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Comparative study of some conservative methods in treatment of chronic plantar fasciitis

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Abstract: Objective: Aim of this work was to compare the therapeutic effects of platelet rich plasma PRP, corticosteroid injections and Extracorporeal Shock wave therapy ESWT in treatment of chronic plantar fasciitis PF and to study the role of musculoskeletal ultrasonography in diagnosis and assessment of treatment of chronic plantar fasciitis. **Patients and methods:** sixty patients with chronic PF divided into three equal groups 20 each according to the line of treatment; group I treated by PRP injection, group II corticosteroid injection and group III ESWT. All the Patients were evaluated clinically using visual analog scale (VAS), degree of tenderness, functionally assessed using Foot function index score (FFI) and ultrasonographic assessment of plantar fascia thickness and echogenicity of the patients were also evaluated before and 1,3 and 6 months after treatment. **Results:** There was significant improvement of VAS, degree of tenderness and FFI score in the three groups at the end of follow up periods Also, there was significant improvement in the three groups after treatment regarding the plantar fascia thickness and echogenicity by musculoskeletal US at the end of follow up. At the end of follow up periods complete relief of pain was obtained in 65% of patients of group I, and III. **Conclusions**: PRP injection and ESWT are the best treatment modalities for chronic PF when compared with steroid injection after 6 months. Musculoskeletal US was useful tool for evaluation of PF, guided injection for better performance and to assess effect of different treatment modalities.
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Keywords: Planter fasciitis; Platelet-rich plasma; Corticosteroids; extracorporeal shock wave therapy; Ultrasonography

1. Introduction

Plantar fasciitis is one of the most common causes of heel pain. It constitutes 11–15% of the adult foot complaints and the third most common running injury behind patellofemoral pain, and iliotibial band syndrome. [32] It is commonly encountered in athletes and active people, especially those of the middle age group. [21]

The pathology has been thought of an inflammatory process; however, new reports suggest that there is more degenerative process plantar fasciosis. It occurs from increased stress on the plantar fascia which results in progressive, repetitive microtears and degeneration. [21]

Its diagnosis is based on clinical findings such as typical morning pain or after prolonged period of inactivity which is called post-static dyskinesia and localized tenderness over the medial aspect of the heel. Dorsiflexion of the toes and metatarsals may also reveal underlying pain due to the tension placed on the plantar fascia. [21] windlass test provoke symptoms at the plantar fascia by creating maximal stretch. [29,26]

Diagnostic US is the commonest method of radiological assessment in chronic PF specially in refractory cases as it is noninvasive, and effective diagnostic tool for PF and also a valid tool to perform a procedure with a proper selection of injection site, to increase the efficacy and reduce complications of blind injection. [30]

According to the practical guidelines of the American college of foot and ankle surgeons, a reasonable approach for treatment of PF is to start with the lowest risk and lowest cost treatment standard physiotherapy, plantar orthoses and NSAIDs, if not successful, switch to corticosteroid injections or second level physical therapy, such as ESWT. [28]

Corticosteroid injections are an effective modality for pain relief used several years ago. However, the effect seems to be limited and short-lived. Also, a number of complications may occur of

which the most serious are plantar fascial rupture and plantar fat pad atrophy. [8]

Extracorporeal shock wave therapy orthotripsy is a noninvasive procedure that uses single-pulse acoustic waves generated outside the body to a specific site in the body. The treatment causes microtrauma in the damaged tissue which help to its regeneration by producing localized hyperemia, inhibiting pain fiber function, and enabling the growth of new blood vessels neovascularization.[4]

Minimal invasive treatments such as, PRP injections can be used to treat chronic PF. PRP help to generate new tissue and reduce pain in patients with plantar fasciopathy. It is thought to stimulate the healing stages necessary to reverse the degenerative process that can occur in the base of the plantar fascia. [28, 4]

The aim of this study was to compare therapeutic effects of local autologous PRP, local steroid injections and shock wave therapy clinically, functionally and sonographically and to study the role of musculoskeletal ultrasonography in diagnosis, guided injection efficacy and assessment of different treatment modalities of chronic PF.

2. Patients and methods

This study was carried out as a randomized, blind comparative study on 60 patients with chronic PF, attending the Rheumatology and Rehabilitation outpatient clinic in Tanta University Hospitals, Faculty of Medicine. An approval had been obtained from the ethical committee of Tanta University Hospital in accordance to the declaration of Helsinki and all participants signed an informed consent.

Patients with chronic PF at least 6 months duration were included in this study. Clinical diagnosis of the patients was considered in those having inferior heel pain that usually worsens with their first steps in the morning or after a period of inactivity, with maximal tenderness over the anteromedial aspect of the inferior heel, positive windlass test Dorsiflexion of the big toe increases plantar fascia tension and may also cause medial calcaneus pain, this finding is very specific for PF, [29,26] The diagnosis was also confirmed by ultrasonography based on having plantar fascia thickness greater than 4 mm. [13] All our included patients didn't respond to conventional treatment modalities physical therapy, heel cushions and NSAIDs.

Patients were excluded if they had other causes of heel pain such as peripheral neuropathies, nerve entrapment as tarsal tunnel syndrome, Baxter's neuropathy, stress fracture, auto immune or systemic diseases: rheumatoid arthritis, spondyloarthropathy, diabetes mellitus heel pad fat atrophy, plantar fibromatosis and tear of plantar fascia.

Also, patients with medical conditions that are contraindicated to use PRP, corticosteroid injection or shock wave therapy as critical thrombocytopenia platelets < 15,000/µL, severe coagulopathy disorders haemophilia, Chronic liver or renal disease, patients on anti-coagulation therapy, immunosuppressed patients, infection systemic, overlying cellulitis, septic arthritis/bursitis, osteomyelitis and if they had bilateral PF for sonographic comparisons.

The chronic PF patients were allocated into three equal groups 20 patients each who injected with either PRP or steroids guided by ultrasound or receiving ESWT sessions. Group I PRP and group II steroid were injected with twice injections two weeks apart at the site of plantar fascia thickening and maximum tenderness at the medial calcaneal tubercle under complete US guidance. Group I was injected with 3ml PRP prepared by double centrifugation technique after withdrawing of 25 -30 ml of whole blood in 10% sodium citrate tubes. 0.1 ml sod. citrate for each 1ml blood. First centrifugation of blood using a 'soft' spin 1800 revolution per minute rpm for 15 min. to create upper plasma, middle buffy coat and lower red blood cell layer. The supernatant plasma was transferred containing platelets into another sterile tube without anticoagulant. The second centrifugation of the supernatant plasma at a higher speed a hard spin 3200 rpm for 10 min. The lower 1/3rd is PRP and upper 2/3rd is platelet-poor plasma PPP. At the bottom of the tube, platelet pellets are formed. PPP was removed and the platelet pellets were suspended in a minimum quantity of plasma 2-3mL by gently shaking the tube. [1] We did not add activator neither thrombin nor calcium chloride to PRP before injection, exogenous activation of PRP is not needed in soft tissue injections. [11]

Group II was injected with 1 ml of 8mg/2ml of dexamethasone sodium phosphate combined with 1mg mepecaine 3% as local anesthesia.

Precautions of injection technique of both group I and II

All the patients in group I stopped NSADs for 10 days before the injection. The injection was given with sterile aseptic precautions. Sterilization was made by 70% alcohol based solution ethanol by wiping the area of injection site.

Patients were positioned prone or lateral decuitus and maximally tender points were identified. Then the injection was made with medial approach and the ankle is neutral by 22 gauge needle and 3 ml. **Post injection:** Ice pack application was done for 10-15 min for the patients of both groups. We recommended the patient to stop any anti-inflammatory medications for a period of 2- 4 weeks following the procedure except acetamiophene was allowed after PRP injection and if possible throughout 6 months follow up period as they may diminish the effectiveness of PRP by their

anti-platelet effect. However, NSAIDs were recommended for the patients in group II as corticosteroid flare may occur. The patients were recommended to avoid weight bearing activities for 24hrs-72hrs then gradual increase of their activities for 2-4 weeks.

Group III received two sessions, two weeks apart of ESWT produced by DUOLITH SD1 Tower combined treatment of focused shock waves F-SW 2000 shocks, energy level 0.15 mj/mm^2 frequency 4Hz, and Radial shock waves R-SW 3000 shocks, energy level 2.0 bar, frequency 12Hz applied at area of maximum tenderness of plantar fascia attachment at medial calcaneal tubercle.

After treatment, the three groups were trained for daily home exercise program in the form of stretching and strengthening exercises to do at least 3 times per day for 6 months.

Clinical and ultrasonographic assessment:

All patients of our study were subjected to full history taking, thorough physical examination, visual analog scale VAS: 0–10 [22] , "Tenderness grading scale" Hubbard [19], Functional assessment: Foot function index score FFI [5]: The questionnaire is composed by 23 items distributed into three subscales: disability 5 items, activity limitation 9 items and pain 9 items. The sum of the score from all items answered by the patient / divided by the total score.

Complete blood count CBC, ESR, serum uric acid, radiological assessment by plain X-ray to detect calcaneal spur, and ultrasonography plantar fascia thickness and echogenicity. All Patients were assessed before treatment and 1, 3 and 6 months after treatment.

As regard ultrasonographic evaluation, all the patients underwent sonographic using SAMSUNG MEDISON UGEO H60, with linear array transducers frequencies ranging between 10-12 MHz. The plantar fascia is scanned with the patient lying prone with the feet dorsiflexed and hanging over the edge of the table and the ankle dorsiflexed to 90. The transducer is placed in a longitudinal position over the medial aspect of calcaneum.

Sagittal imaging of the plantar fascia was performed once the insertion is identified, Assessment of its thickness and echogenicity was done. The thickness of the plantar fascia was measured at its proximal end near its insertion into the calcaneus 1 cm away from the insertion point to the bone where the plantar fascia crosses the anterior aspect of the inferior border of the calcaneus. A plantar fascia thickness of more than 4 mm and reduced echogenicity were considered positive ultrasonographic findings for plantar fasciitis. Three measurements of the plantar fascia were taken to avoid error due to transducer obliquity, and the average of the 3 was recorded. [13]

Statistical analysis

Data were analyzed by the Statistical Package for the Social Sciences SPSS software version 20.0. Qualitative data were described using number and percent. The Kolmogorov-Smirnov test was used to verify the normality of distribution Quantitative data were described using range minimum and maximum, mean and standard deviation. Significance was considered at p-value <0.05.

The used tests were: Chi-square test X^2: For categorical variables, to compare between different groups. Fisher's Exact or Monte Carlo correction P^{MC}: Correction for chi-square when more than 20% of the cells have expected count less than. F-test ANOVA F: For normally distributed quantitative variables, to compare between more than two groups, Kruskal Wallis test H: For abnormally distributed quantitative variables, to compare between more than two studied groups and Friedman test $^{FR}X^2$: For abnormally distributed quantitative variables, to compare between more than two periods or stages. Cochran's test Q: For Categorical variables, to compare between more than two periods or stages.

3. Results

In the this study, patients receiving PRP in group I had a mean age of 44.30 ± 9.13; 25 –56 years which was comparable to the age of patients receiving corticosteroids in group II 41.45 ± 9.39; 23 – 58years and comparable to patients receiving shock wave therapy in group III 45.85 ± 9.59; 29-60 $p > 0.05$. Table 1.

In group I three of the patients 15% were males and seventeen 85 % were females and were matching with that in group II which included 2 10% males and 18 90% females and matching with patients in group III one 5% was male and 95% was female $p > 0.05$. table 1.

The three groups were matched as regard BMI, most of our patients were obese 50%,70%,55% in group I, II, and III respectively $p > 0.05$. Duration of disease was at least six months, the three groups were matched with no significant difference 11.70 ± 4.26, 9.40 ± 2.52, 10.40 ± 3.69 respectively $p > 0.05$. table 1.

Calcaneal spurs were found in 80%-75%-80% in the three groups respectively with no significant differences $p > 0.05$. Table 1.

There was significant improvement in between the three follow up periods in group I, II and III as regards VAS, degree of tenderness, FFI score and US findings reduced plantar fascia thickness and improved echogenicity i.e reduced percentage of hypoechoic fascia $p < 0.001^*$ table 2. Although, there was re increase VAS, degree of tenderness, FFI score, plantar fascia thickness and percentage of hypoechcoic fascia

in group II after 6 months follow up, they didn't reach the significance level. Table 2.

When we compared the change in improvement of the different parameters in the three groups in the three follow up periods, after one month there was better significant improvement of pain assessed by change of VAS p_1 value = 0.003* change of degree of tenderness p_1 value =0.011*, and change of FFI score p_1 value =0.019* between the three studied groups respectively. Group II show significant improvement of change of VAS, degree of tenderness and FFI score when compared with group I and III p4, p5 <0.05* table 3.

After 3 and 6 months the change in improvement of VAS, degree of tenderness and FFI score in between the three groups was statistical insignificant p2, p3 > 0.05 except change of VAS after 6 months between the three studied groups was statistical significant P3=0.028*. Group II and III showed significant improvement of change of VAS when compared to group II after 6 months ^P4, ^P5<0.05* table 3.

As regard ultrasonographic findings, the change in plantar fascia thickness, there was significant differences after one month between the three groups p1 value =0.042*, but the change reduction in plantar fascia thickness in between the three groups after 3and 6 months were statistical insignificant. p 2, p3 > 0.05. Group II showed significant improvement of change of thickness of plantar fascia when compared with group I after one month P4=0.042* table 3.

Percentage of hypoechoic fascia reduced significantly in each group, however, there was insignificant differences in between the three studied groups in the three follow up periods. table 3.

After 6 months complete relief of pain was obtained in 65% of patients of group I, and III, the differences between them and group II were statistically significant p value =0.011*. The differences of partial improvement of pain in the three groups were statistically insignificant. The least cases with no improvement was in group I and the difference between it and group II was statistically significant. p value =0.013* figure 1.

Table 1 Demographic data and x-ray finding before treatment

	Group I		Group II		Group III		P value
Sex Male Female	No. 3 17	% 15% 85%	No 2 18	% 10% 90%	No 1 19	% 5% 95%	0.863
Age	44.30 ± 9.13		41.45 ± 9.39		45.85 ± 9.59		0.329
BMI	32.08 ± 2.58		30.66 ± 1.73		31.37 ± 2.31		0.142
Duration of complaint	11.70 ± 4.26		9.40 ± 2.52		10.40 ± 3.69		0.281
x-rays findings presence of spur absence of spur	16 80% 4 20%		15 75% 5 25%		17 85% 3 15%		0.917

Table 2 Clinical VAS, degree of tenderness, FFI score and ultrasonographic assessment thickness of plantar fascia and echogenicity in groups I, II, and III before and after 1, 3, and 6 months follow up.

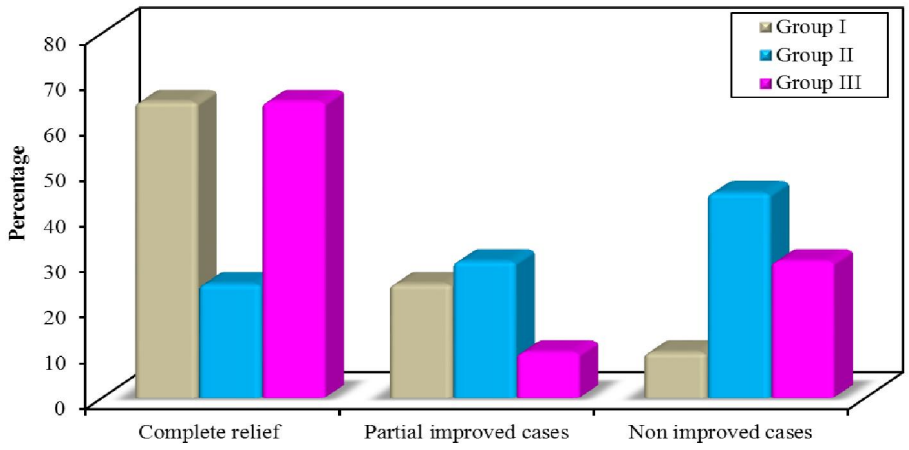
	Group I					Group II					Group III				
	Before	1st month	3rd month	6th month	p	Before	1st month	3rd month	6th month	p	Before	1st month	3rd month	6th month	p
VAS	9.40 ± 0.50	6.45 ± 0.76	3.75 ± 1.52	1.55 ± 2.33	P=<0.001* $^{Fr}\chi^2$=55.75	9.10 ± 0.72	4.70 ± 1.84	3.40 ± 1.90	3.70 ± 3.08	P=<0.001* $^{Fr}\chi^2$39.303*	9.30 ± 0.57	5.95 ± 0.83	4.20 ± 2.04	2.25 ± 3.24	<0.001* $^{Fr}\chi$ 46.021*
Degree of tenderness	2.90 ± 0.72	1.40 ± 0.50	0.50 ± 0.69	0.20 ± 0.62	P=<0.001* $^{Fr}\chi^2$=56.800*	3.0 ± 0.56	1.05 ± 0.69	0.55 ± 0.83	0.75 ± 1.02	P=<0.001* Frχ245.268*	2.75 ± 0.72	1.40 ± 0.60	0.75 ± 0.85	0.60 ± 0.88	<0.001* $^{Fr}\chi$ 46.562*
FFI score	213.5 ± 11.95	156.5 ± 18.29	74.15 ± 44.82	28.25 ± 52.37	P=<0.001* $^{Fr}\chi^2$=55.246*	217.8 ± 8.70	109.7 ± 62.80	64.55 ± 62.37	71.45 ± 82.94	P=<0.001* $^{Fr}\chi^2$ 40.240*	213.6 ± 12.30	151.6 ± 26.49	81.55 ± 61.68	57.40 ± 80.48	<0.001* $^{Fr}\chi^2$44.161*
Thickness of PF	6.55 ± 0.87	6.12 ± 0.96	5.64 ± 0.84	5.56 ± 0.89	P=<0.001* F=26.93*	6.07 ± 1.03	4.93 ± 0.90	4.81 ± 1.02	4.96 ± 1.21	P= <0.001* F=26.821*	6.33 ± 1.32	5.53 ± 1.33	5.35 ± 1.0	5.08 ± 0.88	<0.001* F=13.287
Echogenicity Normoechoic hypoechoic	25% 75%	45% 55%	70% 30%	80% 20%	P=<0.001* Q= 21.143*	35% 65%	65% 35%	70% 30%	60% 40%	P=<0.001* Q=12.429*	15% 85%	55% 45%	75% 25%	80% 20%	\P=<0.001* Q= 29.233

P= p value for comparing the three follow up periods
$^{Fr}\chi^2$ = Friedman test F= F-test ANOVA Q =Cochran's test

Table 3: pain VAS, degree of tenderness, FFI score and thickness of PF between the three studied groups. Comparison of improvement of echogenicity in the three groups in different follow up periods.

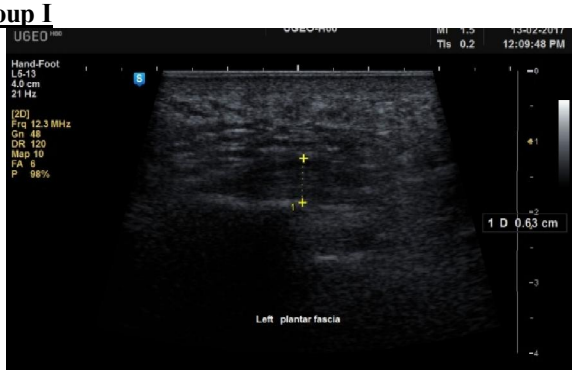
Chang of	Group I			Group II			Group III			p
	Before/1st Flollow up	Before/2nd Flollow up	Before/3rd Flollow up	Before/1st Flollow up	Before/2nd Flollow up	Before/3rd Flollow up	Before/1st Flollow up	Before/2nd Flollow up	Before/3rd Flollow up	
VAS	2.95 ± 0.76	5.65 ± 1.50	7.85 ± 2.35	4.40 ± 1.54	5.70 ±1.84	5.40 ± 3.07	3.35 ± 0.81	5.10 ± 2.0	7.05 ± 3.14	P1=0.003* P2=0.242 P3=0.028* P4=0.001* P5=O.O25* ^P4=0.011* ^P5=0.045*
Degree of tenderness	1.50 ± 0.51	2.40 ± 0.60	2.70 ± 0.80	1.95 ± 0.69	2.45 ±0.76	2.0 ± 0.86	1.35 ± 0.49	2.0 ± 0.86	2.15 ± 1.04	P1=0.011* P2=0.148 P3=0.170 P4=O.039* P5=0.003*
FFI score	57.0 ± 17.06	139.35 ± 41.05	185.25 ± 51.41	108.10 ± 58.90	153.25 ± 60.38	146.35 ± 82.13	61.95 ± 18.51	132.0 ± 58.06	156.15 ± 78.50	P1=0.019* P2=0.109 P3=0.96 P4=0.007* P5=0.014*
Thichness of PF	0.43 ± 0.75	0.91 ± 0.92	0.99 ± 0.98	1.14 ± 0.82	1.26 ±0.92	1.11 ± 1.11	0.81 ± 1.14	0.99±0.99	1.25 ± 1.23	P1=0.042* P2=0.022 P3=0.882 P4=0.042* P5=0.271
Echogenicity of PF Normal Hypoecoic	45% 55%	70% 30%	80% 20%	65% 35%	70% 30%	60% 40%	55% 45%	75% 5%	80% 20%	P1=0.446 P2=0.921 P3=0.256

P1= p value between three groups in change of parameters between before and 1st follow up.
P1of echogenicity of PF comparing between group I and II
P2= p value between three groups in change of parameters between before and 2nd follow up
P2 of echogenicity of PF, comparing between group I and III
P3= p value between three groups in change of parameters between before and 3rd follow up
P3 of echogenicity of PF comparing between group I and III
P4 = p value for comparing between group I and II in first follow up
P5= p value for comparing between group II and III in first follow up
^P4= p value for comparing between group I and II in third follow up
^P5= p value for comparing between group II and III in third follow up



Comparison between the three studied groups as regard improvement of pain at the end of follow up. 65% of patients in group I and III show complete relief of pain, 30%, 45% in group III and II respectively show no improvement.

Group I



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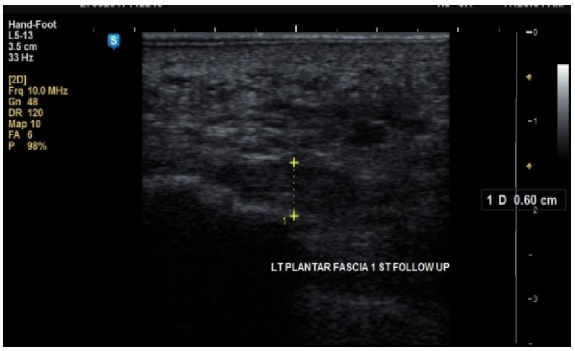

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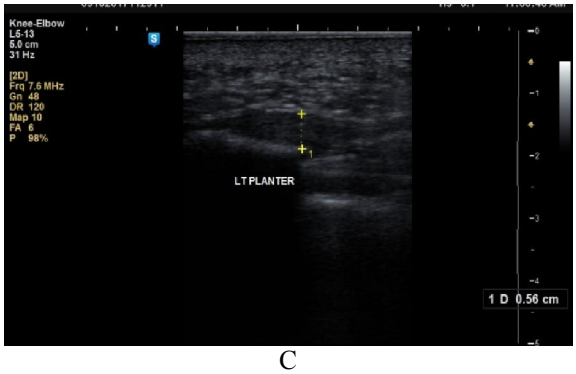

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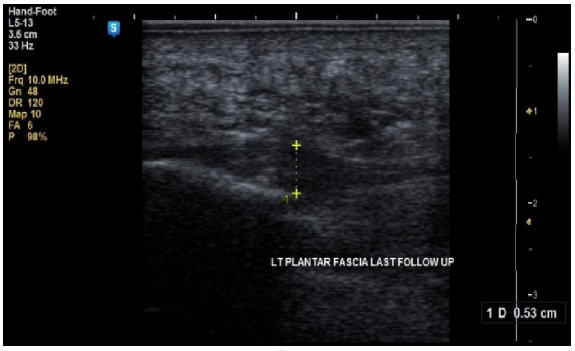
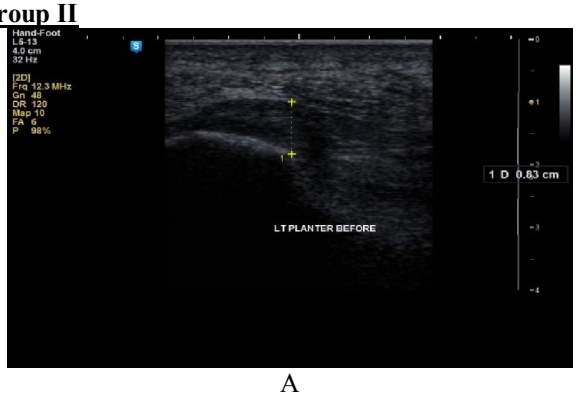


D

Longitudinal axis of left plantar fascia show hypoecchoic fascia and its thickness was 6.3 mm before treatment. Improvement of thickness 5.3 mm and echogenicity at the end of follow up.

Group II



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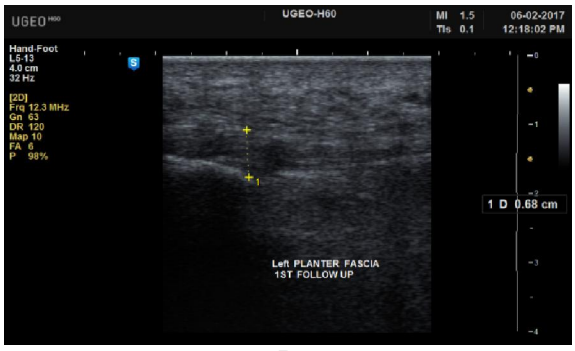

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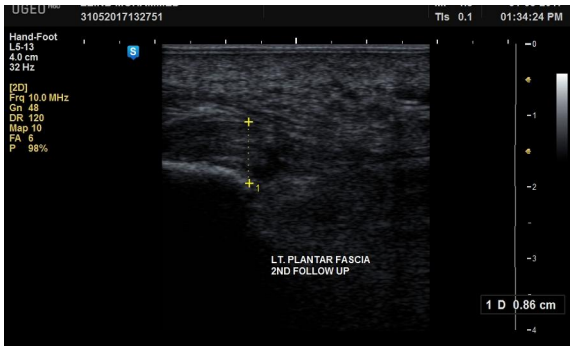

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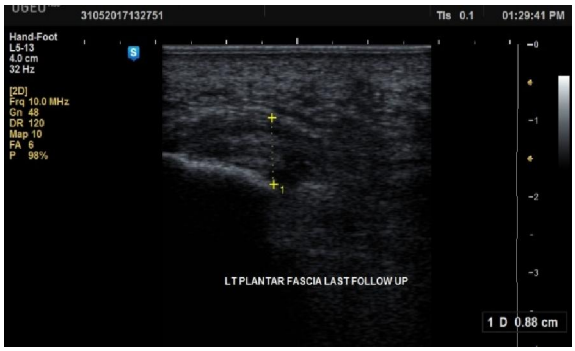
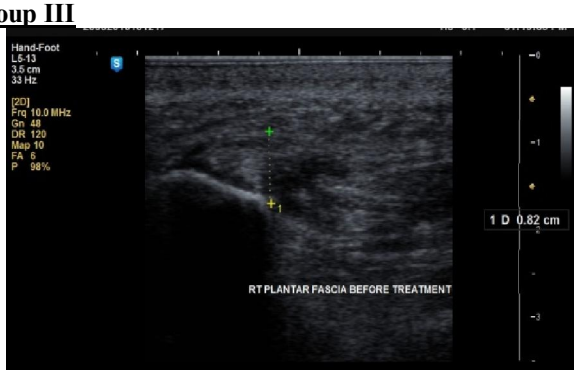


D

Longitudinal axis of left plantar fascia show hypoecchoic fascia and its thickness was 8.3 mm before treatment

Rapid improvement of thickness 6.8 mm and echogenicity at 1st follow up, Increase of thickness and reduction of echogenicity at 2nd and 3rd follow up.

Group III



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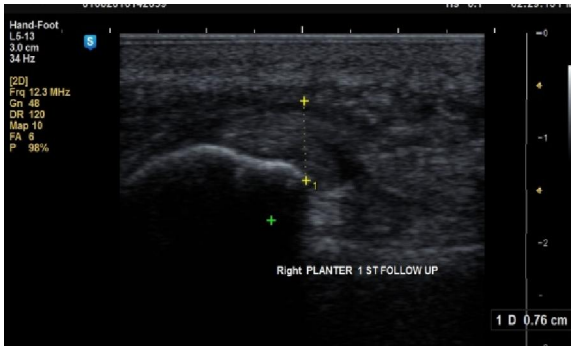

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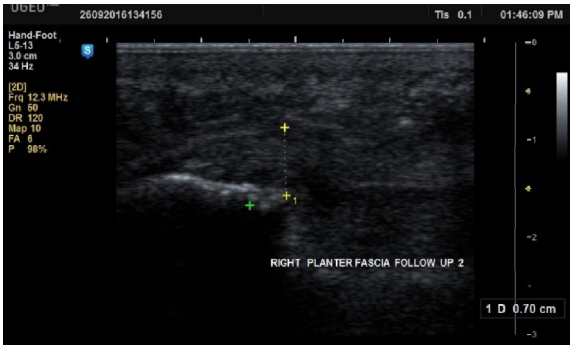

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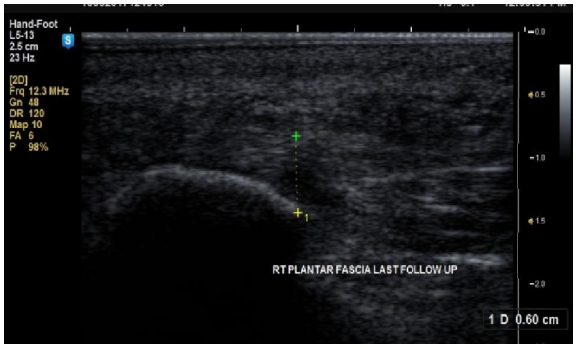

D

Longitudinal axis of right plantar fascia show hypoecchoic fascia and its thickness was 8.2 mm before treatment Improvement of thickness 6 mm and echogenicity at the end of follow up.

4. Discussion

Plantar fasciitis is the most common cause of heel pain in middle age population and especially those with prolonged weight-bearing on their feet like athletes or soldiers. [3] Our study was designed to compare the effect of autologous PRP injection with the classic steroid injection and shock wave therapy in treatment of chronic PF both clinically, functionally and sonographically within 6 months and evaluate role of ultrasonography in diagnosis and follow up effects of treatment in chronic plantar fasciitis. In group I patients treated with PRP, there was significant reduction of pain and degree of tenderness after 1, and 6months follow up when compared with before treatment.

These results show agreement with **Baza et al. 2017** [3] who made a study on 44 patients with chronic PF treated with two injections of PRP separated by 2 weeks under US guide, and they found significant improvement of VAS score from an average of 8.14 pre injection to 2.59 at the 4th month post injection.

Ragab et al. 2012 [27] studied ultrasound guided PRP injection in 20 patients with chronic PF. Their patients were assessed for the pain by VAS before and after the injection and ultrasound measurement of the plantar fascia thickness was done. They found that 88% of patients had complete satisfaction, two patients 8% were satisfied but with reservations and one patient 4% was unsatisfied by the VAS.

A possible explanation for pain relief in PRP was related to platelet analgesic properties. Substances released from the dense granules of platelets such as serotonin may have a positive effect on decreasing pain. PRP contains proteins that alter the patient's pain receptors and reduce pain sensation. It also exerts anti-inflammatory effects on injured tendons. [35, 18]

The effect of PRP on PF healing is mainly related to some growth factors and cytokines. The PRP is enriched by platelet-derived growth factor, endothelial growth factor and transforming growth factor as well as some anti-inflammatory and pro-inflammatory cytokines interleukin IL -4, IL-8, IL-13, IL-17, tumor necrosis factor-α and interferon-α. The combination of these growth and anti-inflammatory components can initiate the healing stages necessary to reverse the degenerative process at the base of the plantar fascia, enhance fibroblast migration and proliferation, up-regulate vascularization and also can increase collagen

production and deposition. However, these influences seem to be dose-dependent and thus obtaining optimal dosage with maximized effect is necessary. [33,24]

In group II, patients treated with corticosteroid, there was significant reduction in pain and degree of tenderness in the three periods of follow up when compared with before treatment. Our results partially supported by **Crawford et al. 1999** [10] who demonstrated that steroid injection produced relief of heel pain at 1 month, which did not persist at 3 months' follow-up.

Genc et al. 2005 [15] evaluated the long-term efficacy of steroid injection for PF using clinical parameters and high-resolution US. They found significant improvements in US findings at 1 and 6 months follow-ups and marked improvement in VAS values as well. These findings reflect the positive long-term effects of local steroid injection for PF. This was different from our results which supported by **Crawford et al. 1999** [10] who demonstrated that steroid injection produced relief of heel pain at 1 month, which did not persist at 3 months' follow-up.

Pain relief is mediated through its anti-inflammatory effect; it restricts the accumulation of leukocytes and macrophages and reduces the release of vasoactive kinins. [31, 16] However, as described, histopathological studies indicate that PF is predominantly a degenerative disorder, with limited involvement of chronic inflammatory processes. Consistent with these findings, absence of inflammation is also reported in the tendinopathy literature. [9]

So, the action of corticosteroid can be explained by that it has been shown to inhibit fibroblast proliferation and expression of ground substance proteins. It is possible that these known effects may be of benefit in the treatment of PF, as increased fibroblast proliferation and excessive secretion of destructive enzymes are commonly reported features of the condition. [25]

In group III, patients treated with combined therapy of focused and radial shock wave therapy, there was significant reduction in pain and degree of tenderness in the three periods of follow up when compared with before treatment. In our study we used combined focused and radial ESWT to maximize its effects. The effectiveness of each type or combinations have been studied in several studies and some reported difficulty in accurate evaluation of the efficacy of general ESWT for chronic PF as the 2 shock wave types have different effectiveness levels and got the benefits of both modalities as reported by **Yin et al. 2014** [34] who found in a meta-analysis study difficulty in determination which was more effective.

Chang et al. 2012 [6] have done a systematic review and network meta-analysis to study and compare the effectiveness of focused shock wave therapy of different intensity levels and radial shock wave therapy for treating PF. They concluded that setting the highest and mostly tolerable energy output within medium intensity ranges is the ideal option when applying focused SW therapy on PF. Because high-intensity focused SW therapy requires adjuvant local anesthesia, which may be harmful to final outcomes.0.25 mJ/mm 2 is considered appropriate, and most patients can tolerate it without prior anesthesia.

In our study, medium intensity 0.15 mJ/mm 2 focused SW was used during the session. Nevertheless, **Liang et al. 2007** [23] suggested that high and medium-intensity treatments exhibited nearly the same improvement in pain.

The beneficial effects of shock wave therapy in treatment of chronic PF and relief of pain are attributed to several mechanisms:

First of all destruction of unmyelinated sensory nerve fibers and eliciting neovascularization in degenerative tissues. Its effectiveness is influenced mainly by intensity levels, as reported by **Chow and Cheing 2007** [7] who found that directing focused SW therapy with a maximum tolerable energy density destroyed more unmyelinated sensory nerve fibers and might contribute to long-term analgesia. Hyperstimulation analgesia in which over stimulation of the treated area would lead to diminished transmission of signals to brain stem that would block gate-control mechanism or influence pain transmission by acting on substance P and calcitonin gene related peptide expression in the dorsal root ganglion and on neurovascular sprouting. [14]

Dorotka et al. 2006 [12] found that regarding the relationship between the intensity level and the reduction in pain scales, every 0.1mJ/mm 2 increase in therapeutic intensity might be associated with a 0.273 decrease in VAS in focused SW.

Also, shock wave therapy had anti-inflammatory effects through the release of nitric oxide which has antalgic, angiogenitic and anti- inflammatory effects. [14]

And finally, mechanical and physical effects of SW therapy is converted into biochemical signals, mechanical load on the cytoskeleton leads to cell responses and increase protein synthesis and tissue regeneration. ESWT has been showed to induce anabolic response of tendons and ligaments tissues and increased vascularization in bone –tendon junction through the release of growth factor. [14]

At the end of follow up periods, complete relief of pain was obtained in 65% of patients of group I and III, the differences between them and group II were statistically significant. The least cases with no improvement was in PRP group 10% and the difference between it and corticosteroid group was statistical significant.

So, corticosteroid show rapid onset short duration effect when compared to PRP and shock wave therapy which showed more durable effects, and this confirms the reports obtained by other studies suggesting improvement in the healing process of tendinous structures after local injection of PRP and SW therapy, steroid injections only serve as an anti-inflammatory agent that cease the inflammation early within days and has a nearly negligible effect on regeneration; remodeling and maturation phase which occurs at a much slower rate compared with the PRP environment rich in growth factors.

Our results is supported by the conclusion of a meta- analysis done by **Hsiao et al 2015** [17] which compared the efficacy of PRP, corticosteroids and SW therapy and their results showed that PRP followed by corticosteroids were best in providing early pain relief, however PRP and SW therapy showed better pain reduction than corticosteroids at 6 months.

Lee and Ahmad 2007 [20] compared autologous blood injection with corticosteroid injection. They found that although autologous blood significantly decreased pain levels and increased tenderness thresholds over the six-month follow-up period, corticosteroid was considered superior in terms of speed and, probably, extent of improvement.

Ball et al. 2013 [2] reported significant benefits with corticosteroid injection in the short and medium term. However, corticosteroid injection has high frequency of relapse and recurrence of pain after 6 months.

In conclusion, musculoskeletal US was helpful not only in diagnosis of plantar fasciitis but also to guide and to evaluate the effects of treatment. The best improvement of chronic PF was in the group treated with corticosteroid injection obtained early after one month follow up. Better improvement of pain in PF was in patients treated with PRP or SW therapy when compared with corticosteroid injection after 6 months follow up period. So, we recommend the use of MSK US in diagnosis, guidance during injection and to evaluate the effects of treatment of chronic PF. Platelet-rich plasma and SW therapy are effective in relieving pain and improving function in the treatment of primary chronic PF, so we recommend them in the treatment to obtain superior results after failure of corticosteroid and traditional physical therapy. Further studies on large scale of patients and longer period of follow up to confirm our results are recommended.

Our study is one of the studies which designed to compare the use of PRP, corticosteroid and ESWT for the treatment of chronic PF. However, this study has some limitations. First we did not include a placebo or control group or group who had excersises treatment only which had very effective role in treatment of chronic plantar fasciitis. There were some factors which were attributed to failed treatment in the three groups such as increase in activity level of the patients, changes in lifestyle, weight gain, and shoe changes. In group II, our patients were injected with dexamethasone sodium phosphate, which had short duration of action when injected locally, this may be the cause why 30% of patients showed partial improvement, and 45% of patients showed no improvement at the end of follow up periods. However, Dexamethasone phosphate was used in our study as it is freely water soluble so the preparation is not particulate in the soft tissue and taken up rapidly by the cells to avoid hazards of steroid injection as twice injections was performed. however, other preparations as corticosteroid esters are highly insoluble in water and thus form microcrystalline suspensions. In group III, our patients received two sessions of combined treatment with intensity level 0.15mj mm in focused shockwave, we think, intensity level of 0.25mj.mm for at least 3 sessions is the best and recommended regimen in treatment of chronic plantar fasciitis and this was the cause why 30%of patients showed no improvement at the end of follow up periods in our study.

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References

1. Anitua E, Prado R, Sánchez M, et al: Platelet-rich-plasma: Preparation and formulation. Oper Tech Orthop.2012: 22:25–30.
2. Ball E, McKeeman H, Patterson C, et al: Steroid injection for inferior heel pain: a randomised controlled trial Ann Rheum Dis.2013:72: 996-1002.
3. Baza A, Gad A, and Walyb M: Ultrasound guided injection of platelet rich plasma in cases of chronic plantar fasciitis The Egyptian Journal of Radiology and Nuclear Medicine.2017: 48 (1): 125-132.
4. Berbrayer D and Fredericson M: Update on Evidence-Based Treatments for Plantar Fasciopathy. PM & R. 2014: 6 (2): 159-169.
5. Budiman-Mak E, Conrad K, Roach K, et al: The Foot Function Index: a measure of foot pain and disability. J Clin Epidemiol.1991: 44:561–570.
6. Chang k, Chen S, Chen W, et al: Comparative Effectiveness of Focused Shock Wave Therapy of Different Intensity Levels and Radial Shock Wave Therapy for Treating Plantar Fasciitis: A Systematic Review and Network Meta-Analysis. Archives of Physical Medicine and Rehabilitation.2012: 93 7: 1259-1268.
7. Chow I and Cheing G: Comparison of different energy densities of extracorporeal shock wave therapy ESWT for the management of chronic heel pain. Clin Rehabil.2007: 21: 131-141.

8. Cole B and Schumacher H: Injectable corticosteroids in modern practice. J. Am. Acad. Orthop. Surg.2005: 13: 37-46.
9. Cook J and Purdam C: Is tendon pathology a continuum? A pathology model to explain the clinical presentation of load-induced tendinopathy. Br J Sports Med.2009: 43:409-416.
10. Crawford F, Atkins D, Young P, et al: Steroid injection for heel pain: evidence of short term effectiveness. A randomised controlled trial Rheumatology.1999: 38: 974-977.
11. Dhurat R and Sukesh M: Principles and Methods of Preparation of Platelet-Rich Plasma: A Review and Author's Perspective J Cutan Aesthet Surg. 2014: 7 4: 189–197.
12. Dorotka R, Sabeti M, and Jimenez-Boj E: Location modalities for focused extracorporeal shock wave application in the treatment of chronic plantar fasciitis. Foot Ankle Int. 2006:27:943-947.
13. Draghi F, Gitto S, Bortolotto C, et al: Imaging of plantar fascia disorders: findings on plain radiography, ultrasound and magnetic resonance imaging insights Imaging.2017:8 (1): 69–78.
14. Fouda Z and El Laithy M: Effect of law energy versus medium energy radial shock wave therapy in the treatment of chronic plantar fasciitis. International Journal of Physiotherapy.2016: 3 (6): 5-10.
15. Genc H, Saracoglu M, Nacır B, et al: Long-term ultrasonographic follow-up of plantar fasciitis patients treated with steroid injection. Joint Bone Spine. 2005:72 1: 61-65.
16. Hong H, Yoon S, Moon D et al: Comparison of high- and low-dose corticosteroid in subacromial injection for periarticular shoulder disorder: a randomized, triple-blind, placebo-controlled trial. Arch Phys Med Rehabil. 2011:92 12: 1951-60.
17. Hsiao M, Hung C, Chang K, et al: Comparative effectiveness of autologous blood-derived products, shock-wave therapy and corticosteroids for treatment of plantar fasciitis: a network meta-analysis. Rheumatology.2015: 54 9: 1735–1743.
18. Ibrahim DH, El-Gazzar NM, El-Saadany HM, El-Khouly RM. Ultrasound-guided injection of platelet rich plasma versus corticosteroid for treatment of rotator cuff tendinopathy: Effect on shoulder pain, disability, range of motion and ultrasonographic findings. The Egyptian Rheumatologist. 2019 Apr 1;41(2):157-61.
19. Kannan P: Management of myofascial pain of upper trapezius: a three group comparison study. Glob J Health Sci. 2012: 4 (5):46-52.
20. Lee T and Ahmad: Intralesional autologous blood injection compared to corticosteroid injection for treatment of chronic plantar fasciitis. A prospective, randomized, controlled trial. Foot Ankle Int. 2007:28: 984-990.
21. Lemont H, Ammirati K, and Usen N: Plantar fasciitis: A degenerative process fasciosis without inflammation. J Am Podiatr Med Assoc2003:.93: 234-237.
22. Li D, Puntillo K, and Miaskowski C: A review of objective pain measures for use with critical care adult patients unable to self-report. Journal of Pain.2008: 9 1: 2-10.
23. Liang H, Wang T, and Chen W: Thinner plantar fascia predicts decreased pain after extracorporeal shock wave therapy. Clin Orthop Relat Res. 2007:460:219-225.
24. Martinelli N, Marinozzi A, Carnì S, et al: Platelet-rich plasma injections for chronic plantar fasciitis. Int Orthop. 2013:37 8:39–42.
25. Mukudai S, Mastuda K, and Kawata M: Differential responses to steroid hormones in fibroblasts from vocal fold, trachea and esophagus. Endocrinology.2015165 3:1000-1009.
26. Neufeld S and Cerrato R: Plantar fasciitis: evaluation and treatment. J Am Acad Orthop Surg.2008: 16:338 – 346.
27. Ragab E. and Othman A.: Platelets rich plasma for treatment of chronic plantar fasciitis. Arch Orthop Trauma Surg. 2012:132:1065–1070.
28. Razzano C, Carbone S, Mangone M, et al: Treatment of Chronic Plantar Fasciitis with Non invasive Interactive Neurostimulation: A Prospective Randomized Controlled Study. The Journal of Foot and Ankle Surgery. 2017:56 4:768-772.
29. Ryan G: Injuries to the lower leg, How to manage plantar fasciitis. In: MacAuley D and Thomas M, eds. Best Evidence-based Sports Medicine, 2nd ed. Blackwell Publishing. Section 2007: 6:p.586-600.
30. Saba E and El-Sherif S: Ultrasound-guided versus palpation-guided local corticosteroid injection therapy for treatment of plantar fasciitis. The Egyptian Rheumatologist. 2016:38 2:123-131.
31. Skedros JG, Hunt KJ, and Pitts TC: Variations in corticosteroid/anaesthetic injections for painful shoulder conditions: comparison among orthopaedic surgeons, rheumatologists, and physical medicine and primary-care physicians. BMC Musculoskelet Disord.2007: 8:63.
32. Taunton J, Ryan M, Clement D, et al: A retrospective case-control analysis of 2002 running injuries. British Journal of Sports Medicine.2002. 36 2:95–101.
33. Vahdatpour B, Kianimehr L, Moradi A, et al: Beneficial effects of platelet-rich plasma on improvement of pain severity and physical disability in patients with plantar fasciitis: Adv Biomed Res. 2016:285:179.
34. Yin M, Ye J, Yao M, et al: Is extracorporeal shock wave therapy clinical efficacy for relief of chronic, recalcitrant plantar fasciitis? A systematic review and meta-analysis of randomized placebo or active-treatment controlled trials. Arch Phys Med Rehabil.2014: 95:1585–1593.
35. Zhang J and Wang J: PRP treatment effects on degenerative tendinopathy–an in vitro model study. Muscles Ligaments Tendons J.2014: 4:10-17.