

Immediate Effect of Iontophoresis with Short Foot Exercises on Pain and Rom in Plantar Fasciitis

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Abstract: *Plantar fasciitis, a prevalent cause of heel pain, involves inflammation and structural breakdown of the plantar fascia, often due to overuse, increased exercise, weight gain, or aging. This study investigates the immediate effects of iontophoresis with diclofenac sodium combined with short foot exercises on pain and range of motion ROM in individuals aged 18 - 30 years with plantar fasciitis. Using the Visual Analog Scale VAS and goniometry, 28 participants were assessed pre - and post - treatment. Results showed a significant reduction in pain mean difference 2.30, $p < 0.000$ and an increase in ankle plantar flexion and dorsiflexion ROM $p < 0.000$. The study concludes that iontophoresis with diclofenac sodium, alongside short foot exercises, is effective in alleviating pain and improving ROM in plantar fasciitis patients.*

Keywords: plantar fasciitis, iontophoresis, diclofenac sodium, heel pain, range of motion

1. Introduction

Plantar fasciitis is the most common cause of heel pain and pain on the plantar aspect of the foot.¹⁻² It mostly involves pain at the origin of the plantar fascia at the calcaneal insertion point as it is stretched during standing and walking activities. Plantar fasciitis is an injury in which there is overuse of plantar fascia causing inflammation at the origin of the plantar fascia and is characterized by plantar heel pain that is provoked by taking the first few steps in the morning and by prolonged standing.³ It is characterized by scarring, inflammation, or structural breakdowns of the foot's plantar fascia. It is mostly caused due to overuse of the plantar fascia, increase in exercise, weight or age. Risk factors for plantar fasciitis are increased body weight and body mass and with a BMI more than 30kg/m². Plantar fasciitis is most commonly seen between the age of 40 - 60 years in the general population and in younger people among runners.⁴

The plantar fascia gives structural support to MLA which extends along the sole of the foot. In recent years there has been some discrepancy over the classification of the plantar fascia: specifically, some reference it as a true fascia, while others categorize it as an aponeurosis.⁵ With all definitions coming from the Farlex Partner Medical Dictionary, fasciae, aponeuroses, ligaments, and tendons all consist of highly organized, tightly packed, dense, regular connective tissue, originating from and maintained by fibroblasts. Additionally, almost all of the literature reviewed mentions heightened severity of pain associated with the first steps of a patient's day after rising from a sleeping position, with symptoms often gradually diminishing throughout the day, excluding prolonged weight bearing activities. In concert with the theory of plantar fasciitis being a misnomer for a noninflammatory disorder, this increased pain in the morning is hypothesized to be a result of a healing effort during sleep as a patient sleeps, and they experience plantar flexion, fibrosis occurs in the afflicted tissue⁶ This adaptive process which lasts overnight is insufficient to overcome the loading force of the first few steps upon waking, yet it is enough to

cause severe pain as the newly laid collagen fibres are torn and the degenerative process begins again.⁶

In a normal walking motion, the heel is the first part of the foot to make contact with the ground surface. Following this initial contact, as the foot pronates, the tibia rotates inward simultaneously stretching the plantar fascia while MLA gets compressed into a flatter position. It is the consensus in most literature that repetitively performing this motion can strain predisposed fascia and lead to plantar fasciitis.⁷

Most patients with plantar fasciitis have tightness of the Achilles tendon. In addition, research has shown that the plantar fascia becomes shortened as a result of pain. A tight Achilles tendon or contracted plantar fascia places increased stress on the inflamed fascia during gait.¹² This cycle of tightness and plantar fasciitis should be interrupted as soon as possible by exercises to stretch the Achilles tendon and plantar fascia.⁸

The pathogenesis of plantar fasciitis has long been linked to that of both tendinitis and insertitis, inflammation of a tendon or insertion, respectively.³⁶ Although microtrauma of the connective tissue is continuous with the pathologies of these other conditions, a relatively recent observation has led to a new school of thought when it comes to this injury. Unlike traditional inflammatory conditions, there seems to be no evidence of an inflammatory response when considering plantar fasciitis.⁹

Combination of treatment modalities have been more effective in managing plantar fasciitis rather than administering only one treatment at a time.^{15, 16} Although many authors agree that mechanical treatment should be considered a cornerstone of any plan of treatment, one debate remains regarding the most effective form of mechanical intervention.^{17, 18} Mechanical treatment modalities help in decreasing the load and stress applied to inflamed plantar fascia during activity to a tolerable level. Various modalities used may include foot orthoses, foot taping, footwear, night splints, rest, and walking casts.¹⁰

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Iontophoresis is an electrotherapy technique in which medically useful ions are driven through the patient's skin into the tissues. The basic principle is to place the ions under an electrode with the same charge. A constant galvanic current is then applied and the ion is electrically propelled into the patient. Iontophoresis is a physical enhancement technique, which consists in the application of low - density current to a membrane in order to promote the penetration of a substance, either charged or neutral, across this membrane.¹¹

An iontophoretic device consists of a power supply connected to a positively charged electrode, the anode, and a negatively charged one, the cathode. The charged drug in solution is placed under the electrode that carries the same charge. When current is applied, the drug is transported in the subjacent tissue, and can reach the systemic circulation.¹¹

When the drug is positively charged, it is placed under the anode, and the processes called anodal iontophoresis. On the contrary, when it is negatively charged, it is placed under the cathode, and the process is called cathodal iontophoresis. Usually the electrodes of choice are silver/silver chloride, since they do not cause water electrolysis. In this way, there is no production of protons that could compete with the drug to carry the charge, and there is no sharp decrease in the pH, which could lead to acid - induced burns and may have an adverse effect on drug stability.¹²

Different factors, linked either to properties of the drug itself or to the properties of the iontophoretic system, can influence iontophoretic transport. The factors directly related to the drug are its concentration in the donor solution, its physicochemical properties and the presence in the formulation of competing ions.¹³

Many such stretching and strengthening programs share a focus on the gastrocnemius complex: the combination of the more superficial, superior gastrocnemius muscle and the deeper soleus muscle, attached to the calcaneus by the Achilles tendon. Tightness in these muscles, which as a collection comprise the calf muscle, can be responsible for worsening of the plantar fasciitis condition. This occurs mainly by increasing the degree of plantar flexion in the state of a resting foot, thereby causing increased contraction of the fascia and subsequently greater pain upon weight bearing and dorsiflexion.¹⁸ Therefore, stretching the calf can decrease tightness in these muscles, increase the flexibility of the connective tissues comprising the entire plantar surface and also build strength in the muscles of the foot. All of these factors contribute to lessening pain associated with plantar fasciitis.¹⁴

Strengthening programs play an important role in the treatment of plantar fasciitis and can correct functional risk factors such as weakness of the extrinsic and intrinsic foot muscles.^{26,27} Strengthening exercises for the extrinsic muscles should emphasize the inverter and plantar flexor muscle groups.²⁸ Exercises used to strengthen the intrinsic muscles include towel curls and toe taps. Exercises such as picking up marbles and coins with the toes are very effective in plantar fasciitis.¹⁵

2. Methods and Materials

Ethical Clearance was obtained from the Institutional Ethical Committee. After finding their suitability as per the inclusion criteria the subjects were requested to participate in the study. Participants were briefed about the nature of the study and the intervention. A Written informed consent was obtained from all the subjects who are willing to participate in the study All the participants were assessed using VAS and Ankle ROM, pre - treatment and immediately after treatment. A baseline assessment of Variables was done. Subjects were treated with iontophoresis with diclofenac for 10min along with short foot exercises. Age groups of subjects was between 18 - 30.

Iontophoresis comprises electric impulses from a low - voltage galvanic current stimulation unit to drive ions into soft tissue structures. Solution for iontophoresis was made by using distilled water along with 4 mg/mL diclofenac, following which the solution was poured into a water bath. Electrodes were fixed; red positive electrode was placed under the metatarsal heads and the black negative electrode was placed under the calcaneal bone. A galvanic current up to 4 mA for 10 min and a total dose of 40 mA was delivered over a period of time determined by the patient's sensitivity. Short foot exercises were given to the subjects after receiving iontophoresis treatment for 3 sets of 5 repetitions.

For short foot exercises each subject was instructed to sit on a height - adjustable chair and bend the hip joint, knee joints, and ankle joints to 90° and a towel was placed below the feet. the opposite foot was placed behind the test foot. Thereafter, the subject was instructed to pull the head of the first metatarsal bone toward the heel without bending the toes and maintain the state for 20 sec. During the exercise, to prevent the forefoot and the heel from being lifted off the ground and smoothly induce the flexion of the head of the metatarsal bone, the measurer gently supported the heel. Each exercise had 3 sets, and the sets were repeated 5 times. Two minutes of rest was allowed after every set.^{11 - 12} The exercise was performed for 15 mins.¹³

3. Result

The present study titled "Immediate effect of iontophoresis with short foot exercises on Pain and ROM in Plantar fasciitis – A Clinical Trial." Included 28 subjects who received Iontophoresis with diclofenac sodium for 10 min and short foot exercises. PRE AND Post Treatment Pain and ROM was taken in terms of VAS scale and Goniometer.

4. Statistical Analysis

Statistical analysis for the present study was done so as to verify the results obtained. For this purpose, data was entered into an excel spread sheet, tabulated and subjected to statistical analyses. Various statistical measures such as Mean, Standard deviation and test of significance were used. Demographic data i. e. the comparison of the Age, Height, weight and BMI were analysed. Comparison of pre - intervention and post intervention was done by using Paired t - test. Probability values less than 0.05 were considered statistically significant.

Gender distribution

The total number of male were 13 and female subjects were 15

Age distribution

Age of the subjects in the study was between 18 to 60 years. the mean age of subjects was 20.50 ± 1.50 . (Table no.1) (Graph no.1)

Weight distribution

The weight of the subjects in the study was compared. The mean weight of the subjects was 57.39 ± 7.15 . (Table no.1) (Graph no.1)

Height Distribution

The height of the subjects was compared. The mean height was 159.71 ± 7.67 cm. (Table no 1) (Graph no 1)

BMI distribution

The Mean BMI of subjects was compared and the mean was 21.75 ± 2.53 . (Table no 1) (Graph no 1).

Outcome measures**Pain**

In the study the mean and SD values of pre - Vas scale was 6.15 ± 0.98 and Post Vas was 3.84 ± 0.65 with difference of 2.30 ± 0.82 . The t value and p value of Pre and Post VAS scale was 14.770 and 0.000 which is statistically significant. (Table no.2) (Graph no.2)

The mean value indicated changes post treatment and higher values are recorded for post treatment outcome. Since post mean value is higher than the pre - mean value which is desired condition and also the standard deviation shows the limited consistency with post treatment value which is more than the pre - treatment value.

ROM

In the study the mean and SD values of plantar flexion Pre ROM - scale was 32.60 ± 3.32 and Post ROM was 37.82 ± 3.48 with difference of $- 5.21 \pm 1.98$ and Dorsiflexion Pre ROM - was 34.33 ± 3.45 and Post ROM 39.24 ± 3.57 with difference of $- 4.91 \pm 1.66$. The t and p value of Pre and Post ROM scale of Plantar flexion was 13.879 and 0.000 and Dorsiflexion was 12.699 and 0.000 which is statistically significant (Table no.3) (Graph no.3)

Based on the results of the paired sample t - test analysis at 5% significance level, the null hypothesis H_0 was rejected and the alternative hypothesis H_a was accepted, since paired sample t - test has revealed a significant statistical reliable difference between the pre & post treatment values with p - value is less than the 5% significance level (i. e. $0.000 < 0.05$) in our study and therefore it justifies the acceptance of alternative hypothesis based on the paired sample t - test procedure.

5. Discussion

The present study was conducted to know immediate effect of Iontophoresis with short foot exercises on Pain and ROM

in Plantar fasciitis. The intervention was given for Ten minutes, VAS and ROM were used as outcome measures.

In present study subjects were with age group between 18 - 30. The mean age of participants was 20.50 ± 1.50 , as most of our subjects were athletic population. In athletes there is more amount of exercise and due to incorrect training and inadequate footwear there is overuse of the plantar fascia leading to plantar fasciitis³. In previous studies the age group of subjects was between 40 - 60 with mean age of 44.13. The reason behind taking this age group was that the prevalence of Plantar fasciitis is most common between the age of 40 - 60 years in the general population and in younger people, runners and people having habit of bearing more weight on single leg.⁷

Mean BMI of subjects in our study was 21.75 ± 2.53 as most of our subjects were athletes and used to work out on daily basis Previous studies were conducted in which the mean BMI was 26 ± 1.22 . One of the risk factors for plantar fasciitis is increased BMI. The prevalence of plantar fasciitis was seen in people having BMI between 25 - 30. Another study showed that plantar fasciitis was seen in people having BMI more than 30.9

To determine the effects of a combination of dexamethasone with lidocaine hydrochloride for the treatment of subjects with plantar fasciitis. Mean difference of Pre and Post VAS was 1.95 ± 0.75 showing significant amount of pain relief compared to previous study. In our study the difference between mean values of pre - Vas and Post Vas was 2.30 ± 0.82 with p value of 0.000. the amount the amount of pain reduced in our study was more compared to the previous study as the subjects included in previous study were chronic cases of plantar fasciitis in which there was more of restriction and less of pain and the intervention was given for 2 weeks where's in our study subacute and chronic cases of plantar fasciitis and only one session of intervention was given.¹⁵

Effectiveness of iontophoresis with dexamethasone in managing Chronic Achilles tendon pain in 25 subjects study was done and concluded that there was no decrease in pain. The pain was not reduced may be because iontophoresis is effective in reducing acute pain.¹⁶ In our study iontophoresis with diclofenac sodium was used to treat plantar fasciitis and it was concluded that it was effective in decreasing pain with p value of 0.000. The pain reduction was may be because diclofenac sodium being a NSAID helped in decreasing the inflammation and giving a sedative effect and reducing the pain.¹⁶

Subjects with lateral elbow tendinopathy (LET) were treated with dexamethasone and lidocaine hydrochloride. VAS was measured after treatment which showed that there was a decrease in VAS ($p < 0.01$) and increase in ROM ($p < 0.05$). The reduction in pain was may be because dexamethasone iontophoresis can replace local steroid injection, decrease local pain rearrange the collagen fibres near to insertions in the periosteum and restore the function and strength of the wrist extensor muscles as per the study. The difference between other traditional physical therapy methods and iontophoresis was that it helped in reducing pain in a faster way and permits the subjects to be functional showing results

similar to our study with p value of 0.000 which was statistically significant.¹⁷

In our study the difference between mean values of prepost VAS was 2.30±0.82 with p value of 0.000 which was statistically significant. Previous study was conducted to check the effect of phonophoresis on plantar fasciitis in which the mean ±SD VAS was 8.20±0.86 with p value (<0.41) which was more compared to our study. The pain reduction was more in their study as the pain relief in phonophoresis may be due to an effect on the central mechanism of nociception. The Induced drug may have reduced the formation of prostaglandin through the inactivation of cyclooxygenase (an enzyme that converts fatty acid into interstitial swelling) which may have reduced the inflammation at the teno periosteal junction there by reducing the pain. In our study the decrease in the pain was may be because of sedative effect of diclofenac sodium which penetrates in to the soft tissues which helped in decreasing inflammation and rearrangement of muscle fibers. The amount of pain reduction in their study was more as the treatment sessions were 5 and ours was only 1 session.¹⁸

Lateral epicondylitis subjects were treated by iontophoresis with diclofenac sodium and other group were treated with iontophoresis with sodium salicylate. After the treatment, pain was decreased in both groups but greater decreases in pain (VAS p <0.05) was seen in group treated by diclofenac sodium thus the study concluded that iontophoresis with diclofenac sodium was more effective in decreasing pain than that of sodium salicylate. Thus, supporting our study which indicates that iontophoresis with diclofenac sodium is effective in decreasing pain in plantar fasciitis because of sedative effect of the drug.⁶

Our study showed that there was increase in Ankle ROM, with p value of 0.000 for Ankle Plantar flexion and 0.000 for Ankle Dorsiflexion. The increase in Ankle ROM was may be because the pain was reduced and the subjects were comfortable doing the Ankle plantar and dorsiflexion without any hesitation. Previous studies conducted on subjects with shoulder stiffness showed increase in shoulder flexion and extension (p<0.01) showing similar results to our study.⁵

Subjects with chronic plantar heel pain were treated with dexamethasone with exercises and it was concluded iontophoresis with exercise was effective in reducing pain and increasing Plantar and Dorsiflexion for short duration, after 4 - 5 days the pain was induced again because pain relief in chronic condition requires a more number of treatment sessions. Our study showed that iontophoresis of diclofenac sodium with short foot was effective in increasing ROM of foot as the pain was reduced because of anti - inflammatory properties of the drug which reduced the inflammation and allowed the subjects to perform the movement at the foot followed by short foot exercises which helped in strengthening of intrinsic muscle of foot.⁹

Advantages of Iontophoresis over other local injections, without side effects are that it permits consistent drug delivery, a low systematic dose is administered, the sterile barrier of the skin is not compromised, which is of particular importance when corticosteroid drugs are used, the treatment

is painless. Pain due to needle insertion and tissue tension caused by the subcutaneous injection of a fluid volume is not produced, and the treatment is atraumatic. Tissue damage due to needle penetration and the subcutaneous injection of a bolus of fluid is avoided.⁹

Various Interventions such as iontophoresis, ultrasound, mobilization/ manipulation, soft tissue release techniques and therapeutic exercise have been used to treat subjects with plantar fasciitis; but these have different levels of evidences in regard to their effectiveness. Since many years Ultrasound has been used in the treatment of musculoskeletal conditions. Podiatrists and physiotherapists use therapeutic ultrasound and is prescribed by physicians in their treatment of plantar fasciitis and plantar heel pain¹³Iontophoresis is an electrotherapy technique in which medically useful ions are driven through the patient’s skin into the tissues. The basic principle is to place the ions under an electrode with the same charge. A constant galvanic current is then applied and the ion is electrically propelled into the patient.¹³

This technique is being used by many doctors to treat postoperative subjects who are recovering from invasive back surgery. Transdermal medicines help in speeding the healing process and increase the effectiveness of pain management exponentially for some subjects.¹⁹

It has attracted much interest as it is applied to common musculoskeletal conditions such as lateral elbow tendinopathy (LET). It uses continuous direct current of low amperage to introduce topically applied physiologically active ions through the body surface with the advantages of including its non - invasive nature, uniform absorption, and absence of systemic side effects such as gastrointestinal distress. Studies have shown clinically relevant improvements in PF symptoms using iontophoresis of dexamethasone and acetic acid. Nonsteroidal anti-inflammatory drugs.²⁰

Tables

- 1) Descriptive statistical analysis for demographic variables

Variables	MEAN ± SD
AGE (yrs)	20.50±1.50
HIEGHT (cm)	159.71±7.67
WIEGHT (kg)	57.39±7.15
BMI (kg/m ²)	21.75±2.53

- 2) Comparison of Pre and Post VAS Scale with respect to Mean, SD, t value and p value.

Pair	Mean±SD	Mean Diff± SD Diff	t value	P value
Pre - VAS scale	6.15±0.98	2.30±0.82	14.770	0.000
Post VAS scale	3.84±0.65			

- 3) Comparison of pre and post Ankle ROM with respect to Mean, SD, t value and p value.

Pair		Mean ± SD	Mean Diff±SD diff	t value	p value
Pre ROM - Scale	Plantar flexion	32.60±3.32	-5.21±1.98	13.879	0.000
	Dorsi - flexion	34.33±3.45			
Post ROM scale	Plantar flexion	37.82±3.48	- 4.91±1.66	12.699	0.000
	Dorsi flexion	39.24±3.57			

Photos



Apparatus and Equipment

Photograph 3: Short foot exercise



Short foot exercises



Iontophoresis

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