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Effectiveness of Dexamethasone Iontophoresis with Plantar Fascia Stretching for Plantar Fasciitis

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Abstract: ***Back ground and purpose: Plantar fasciitis is an overuse injury resulting from repetitive microtears of the plantar fascia at origin on calcaneus. Plantar fasciitis is a common problem in adult population which occurs over wide age range and is seen in both sedentary and athletic individuals. The purpose of my study was to evaluate the effectiveness of dexamethasone iontophoresis with plantar fascia stretching in relieving pain and improving ankle ROM (Plantar flexion and Dorsiflexion). Subjects: 30 patients with plantar fasciitis were included. Method: 30 patients diagnosed with plantar fasciitis were included in the study. They were treated with dexamethasone iontophoresis with plantar fascia stretching. The current of upto 4.0mA was applied for 10minutes. After the treatment all patients were made to perform plantar fascia stretching exercise. 12 treatment sessions were given for 4weeks. They were assessed for pain by Visual analogue scale (VAS), and Ankle plantar flexion and dorsiflexion Range of Motion (ROM) by Goniometer on 1st day (pre-test) and on last day (4th week). Result: Patients showed statistically significant improvements at 4th week of intervention. Conclusion: Dexamethasone iontophoresis with plantar fascia stretching exercise was highly significant in relieving pain and improving the Ankle dorsiflexion / plantar flexion range of motion in patients with plantar fasciitis (p<0.001) after 4th week of intervention.***

Keywords: Plantar fasciitis, Windlass mechanism, Dexamethasone Iontophoresis, Plantarfascia stretching exercises, VAS, ROM

1. Introduction

The Plantar fascia is an extremely strong structure composed of a thin multilayered fibrous aponeurosis. The fascia divides into medial, central and lateral components. The central portion is the most dominant and usual sites of pathologic disorders. It originates on the plantar surface of the posteromedial calcaneal tuberosity and runs forward to form the medial longitudinal arch. Distally, five tracts are formed with superficial and deep components [1, 2].

The superficial portion anchors the skin providing support from shear forces. The deep portion of the plantar fascia attaches to the plantar plates of the metatarsophalangeal joints and the bases of the proximal phalanges of the toes by connections to the flexor tendon sheaths. The medial component is the fascial covering of the abductor hallucis. The lateral component originates from the lateral margin of the medial calcaneal tubercle [1, 2].

The medial process of the calcaneal tubercle serves as the point of origin of the abductor hallucis, flexor digitorum brevis and abductor digiti minimi muscles. The plantar fascia is innervated by the medial calcaneal nerve, a branch of posterior tibial nerve [1, 2].

Histologically, the extracellular matrix within plantar fascia is comprised of collagen (type 1) and elastin (a protein which increases elasticity), GAG's (a carbohydrate structure which adds resiliency), fibroblasts (cells which produce collagen), and water. The collagen fibers are highly organised and run longitudinally within fascia. Although elastin, GAG's, fibroblasts and water are integrated within the structure of plantar fascia, the collagen fibers provide most of the strength [2, 3].

PATHOMECHANICS

When a repeated load is applied on the fascia, the chance of injury is greater. The body sends inflammatory cells to the injured site to initiate the healing process. The elastic fibers are present in longitudinal strands and in way bundled networks. These elastic fibers may alter orientation from wavy to straight under increasing amount of acute and chronic loading leading to stiffening of the fascia [3, 4].

The plantar fascia acts as a stabilizer of the longitudinal arch which is important in the propulsive phase of gait as it serves to make the foot a rigid lever via the "windlass effect mechanism".

The windlass mechanism describes the manner by which the plantar fascia supports the foot during weight bearing activities and provides information regarding the biomechanical stresses placed on the plantar fascia [5].

A "windlass" is the tightening of a rope or cable. The plantar fascia simulates a cable attached to the calcaneus and the metatarsophalangeal joints. Dorsiflexion during the propulsive phase of gait winds the plantar fascia around the head of the metatarsal. This winding of plantar fascia shortens the distance between the calcaneus and metatarsals to elevate the medial longitudinal arch. The plantar fascia shortening that result from hallux dorsiflexion is the essence of the windlass mechanism principle [5]. Thus each time the foot passes from heel rise to toe off in stance phase of the gait cycle, the plantar fascia is placed under increased tension [2, 5].

Plantar fasciitis is a common occupational or sport related repetitive strain injury [6]. It is an overuse injury resulting from repetitive microtears of plantar fascia at its origin on the calcaneus [7]. Kwong et al classified it as a syndrome resulting from repetitive trauma to the plantar fascia at its origin on the medial tubercle of the calcaneus. It is an inflammation of plantar fascia and the perifascial structure [5]. Plantar fasciitis represents the fourth most common injury to the lower limb and represents 8-10% of all present injuries to sports clinic (Ambroius 1992, Nike 1989) [7, 8]. Plantar fasciitis can occur among all age groups, sex,

ethnicity or activity levels. It is most frequently seen in overweight male runners (BMI >25kg/m^2) older than 30years of age [9]. It is commonly seen in 30-60years of age group [8]. It is estimated that more than two million people receive treatment for plantar fasciitis in United States each year [6].

Etiology

The factors that have been said to precipitate the condition can be divided into anatomical, biomechanical and environmental factors. Anatomical factors include low arch or pes planus, high arch or pes cavus, sudden gain in body weight or obesity, unequal leg length and fat pad atrophy. Biomechanical factors include tight achilles tendon or equines, weak plantar flexor muscles, weak intrinsic muscles, excessive subtalar joint pronation and externally rotated lower extremity. Environmental factors include trauma, unyielding surfaces, going barefoot, improper or excessive worn foot wear, occupation involving prolong weight bearing and inadequate stretching. In most cases combination of these factors leads to the developmental of plantar fasciitis [5, 6, 10, 11]

Pes planus with excessive pronation is the most common mechanical cause of structural strain on the plantar fascia resulting in plantar fasciitis. Thordarson et al found that the posterior tibialis muscle provided the most significant dynamic arch support during stance phase of gait. The posterior tibialis eccentrically lengthens to control pronation and reduce the tension applied to the plantar fascia during weight acceptance. Excessive pronation can cause posterior tibialis weakness and plantar fascia elongation. The elongation minimises efficient use of foot's windlass mechanism because of instability during propulsive phase of gait [5].

The literature reports heel cord tightness in patients with plantar fasciitis. A tight heel cord limits the amount of dorsiflexion available during gait. A person with a flexible foot type can compensate for lack of ankle dorsiflexion by unlocking the mid tarsal joint because dorsiflexion and abduction are movements allowed at mid tarsal joint's oblique axis. This increased motion results in excessive pronation that can stress the plantar fascia [5]. A Cavus foot lacks normal joint's mobility. It also has limited pronation to dissipate forces. Decreased shock absorption results in increased tension forces being applied to the insertion of the plantar fascia at the medial calcaneal tubercle [5].

Patients with a cavus foot have a decreased distance between the calcaneus and metatarsal heads. Patient with a cavus foot also have a rigid, plantar flexed first ray that can further shorten this distance. This position efficiently increases the "winding" under the first metatarsal head as described by the windlass model. Therefore, the combination of high arch and plantar flexed first ray places a continuous tension on the plantar fascia that can lead to adaptive tissue shortening [5].

2. Signs and Symptoms

Patients typically present with inferior heel pain on weight bearing and pain often persists for months or even years. Pain associated with plantar fasciitis may be throbbing, piercing, especially with few steps in morning or after periods of inactivity. The discomfort often improves after further ambulation but worsens with continued activity, often limiting daily activities. Walking barefoot on toes or upto stairs may exacerbate the pain [12]

Diagnosis

On examination, patient usually has a point of maximal tenderness over medial calcaneal tuberosity and the medial longitudinal arch. These findings are exacerbated by maintaining digital pressure over the tender aspect of medial longitudinal arch and then recreating the windlass mechanism by dorsiflexing the big toe to approximately 65^0 [6].

Investigation

According to several small case control studies that compared patients with and without plantar fasciitis, thick aponeurosis identified by Ultrasonography is associated with plantar fasciitis. Radiography may show calcification in the soft tissues around the heel or osteophytes on the anterior calcaneus (heel spurs). The presence of heel spur is associated with plantar heel pain in 50% of patients; only 15-19% of asymptomatic patients demonstrate spurs. Bone scan can show increased uptake at the calcaneus and MRI can show thickening of plantar fascia. But accuracy of these tests remains inconclusive [1, 12].

Conservative Treatment

Non-operative treatment options for plantar fasciitis include non-steroidal anti-inflammatory drugs (NSAID'S), heel pad or cup, orthoses, short leg cast, night splint, physiotherapy, steroid injections, shoe modifications, activity modification, weight reduction, ice, heat and rest. Athletic taping is also used. The two types of orthoses that are occasionally used for the treatment of plantar fasciitis are a three-quarter length orthosis and a UCBL insert. Both attempts to unload the plantar fascia during weight bearing [1].

Surgical Intervention

The indication for surgical intervention for the treatment of plantar fasciitis is the failure of conservative therapy for at least 1year. The procedures are open plantar fascia release, endoscopic plantar fascia release and nerve to abductor digiti quinti release [1].

Iontophoresis has been described as an additional treatment modality for plantar fasciitis. Iontophoresis is a process in which ions in solution are transferred through the intact skin via electrical potential using bipolar electrodes. It is based on principle that like charges repel. Positive ions are carried through the skin at the positive electrode and negative ions are carried through at the negative electrode.

Iontophoresis is primarily used to deliver the anti-inflammatory drug dexamethasone. This is the most popular and well- researched application of iontophoresis in rehabilitation [14, 15].

Dexamethasone is a corticosteroid drug that is used primarily for its anti- inflammatory effects. It is used most often for the treatment of soft tissue and other musculoskeletal inflammation.

When used for iontophoresis, dexamethasone must be in the form of a dexamethasone sodium phosphate solution. In this form, the drug forms negatively charged ions of dexamethasone phosphate that can be driven through the skin with negatively charged iontophoresis electrode [14, 15].

Treatment with iontophoretically delivered dexamethasone has been shown in controlled clinical trials to help patients with medial and lateral epicondylitis, rheumatoid arthritis of knee, Achilles tendinitis, plantar fasciitis and temporomandibular joint dysfunction [15]. Treatment with dexamethasone iontophoresis reduced pain and improved function in patients with wide range of inflammatory conditions. The use of this treatment modality, in conjunction with other interventions, including exercise, activity modification and manual therapy may accelerate symptom resolution and help optimize clinical outcomes in a wide range of patients [15].

Stretching is a general term used to describe any therapeutic maneuver designed to increase mobility of soft tissues and subsequently improve range of motion by elongating structures that have adaptively shortened and become hypomobile over time [13].

3. Methodology

Research Design: One group pre and post-test study design.
Sample Size: 30 subjects
Sampling Design: Purposive Sampling.

Statistical Analysis:
a) Descriptive statistics namely percentage (%), Mean and Standard deviation (SD).
b) Inferential statistics- paired "t" test or Wilcoxon Signed rank test depending on normality of data.

Source of Data
1) Out Patient Department of Orthopedics in Kempegowda Institute of Medical Sciences Hospital and Research Center, Bangalore.
2) Out Patient Department of Physiotherapy in Kempegowda Institute of Medical Sciences Hospital and Research Center, Bangalore.

Materials Used
- Electrical stimulation apparatus with iontophoresis unit.
- Iontophoretic electrode
- Lint pads
- Cotton and spirit
- Rubber straps
- Drug- dexamethasone sodium phosphate solution
- Pen
- Goniometer
- Chair with back support
- Treatment couch, Mackintosh and Pillows

Inclusion Criteria
- 25-60years of both males and females.
- Pain over medial calcaneal tuberosity and medial longitudinal arch along the length of the foot.
- Pain provoked by taking first steps in morning.
- Duration of symptoms more than 4weeks.
- Patients with Hypertension and rheumatoid arthritis.

Exclusion Criteria
- Patient with history of diabetes and Systemic metabolic diseases.
- Patients with neurological deficits.
- Foot deformities and calcaneal fracture.
- Foot tumor or foot trauma.
- Tarsal tunnel syndrome.
- Patients who had treatment on their same foot due to heel pain prior to study.
- Patients who underwent any previous foot surgeries.
- Fat pad atrophy, sub calcaneal bursitis or calcaneal periostitis.

4. Procedure

30 patients with plantar fasciitis who volunteered to participate and those who fulfilled the inclusion criteria were included in this study. All patients signed the consent forms. Prior to the treatment all patients were assessed for pain by Visual Analog Scale (VAS) and Range of Motion (ROM) of ankle dorsiflexion/ plantar flexion by Goniometer.

The treatment area was cleaned thoroughly with the spirit. Then, iontophoretic (-) electrode was hydrated with dexamethasone sodium phosphate solution and placed over plantar aspect of foot and anode (+) electrode was placed 4 to 6 inches away from treatment electrode (plantar aspect of forefoot). Then current of upto 4.0mA was applied depending on each patient sensitivity for 10min.

After the treatment all patients was instructed to perform plantar fascia stretching exercise sitting with affected leg crossed over the contralateral leg, then by fixing the heel with help of one hand and then placing the fingers across the base of the toes on the bottom of the foot and pull the toes back toward the shin by other hand until they felt a stretch in the arch of the foot. Then patient was instructed to hold the each stretch for a count of 10 and repeat it 10 times for 3 sets. The iontophoresis with stretching can be given 3 times a week for 4 weeks. 12 treatment sessions were given for 4weeks.

Assessment of Pain
The Visual Analog or Analogue Scale (VAS) is designed to present to the respondent a rating scale with minimum constraints. Respondents mark the location on the 10-centimeter line corresponding to the amount of pain they experienced. This gives them the greatest freedom to choose their pain's exact intensity. It also gives the maximum opportunity for each respondent to express a personal response style. VAS data of this type is recorded as the number of millimeters from the left of the line with the range 0- 100.

Range of Motion
Active ankle ROM for dorsiflexion and plantar flexion is measured by Goniometer prior and post treatment sessions.

Intervention

-

Dexamethasone Iontophoresis

Plantar fascia stretching exercise

Parameters

- Type of current – direct or galvanic current
- Current amplitude – 4mA
- Drug and dosage – 0.4% dexamethasone sodium phosphate solution
- Treatment time – 10min

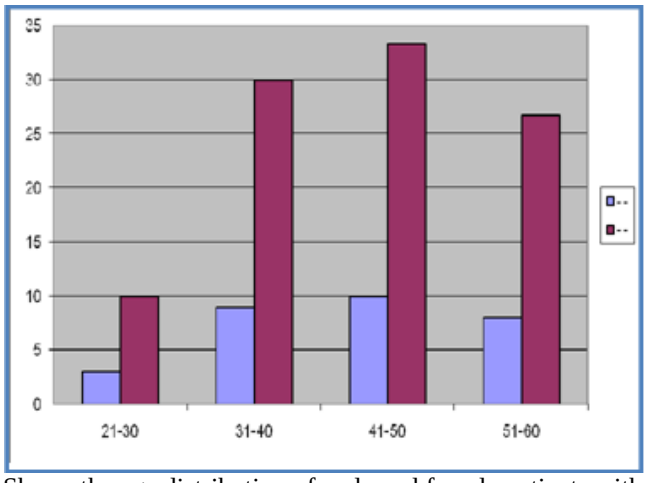
Materials Used

5. Tables & Graphs

Study Design: A one group pre and post test study with 30 patients diagnosed as plantar fasciitis is undertaken to study and to evaluate the effectiveness of dexamethasone iontophoresis with plantar fascia stretching for plantar fasciitis.

Table 1: Age distribution of patients studied

Age in years	Number of patients	%
0-10	-	-
11-20	-	-
21-30	3	10
31-40	9	30
41-50	10	33.33
51-60	8	26.7
Total	30	100.0



Shows the age distribution of male and female patients with plantar fasciitis

I have taken 30 no. of patients in different age groups, out of which 3 no. of patients (10%) where they are lying in the age group between 21-30 years, 9 no. of patients (30%) where they are lying in the age group between 31-40 years, 10 no. of patients (33.33%) where they are lying in the age group between 41- 50 years and another 8 no. of patients (26.7%)

where lying in the age group between 51-60 years.

Table 2: Gender distribution of patients studied

Gender	Number of patients	%
Male	12	40.0
Female	18	60.0
Total	30	100.0

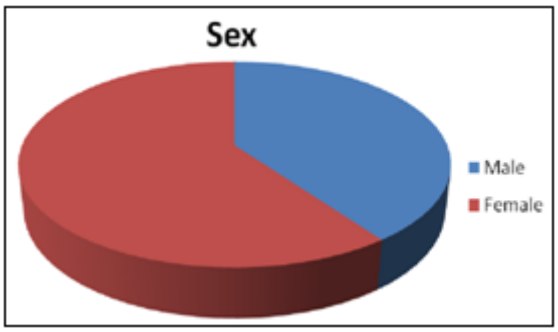


Table 2 shows the gender distribution of patients taken for this study. In this table, 12 no. of male patients (40%) and 18 no. of female patients (60%) are taken out of 30 patients.

Table 3: Evaluation of effect based on VAS score

VAS score	Pre-test	Post test (4th week)
No pain (0)	0	1 (3.3%)
Mild pain (1-3)	1 (3.3%)	13 (43.4%)
Mod pain (4-6)	12 (40.0%)	14 (46.7%)
Severe pain (7-10)	17 (56.7%)	2 (6.7%)
Total	30(100.0%)	30(100.0%)
Mean ± SD	6.65±1.62	3.68±1.77
Inference	56.7% had severe pain at pre-test had improved significantly with 46.7% in Moderate pain and 43.3% improved to Mild pain with P<0.001**, by Students paired t test.	

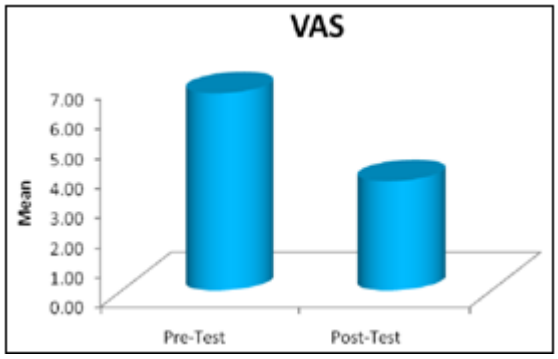


Table 3 shows the effectiveness of dexamethasone iontophoresis with plantar fascia stretching exercises for plantar fasciitis by using Visual Analogue Scale.

The mean and standard deviation of the patients in the pre-test (6.65±1.62) and at the end of the 4th week the mean and standard deviation of the pain is significantly reduced to (3.68±1.77). 56.7% had severe pain at pre-test had improved significantly with 46.7% in Moderate pain and 43.3% improved to Mild pain with P<0.001**, by Students paired t test.

Table 4: Evaluation of effect based on Range of Motion (Ankle dorsiflexion)

Dorsiflexion (Degree)	Pre-test	Post test	Mean Difference (C.I)	% Increase	p* value, significance
Mean	14.40	17.70	3.3 (2.7 -3.89)	22.9	P<0.001, Highly significant
SD	2.85	1.88	1.60		

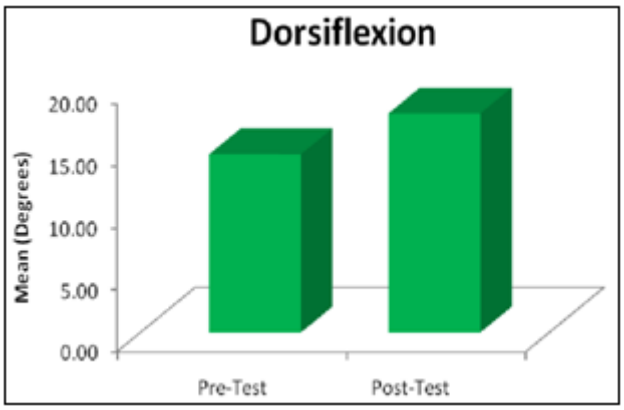


Table 4: shows the effectiveness of dexamethasone iontophoresis with plantar fascia stretching exercises for plantar fasciitis by using Range of motion (Ankle dorsiflexion). The mean and standard deviation of the patients in the pre-test (14.40±2.85) and at the end of 4th week the mean and standard deviation of dorsiflexion range is significantly increased (2.85±1.88) with p<0.001** by Students paired t test.

Table 5: Evaluation of effect based on Range of Motion (Ankle plantar flexion)

Plantar flexion (Degree)	Pre-test	Post test	Mean Difference (C.I)	% Increase	p* value, significance
Mean	40.70	46.23	5.53(4.84 - 6.22)	13.6	P<0.001, Highly significant
SD	3.67	3.15	1.85		

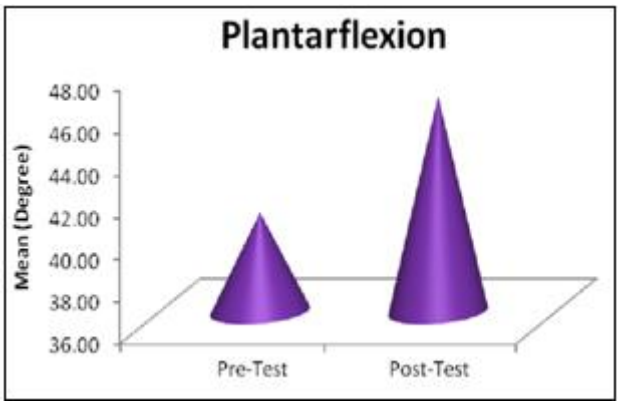


Table 5 shows the effectiveness of dexamethasone iontophoresis with plantar fascia stretching exercises for plantar fasciitis by using Range of motion (Ankle Plantar flexion). The mean and standard deviation of the patients in the pre test (40.70±3.67) and at the end of 4th week the mean and standard deviation of plantarflexion range is significantly increased (46.23±3.15) with p<0.001** by students paired t test.

6. Results

Statistical Methods: Descriptive statistical analysis has been carried out in the present study. Results on continuous measurements are presented on Mean SD (Min- Max) and results on categorical measurements are presented in Number as frequencies and percentages (%). Independent Samples T test has been applied to find the significance of study parameters between groups.

Paired Samples T test has been used to find the significance of pre- and post-intervention of outcome variables within each group. The Crosstabs procedure forms tables and provides a variety of tests and measures of association for tables has been used to find the significance of parameters on categorical scale between two or more groups.

1) Arithmetic mean =

$$\frac{\text{Sum of all the values}}{\text{No. of values}} = \frac{\Sigma X}{n}$$

2) Standard deviation:

$$SD = \sqrt{\frac{\Sigma(X - \overline{X})^2}{n-1}}$$

3) Student's paired 't' test:

$$T = \frac{\text{mean of paired differences}}{\text{S.E of paired difference}}$$

Statictical Software: The Statistical software namely SPSS 15.0, Stata 8.0, MedCalc 9.0.1 and Systat 11.0 analysis of the data and Microsoft word and Excel have been used to generate graphs, tables etc.

7. Discussion

Plantar fasciitis is a common cause of heel pain in adults. It is a syndrome resulting from repetitive trauma to plantar fascia at its origin on the medial tubercle of the calcaneus.

Prevalence of plantar fasciitis is higher in women during middle age; this is due to weight issues and lack of activity. It is also influenced by biomechanics. Women tend to have wider pelvis than men for child bearing reasons and that can put them into a disadvantage mechanically with the knees and feet. Women who wear high heels much of time are prone to fasciitis because the calf muscles and fascia becomes tight due to the positioning of foot and ankle (Advance for Physical Therapy and Medicine 2010).

Pain is the common symptom which occurs over the inferior heel with first few steps in the morning and may also occur with prolong standing. The pain is usually caused by collagen degeneration at the origin of the plantar fascia at the medial tubercle of the calcaneus. This degeneration is similar to chronic necrosis of tendonosis, which features loss of collagen continuity, increases in ground substance and vascularity, and the presence of fibroblasts rather than the inflammatory cells usually seen with the acute inflammation of tendonitis. The cause of the degeneration is repetitive microtears of the plantar fascia that overcome the body's ability to repair itself [10].

In this study, patients who underwent iontophoresis with plantar fascia stretching experienced greater relief of symptoms and improvement in function. The advantage of using iontophoresis include the following: - iontophoresis is a non-invasive and painless procedure for the local administration of anti- inflammatory medications. Iontophoresis of corticosteroid yields local tissue concentrations that are lower than those achieved with injection but greater than those achieved with oral administration [9, 14].

The VAS score at the pre-test was 6.65±1.62 and was decreased to 3.68±1.77 at the end of 4th week, the outcome measures based on percentage change of VAS is highly significant with p<0.001. Pain being a sign of inflammation would have been reduced due to the anti-inflammatory effect of dexamethasone and its efficiency in yielding local tissue concentrations[14].

The ankle dorsiflexion ROM at pre-test was 14.40±2.85 and was improved to 17.70±1.88 at the end of 4th week, the outcome measures based on percentage change of ankle dorsiflexion ROM is highly significant. The ankle plantar flexion ROM at pre-test was 40.70±3.67 and was improved to 46.23±3.15 at the end of 4th week, the outcome measures based on percentage change of ankle plantar flexion ROM is highly significant.

This improvement in ankle ROM (Dorsiflexion 22.9%; Plantarflexion 13.6%) could be attributed to stretching of plantar fascia which by recreation of the Windlass mechanism, limits repetitive microtrauma and associated chronic inflammation[13].

8. Conclusion

Dexamethasone iontophoresis with plantar fascia stretching exercise was highly significant in relieving pain and improving the Ankle dorsiflexion / plantar flexion range of motion in patients with plantar fasciitis ($p<0.001$).

9. Summary

This study was done to assess the "Effectiveness of dexamethasone iontophoresis with plantar fascia stretching for plantar fasciitis in relieving pain and improving ankle range of motion". A single prospective clinical study with 30 patients diagnosed as plantar fasciitis between the age group of 25-60 years satisfying the inclusion criteria were considered for the study so as to evaluate the effectiveness of dexamethasone iontophoresis with plantar fascia stretching for plantar fasciitis in relieving pain and improving ankle range of motion.

The pain score were noted by VAS and the Ankle dorsiflexion / plantar flexion ROM was measured by using the Goniometer. Using the scores obtained by VAS and ROM its significance, effectiveness and the percentage was calculated and were plotted in the graphical manner.

The statistical analysis of the VAS (3.68±1.77) and ROM (Dorsiflexion 17.70±1.88**;** Plantar flexion 46.23±3.15) showed significant reduction of pain and improvement of Ankle dorsiflexion and plantar flexion ROM after 4weeks of intervention.

Therefore, this study concludes that "Dexamethasone iontophoresis with plantar fascia stretching exercise was highly significant in relieving pain and improving the Ankle dorsiflexion / plantar flexion range of motion in patients with plantar fasciitis ($p<0.001$)".

10. Limitations

- The study was of short-term duration.
- The sample size was small.
- Duration of follow up was limited: Since the study was of short duration, the long term effects on pain and range of motion limitations are not known.

11. Conclusion

Dexamethasone Iontophoresis with plantar fascia stretching is effective in relieving pain and improving ankle range of motion (Plantar flexion and Dorsiflexion) after 4weeks of intervention in patients with plantar fasciitis.

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