducted a randomized control trial to assess the effectiveness of trigger point dry needling for plantar heel pain with 80 patients (40 for each group) who were assigned to two groups as real dry needling and sham dry needling using a simple block randomization procedure. Patients with bilateral pain treated for both legs [92]. Myofascial trigger points were identified using list of observations and list of essential criteria [85]. Flat palpation or pincer palpation was used to palpate the trigger point according to muscle anatomy [78]. Real dry needling group received dry needling treatment according to the protocol explained in Rahbar et al., (2018) [90]. They used non penetrating acupuncture needles according to the procedure described by Tough et al., (2009) to sham dry needling group and needle was sterilized before each treatment [93]. Sham needle with its guide tube placed over the skin of the trigger point and needle was tapped. Guide tube was removed and needle was moved up and down for six to seven times. They removed the needle after five minutes by placing a finger on either side of the point treated. Both groups had 6 treatment sessions once in a week and one session lasted up to 30 minutes. A modified pain-monitoring model used to measure the activity level of the patient during the treatment period. It was used to guide the rehabilitation of patients with achilles tendinopathy [94] and patellofemoral pain syndrome [95]. Patients were allowed to do perform any exercises which pain sensation not exceeds 5 of the visual analogue scale. Primary outcomes were measured in base line and after 2, 4, 6 and 12 weeks. The pain subscale of the Foot Health Status Questionnaire (FHSQ) and visual analogue scale (VAS) were taken as primary outcomes. First step pain severity was measured using VAS. They used 6 weeks as the end point to measure the effectiveness of the dry needling for plantar fasciitis. Secondary outcomes measured in baseline, 6 and 12 weeks. Foot Health Status Questionnaire (FHSQ), short form-36 (SF-36) - health related quality of life and Depression, Anxiety and Stress Scale short version (DASS-21) were used as secondary outcomes. Both groups showed pain reduction after 6 weeks time but there was a significant improvement in pain in the real dry needling group compared to sham dry needling group. There was no significant different between two groups in health related quality of life and Depression, Anxiety and Stress Scale short version after 6 and 12 weeks. Needle site adverse effect complains were more in the real dry needling group compared to sham dry needling group. They concluded dry needling is an effective treatment method to treat plantar heel pain [92].

Al-Boloushi et al., (2019) conducted a randomized control trial with total 94 patients. They were assigned to two groups as dry needling group and percutaneous needle electrolysis group. Both groups received one treatment session per week

over 4 weeks. Initially all participants were instructed to follow self stretching programme. Then a needle was inserted to the identified myofascial trigger point and manipulated the needle in a manner described by Hong, (1994). An electrotherapy modality which produces continuous galvanic current was used in percutaneous needle electrolysis group. It transmitted the current through the needle to the trigger point with 1.5 mA intensity. Primary outcome measure was Foot Health Status Questionnaire and it was measured at baseline and at 4, 8, 12, 26, and 52 weeks post-treatment. Secondary outcome was pain intensity which patient experienced during previous 48 hours. It was measured using visual analogue scale at baseline and at 4, 8, 12, 26, and 52 weeks post-treatment. They assessed quality of life using EuroQoL-5 dimensions (EQ-5D) [96]. Percutaneous needle electrolysis has ability to promote regeneration of injured tendons [97, 98]. But more research studies should be conducted to find out the additional effects of percutaneous needle electrolysis over only dry needling treatment in plantar fasciitis.

Dunning et al., (2018) conducted a research study on electrical dry needling. 111 patents were assigned to two groups. One group received electrical dry needling, manual therapy, exercise, and ultrasound therapy. Other group received manual therapy, exercise, and ultrasound therapy. Treatments were given for 4 weeks and re-assessments were done at 1 week, 4 weeks, and 3 months after first treatment. Both groups received 6 sessions of manual therapy, self stretching protocol for plantar and achilles tendon stretching, foot intrinsic muscle strengthening exercise and therapeutic ultrasound. Electrical dry needling group received of electrical dry needling using a standardized 8 point protocol for 20 minutes for 6 sessions. Their primary outcome was first-step pain in the morning and it was measured using Numeric Pain Rating Scale. Resting foot pain, pain during activity, the lower extremity, pain during activity, the Lower Extremity Functional Scale, the Foot Functional Index, medication intake, and the Global Rating of Change were used as secondary outcomes. They concluded electrical dry needling with exercise, manual therapy and ultrasound is more effective in pain reduction in plantar fasciitis compared to only exercise, manual therapy and ultrasound approach [99].

El Mallah, Elattar and Zidan, (2017) have conducted a research study with 30 patients with unilateral plantar fasciitis. One group received one injection of Platelet-rich plasma to the plantar fascia and other group received dry needling treatment to the myofascial meridians trigger points on their superficial back line. Their conclusion was both treatment methods are effective in pain reduction in plantar fasciitis and Platelet-rich plasma has encouraging results [100].

## VII. EXTRACORPOREAL SHOCK WAVE THEORY

The Extracorporeal shock wave therapy is the use of externally applied acoustic shock waves which was initially used for treat of calculi in the urinary, renal, biliary, and salivary systems. Then it evolved with various forms of shock wave therapies targeting musculoskeletal disorders including plantar fasciitis [101].

In ESWT, electrohydraulic, piezoelectrical and electromagnetic processes produce shock waves. Due to its non-invasive nature, rapid recovery, and comfort for patients' daily lives, extracorporeal shock wave therapy (ESWT) has been commonly used as an alternative treatment choice for PF for decades [102]. The exact mechanism of ESWT in the management of musculoskeletal pain remains unclear; however, numerous studies have shown that it may disrupt sensory non-myelinated nerve fibers and induce neovascularization and production of collagen in degenerative tissues [103]. As treatment options for PF, both centered shock wave (FSW) and radial shock wave (RSW) treatments have recently been introduced. RSW spread from the applicator is not tissue-focused relative to FSW [104]. The radial technique can be used to treat the painful region instead of a point, and an advantage of RSW therapy is extended treatment area [105,106]. The function of ESWT in relieving heel pain has been demonstrated by several studies. There have been positive and negative results, however. However, Speed et al [107] and Marks et al [108] found no significant difference between ESWT and sham therapy.

Buchbinder et al., (2002) evaluated 166 patients with general pain, morning pain, pain during activity, ability to walk, and two types of scoring as primary and secondary outcome measures. However, no statistically significant difference was recorded between the ESWT and placebo groups. This finding is contradicted with most other similar studies, which displayed a consistent and significant improvement with ESWT compared to control [109]. Two major differences can be identified in the protocols used by Buchbinder when compared with Rompe's protocols [110]. Patient inclusion was allowed with a minimum duration of symptoms of 6 weeks. Most of other studies included patients with 26 weeks to 52 weeks of minimum duration of symptoms. As the spontaneous resolution of plantar fasciitis among most patients can be expected within 52 weeks of diagnosis, six weeks is considered as a short duration in regard to this condition. Ultrasound-confirmed plantar fascia thickening was used to include the patients in the study. However, these findings can be also seen among asymptomatic individuals. This criterion was not used in other similar studies. Rompe used patient feedback to determine the point of maximal tenderness of the heel for applying the shock waves while, Buchbinder used ultrasound-guided procedure to identify point of maximal thickening of the plantar fascia without concerning point of maximum tenderness [109].

Ogden et al., (2002) conducted a meta-analysis on effectiveness of ESWT for chronic plantar fasciitis. They included 8 studies out of twenty published articles according to the minimum inclusion criteria. Their analysis shows that the direct application of shock waves to plantar fascia entheses at the lower calcaneus is a safe and effective non-surgical approach for the treatment of refractory plantar fasciitis. They recommend that the use of ESWT should be weighed before surgery and that ESWT may be superior to cortisone injection, which can rupture the plantar fascia and lead to regular recurrence of symptoms [110].

Chung and Wiley (2002) reviewed 60 abstracts, 25 case series, and 40 randomized controlled trials using ESWT for supraspinatus tendinitis, patellar tendinitis, lateral epicondylitis, and plantar fasciitis. According to their conclusion, although there was no identified clear mechanism for ESWT to function, the pain-relieving effect of shock waves on tendinopathies was reliably reported in the published literature in both case series and prospective, randomized, placebo controlled trials. With ESWT, there are no records of serious adverse effects. There is debate about particular ESWT protocols with respect to energy density, number of sessions and the use of high and low energy devices [101].

## VIII. MANUAL THERAPY

Various types of manual therapy techniques are available to treat the plantar fasciitis. Joint mobilization and soft tissue mobilization (deep tissue massage and myofascial release) are common manual therapy techniques. Joint mobilization helps to enhance the range of motion, and to reduce the pain swelling, restriction and inflammation (111). Myofascial release is used to restore the optimal length, reduce pain and improve activities. A low load and long duration stretch is applied to the myofascial complex in myofascial release technique (112).

Shashua et al., (2015) has done a randomized control trial with 46 patients to assess the effect of additional ankle and midfoot mobilizations on plantar fasciitis. There were two groups in the study and all have completed a baseline assessment. Interventional group received stretching exercise programme for plantar fascia and triceps surae muscles. Patients were asked to perform 2 sets, lasting 30 seconds, three times per day in all exercises throughout the treatment period. Therapeutic ultrasound to the most tendered area was done with frequency of 1 MHz, 1.5 W/cm<sup>2</sup>, 50% pulses for 5 minutes. A manual therapy regime provided with anterior and posterior talocrural mobilization with both weight bearing and non weight bearing status to improve dorsiflexion, subtalar joint mobilization to improve inversion and eversion, and mid tarsal mobilization to improve pronation and supination of the midfoot. All mobilizations performed for 1 to 1.5 minutes with total 5 minute session. Control group received all other treatments except manual therapies. Both groups received 8 sessions within 4 weeks time. Numeric pain rating scale, Lower Extremity Functional Scale and algometry were the outcome measures. After the treatments, all participants have undergone a reassessment. There was no significant difference in three outcome between both groups. Both groups showed a significant difference in numeric pain rating scale and Lower extremity functional scale. Both groups showed significant improvement in dorsiflexion but there was no significant difference between groups. Their conclusion was that the joint mobilization in means of improving dorsiflexion is not superior to stretching and ultrasound alone in management of plantar fasciitis. The limited dorsiflexion is mostly because of the soft tissue restriction rather than problems in joints [113].

Renan-Ordine et al., (2011) has conducted a research study to evaluate the effectiveness of myofascial trigger point manual therapy combined with a self stretching protocol for

the management of plantar heel pain. 60 patients who were diagnosed with plantar heel pain were assigned to two groups as self stretching group and self stretching with soft tissue trigger point manual therapy group. All patients attended the clinic for 4 days per week for 4 weeks period. In self stretching group patients asked to perform standing calf muscle stretching exercises and plantar fascia specific stretching exercises. Patients were instructed to perform intermittent stretching of 20 seconds followed by 20 seconds rest period. Each stretch lasted 3 minutes and whole session took 9 minutes. They had to perform these exercises two times per day. In other group, patients were examined for active trigger points in gastrocnemius muscle. This study used trigger point pressure release technique to release the trigger points. Pressure was applied over the trigger point and the increased muscle resistance was felt by the therapist. The pressure was maintained until the therapist felt the release in the trigger point. At this point pressure was increased to return to previous level of muscle trigger point tension. Whole process took 90 seconds. In addition to that patients underwent neuro muscular techniques over their gastrocnemius muscle. Therapist's thumb placed over the taut band and three longitudinal strokes were performed from ankle side to knee side while patient was in prone position. This technique was applied slowly and with moderate pressure. Outcome measures were SF 36 questionnaire and pressure pain thresholds. According to the results patients who received both self stretching and manual therapy demonstrated greater improvements in both physical function and reduction in pain sensation compared to self stretching only group. They concluded that the usage of trigger point release manual technique with self stretching exercises gave superior results rather than following only a self stretching protocol in plantar heel pain [114].

Pattanshetty and Raikar, (2015) has done a randomized control trial to evaluate immediate effect of three soft tissue manipulation techniques on pain response and flexibility in chronic plantar fasciitis. 60 patients were divided into three groups as myofascial release group, positional release group and stretching group. All patients received one session of therapeutic ultrasound with intensity of 1W/cm<sup>2</sup> and frequency of 1MHz for 5 minutes prior to manual therapy. Visual analogue scale and ankle range of motion were used as outcome measurements. Researchers observed there was a significant reduction in pain in all three groups. Myofascial release group demonstrated significant improvement in ankle range of motion. Stretching group showed less improvement in ankle range of motion compared to myofascial release group. But stretching group demonstrated a higher improvement in ankle range of motion compared to positional release group [115].

Celik, Kuş and Sirma, (2015) has done a research study to compare joint mobilization and stretching exercises vs. steroid injection in management of plantar fasciitis. 43 patients randomly allocated to two groups. Joint mobilization and stretching exercises group received subtalar traction, talocrural posterior glide, subtalar lateral glide, first tarsometatarsal joint dorsal glide, gastrocnemius stretching, and plantar fascia

specific stretching. Patients followed whole manual therapy regime 3 times per week for 3 weeks with total 9 visits. Steroid injection group received only one injection. Foot and Ankle Ability Measure (FAAM) and Visual Analog Scale (VAS) were outcome measures. All measurements were taken prior to the treatments and at 3 week, 6 week, 12 week, and 1 year following the treatments. According to the results both groups had significant improvements in favor of steroid injection group. However, improvements were continued to be shown after 12 weeks and 1 year of treatment in joint mobilization and stretching exercises group only [116].

Muneer et al., (2018) has done a quasi experimental study to evaluate effectiveness of mulligan's mobilization techniques in the treatment of plantar fasciitis. 30 patients with plantar fasciitis received manual mobilization to the affected foot to improve the ankle dorsiflexion and to reduce the pain. Foot function index was the outcome measure. All data were collected prior to the treatments and after four weeks treatment sessions. All domains except limited physical activities were improved in the Foot function index after four weeks of treatments and they concluded that the mulligan's mobilization techniques are useful to reduce the pain in patients with plantar fasciitis [117].

Vinod Babu et al., (2014) has done a research study to evaluate effectiveness of instrumental assisted soft tissue mobilization technique with static stretching in subjects with plantar fasciitis. 40 participants were assigned to two groups as study group and control group. Control group received only conventional exercises while study group received conventional exercises, instrumental assisted soft tissue mobilization, and static stretching exercises to triceps surae, gastrocnemius and soleus muscles. Pain intensity was measured using numerical pain rating scale. Functional disability was evaluated using Foot Function Index Pain Subscale. Active ankle dorsiflexion was measured using a goniometer. After the treatments, there were significant improvements in both groups. After two weeks of treatments study group showed statistically significant, greater improvements compared to control group. Their conclusion was that the instrumental assisted soft tissue mobilization technique with static stretching exercises has better outcomes in relation to pain reduction, ankle dorsiflexion range, and Foot Function Index scores compared to the conventional exercises for plantar fasciitis [118].

Grim et al., (2019) has done a randomized control trial to evaluate effectiveness of manual therapy, customized foot orthoses and combined therapy in the management of plantar fasciitis. 63 patients were assigned to manual therapy group, customized foot orthoses group and combined therapy group. Manual therapy group received talocrural, subtalar and tarsi transversal joints mobilisation. Also, the Sacroiliac joint, symphysis pubis and intervertebral joints were mobilised. The American Orthopaedic Foot and Ankle Society Ankle Hind foot Scale was used to assess the pain and function of the foot. Foot Pain and Function Scale also used as an outcome measure. According to the results, all groups showed statistically significant improvements of both outcome

measure scales with greatest improvements demonstrated by the manual therapy group [119].

Mischke et al., (2016) has done a systematic review on the symptomatic and functional effects of manual physical therapy on plantar heel pain. After reviewing eight articles, they have suggested manual therapy interventions are effective to treat plantar heel pain and there is a need of further studies to validate the findings [120].

### IX. CONCLUSION

Physiotherapy interventions including stretching exercises, strengthening exercises, night splints, taping, dry needling, extracorporeal-shockwave therapy, and manual therapies are reported to be effective in management of chronic plantar fasciitis and should be considered prior to any surgical interventions. Physical therapy interventions are effective with minimal adverse effects unlike interventions like cortisone injection for plantar fasciitis.

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