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Comparison of the effect of shock wave therapy and ultrasound therapy in the treatment of plantar fasciitis

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Abstract
Objective. This study compared the effectiveness of shock wave therapy (SWT) with ultrasound (US) therapy in the treatment of plantar fasciitis (PF).
Study Design: Pre –Post experimental Study Design
Design: A total of 45 patients with unilateral PF were randomly assigned to three study groups. All groups performed home exercises. In addition, the first study group received Four sessions of SWT treatment and the second study group received US treatment. Third Group (CG) received home physiotherapy exercises. The Foot Function Index (FFI) and the American Orthopedic Foot and Ankle Association (AOFAS) hind foot score were determined. Static and dynamic equilibrium were evaluated with the single leg standing test and the functional reach test. Patients were evaluated before and two weeks, after the first treatment.
Results: According to the evaluation results, there was a decrease in FFI values in all groups and these decreases were more prominent in the SWT group than the other two groups ($P < 0.05$). It was observed that the hind foot AOFAS scores increased in both study groups, but this increase was less in the ultrasound group ($P < 0.05$). Static and dynamic balance increased in both study groups ($P < 0.05$).
Conclusions: All group's symptoms were decreased after treatment. However; FFI parameters were reduced more in the SWT group than the other two groups.

Keywords: plantar fasciitis; shock wave therapy; ultrasound therapy; physiotherapy exercise

Introduction
20% to 30% of the patients [1, 2, 3]. PF occurs due to factors that can be anatomical (such as pes planus, pes cavus, the size difference of the lower limbs) [3, 4] bio- mechanical (such as more external rotation in the lower extremities, pronation increase in the subtalar joint, shortening of the Achilles tendon, weakness of plantar flexors) [4, 5] or environmental (such as obesity, improper shoes) [6, 7, 8, 9, 10]. The most important symptom is pain that increases especially in the morning while get- ting out of bed and that can appear after standing inactive for a long time. It is often described as at the heel, over the proximal medial longitudinal arc, around the medial tubercle, and at the plantar fascia adhesion site [3, 10, 11]. Approximately 28% to 66% of patients with PF have also signs of a heel spur [10].
Treatment modalities for PF can be surgical or conservative. The success rate of conservative treatments such as splints, ultrasound therapy, iontophoresis, laser therapy, shock wave therapy, exercise therapy, steroid injection, etc., is 90% to 95% [12, 13]. Surgery should therefore only be a last resort [14, 15, 16, 17].
Some studies have compared different treatment modalities to find the most effective treatment for PF [18, 19, 20]. However, we do not have precise information about the most effective conservative treatment method. It has also been stated that combining treatment modalities is needed for successful treatment [21, 22, 23, 24].
There are no studies comparing the acute effects of shock wave therapy (SWT) and ultrasound (US) treatment in the treatment of PF, and it has been stated that more detailed studies are required [4]. Therefore, this study was designed to compare the acute effects of SWT and US treatment in the treatment of PF.

Methods
Patients
This prospective, single-blinded study was performed in GMCH-32 Chandigarh. Patients diagnosed with PF by an orthopaedician and meeting the study criteria were invited to participate. Patients who agreed to participate in the study signed a written informed consent form.
The sample size of this study was evaluated, and power calculations were performed using an instant sample size calculator. The alpha level used was 0.05, and the b level 20% at a desired power of 80%. These parameters generated a sample size of at least 15 patients per group. The study was therefore completed with a total of 45 patients meeting the inclusion criteria and
Study rules 30 (average age 50 years, range 39 to 59 years) male and female patients with PF were randomly assigned to the SWT (N=15) group and US (N=15) group and CG (N=15).
The inclusion criteria were tenderness on palpation of the heel, presence of pain in the plantar region for at least one month, presence of a calcaneal spur in lateral radiographs of the foot, and unilateral PF. Exclusion criteria consisted of a history of surgery or trauma of the lower extremities, low back surgery (that may

affect the proprioception sense result), limitation of lower extremity joints, neurological and vestibular system disorder, systemic inflammatory disease, steroid injections in the last six months, pacemakers, coagulation problems, using anticoagulant medication, and body mass index greater than 30 kg/m^2 or less than 20 kg/m^2 as they could influence the effectiveness of the applied treatment. In addition, patients who exercised regularly (stretching, aerobic exercises such as walking, running, swimming, etc., for at least half an hour a day, three days a week) were also excluded from the study as it could change the effectiveness of home exercises.

Outcome Measurements

The first evaluation was performed before the first treatment for all three groups. The last evaluation was performed two weeks after the last SWT treatment for the SWT group and two weeks after the last US treatment for the US and CG groups.

The individual's personal information was filled in the form for demographic information.

The patients' pain, disability, and activity limitation were determined with the Foot Function Index (FFI), and they were asked to show their pain level, disability, and activity limitations on a 10 cm visual analog scale (VAS) with measurements made using a ruler. Pain, disability, and activity limitation scores were collected and the category considered separately. Similarly, foot functioning was determined by the American Orthopedic Foot and Ankle Association (AOFAS) hind foot score [13]. Static equilibrium was determined by the one leg stand test, and dynamic equilibrium was determined by the forward functional reach test. These evaluations were made before and after the treatment.

Interventions

Individuals were randomly divided into three groups. Each group was given a home exercise program. In addition to the home exercises, the first study group received a total of four sessions of SWT treatment administered twice a week, and the second study group received a total of ten sessions of US treatment administered five days a week. The third group was used as the control group and did not receive a treatment modality other than home exercises.

All individuals in the study were asked not to perform any exercise other than the home exercise program provided and not to use any orthotic support during the treatment so that the results would not be affected. We gave the patients a schedule for them to note the exercise sessions including the date, the start and end times of the exercise, and the times of the day. We also told the patients to note whether they used any support or performed any exercise other than the ones recommended. Incompliant subjects were dropped out of the study.

SWT Treatment

Individuals in the first group were treated with an SWT device (Enraf Nonius Endo-Puls 811; The Netherlands) at Frequency 10 Hz, Power 60 mJ, 2500 pulses, and 1.8 bar pressure was used. The treatment was performed in the prone position. The most painful point was determined with palpation and marked before starting each treatment. A gel was used to provide conductivity between the probe and the skin during the application. A total of two sessions of SWT treatment were administered once a week for two weeks.

US Treatment

Individuals in the second group were treated with (Medison 2 1/3; Medical Technology, Enraf Nonius, The Netherlands) Power 1.5 W/cm^2, Pulse 50%, Frequency 3 MHz, for 10 Minutes was applied for 2 weeks. The treatment was performed with longitudinal movements in the prone position using the full-contact technique all along the plantar fascia. US treatment was applied with3.0 MHz frequency, power density 1 W/cm^2. During the application, a gel was used to provide conductivity between the US probe and the skin. The patients were treated five days per week for a total of ten sessions.

Home Exercise Program

This program was prescribed to all patients and included stretching of the gastrocnemius and gastrosoleus muscles by standing (standing calf stretch exercise, standing soleus muscle stretch exercise), the Achilles tendon by sitting (towel stretch exercise) and the plantar fascia on a step (plantar fascia stretch exercise). Patients were asked to do the exercises for two weeks, 10 times each morning and evening by counting up to 30.

Statistical Analysis

The data were evaluated using the Statistical Package for the Social Science 15.0 program for Windows and via descriptive statistics analysis (frequency, mean, minimum and maximum, and standard deviation). Before starting the study, a power analysis was performed to determine the number of patients required. The Kolmogorov-Smirnov test was used to determine whether data distribution was normal, and it was determined that the data did not have a normal distribution. We therefore used the Wilcoxon signed rank test to compare the treatment groups' data before and after the treatment. The Kruskal-Wallis test was used to determine the group causing the differences between the three groups. The Mann-Whitney U test was used to make comparisons between the two groups. The statistical significance level was a *P* value of less than 0.05, and we used 95% confidence intervals.

Results

The patients' characteristics are shown in Table 1. There was no significant difference between the three groups ($P > 0.05$).Pretreatment evaluation results are presented in Table 2. Pretreatment values of the AOFAS score and FFI results were similar in all three groups ($P > 0.05$). There was also no difference between the pretreatment. Values of the one leg stance test, functional reach tests, and passive ankle proprioception sense between the groups ($P > 0.05$). These results indicated that our groups were distributed homogeneously before the treatment. After treatment, there was a reduction in the FFI's pain, disability, and activity limitations subtitles in all three groups ($P < 0.05$), but these were most marked in the SWT group compared with the two other groups ($P < 0.05$). The AOFAS score of hind legs increased in all groups, but the end value was less in the control group than in the other groups ($P < 0.05$). An improvement was recorded in the one leg stance and functional reach tests ($P < 0.05$) with no difference between the groups ($P > 0.05$).

Table 1: Patient demographic

Age, y	**50.0066.54(39–59)**	**50.1169.29(32–65)**	**45.2267.64(32–62)**	**4.596**	**0.100**
Education level, y	3.9463.75(1–11)	3.2264.04(0–11)	3.7864.02(0–11)	3.281	0.703
BMI, kg/m^2	28.5861.67(23.51–29.94)	28.4862.15(21.97–29.94)	28.0362.04(22.95–29.97)	1.299	0.522

Discussion

In this study, a total of 45 patients with unilateral PF were randomly assigned to two study groups and one control group. All groups performed home exercises. In addition, the first study group received four sessions of SWT treatment and the second study group received ten sessions of US treatment. At the end of the study, all groups got better. However, FFI parameters were reduced more in the SWT group than the other two groups. In our study, FFI's pain, disability, and activity limitations subtitles were reduced in all three groups after the treatment. This reduction occurred more in the US group than the other groups. The inflammatory process in PF causes pain due to thickening of the plantar fascia and affects the patient's activities in daily living. The SWT treatment increases the cellular activity level and the circulation with its thermal, nonthermal & mechanical effects and heals the inflammatory process while creating an analgesic effect [29].

We believe SWT treatment caused a more significant reduction in pain and decreased activity limitations and disability because of these effects. All three groups in our study and especially the SWT and US groups similarly had a significant improvement in all parameters. We did not have a placebo group, but we had a control group that only used a home exercise program, and the SWT group improved more than the control group, in line with the Gerdesmeyer at al. study. However, our study has only shown short-term effects. The long-term effects could have been different, and the effects of SWT could have been found to be more significant than the other modalities. The AOFAS scores increased in all groups after treatment in our study. Our study is also in line with the relevant literature. Ilieva at al. investigated the effects of ESWT treatment on 21 patients with PF. The patients were evaluated with the visual analog scale and AOFAS in the third, sixth, and 12th months. Pain decreased in all patients, and their AOFAS scores increased with time [31].

We compared the AOFAS scores of the groups among themselves after the treatment and found the AOFAS scores of the groups treated with SWT and US with a combination of exercise to have increased more than the group treated only with exercise. The AOFAS clinical evaluation system evaluates pain, functionality, and sequence. Our result indicates that exercise is an effective treatment method but is not adequate in the rehabilitation of multiple factors such as pain and functionality and that using exercise in combination with other physical therapy modalities might be more useful in the treatment of the PF. There is not much reported on the effectiveness of only one of treatment modality in PF, but it is generally stated that these modalities need to be combined depending on the condition of the patient to achieve success [21, 22, 24, 32]. Different kinds of exercise protocols such as stretching, strengthening, or combinations of the two have been used in PF patients, and they have been shown to be effective in reducing pain[33]. Sweeting *et al*. investigated the effect of stretching exercises on PF in their review. They found low levels of evidence showing that stretching exercises are as effective as the other treatment modalities [28]. This information is also supplemented with our study.

Table 2: Comparison of pre-treatment evaluation results of patients

Pretreatment	US Group	SWT Group	Control Group	v*	*P*
FFI Pain	62.946±9.00	59.066±11.86	54.61±13.17	4.558	0.102
Disability	75.616±19.05	74.61±18.78	63.06±17.64	5.927	0.052
Activity limitation	20.616±6.48	16.22±9.52	17.28±8.57	2.242	0.326
AOFAS hind foot score	30.11±12.49	33.94±14.02	37.50±15.88	2.451	0.294
Single leg stance test, sec	19.94±11.27	17.78±11.37	17.72±9.32	0.491	0.782
Functional reach test, cm	25.06±5.82	24.94±7.96	26.39±6.92	1.517	0.468
Ankle proprioception sense, degrees	17.86±2.11	16.19±1.80	16.99±2.10	5.546	0.062

AOFAS =American Orthopedic Foot and Ankle Association; FFI =Foot Function Index; SWT ¼shock wave therapy; US= ultrasound therapy

Table 3: Comparison of pre- and post-treatment evaluation results of patients*

Pretreatment		**Post-treatment**	**z***	***P***
UST group				
AOFAS hind foot score 0.001‡	30.11±12.49	74.72±13.55	—3.729	
FFI Pain	62.9±4.00	43.28±18.52	—3.553	0.001
Disability	75.61±19.05	47.67±23.72	—3.595	0.001
Activity limitation	20.61±6.48	8.83±7.02	—3.504	0.001
Single leg stance test, sec	19.94±11.27	23.56±8.39	—2.449	0.014
Functional reach test, cm	25.06±5.82	30.78±5.96	—3.306	0.001
SWT group				
AOFAS hind foot score	33.94±14.02	68.39±12.91	—3.725	0.001‡
FFI Pain	59.06±11.86	28.56±12.44	—3.724	0.001
Disability	74.61±18.78	30.78±15.01	—3.724	0.001
Activity limitation	16.22±9.52	4.28±4.53	—3.353	0.001

Single leg stance test, sec	17.78±11.37	24.56±8.66	—2.087	0.042
Functional reach test, cm	24.94±7.96	31.17±4.64	—3.317	0.001
Control group				
AOFAS hind foot score	37.50±15.88	59.50±9.34	—3.550	0.001‡
FFI Pain	54.61±13.17	38.89±16.52	—2.897	0.004
Disability	63.06±17.64	46.78±21.05	—2.275	0.023
Activity limitation	17.28±8.57	11.89±8.61	—1.967	0.049
Single leg stance test, sec	17.72±9.32	25.67±6.94	—3.110	0.002
Functional reach test, cm	26.39±6.92	30.50±3.49	—2.942	0.003
Ankle proprioception sense, degrees	16.99±2.10	16.48±1.51	—1.279	0.201

Table 4: Comparison of post-treatment evaluation results of patients between groups*

FF Pain	**43.28±18.52**	**28.56±12.44**	**38.89±16.52**	**7.743**	**0.021[k]**
Disability	47.67±23.72	30.78±15.01	46.78±21.05	7.330	0.026[k]
Activity limitation	8.83±7.02	4.28±4.53	11.89±8.61	8.621	0.013[k]
AOFAS hind foot score	74.72±13.55	68.39±12.91	59.50±9.34	10.536	0.005[k]
Single leg stance test, sec	23.56±8.39	24.56±8.66	25.67±6.94	1.003	0.606
Functional reach test, cm	30.78±5.96	31.17±4.64	30.50±3.49	0.485	0.785
Ankle proprioception sense, degrees	14.91±2.25	16.50±1.57	16.48±1.51	7.520	0.023[k]

AOFAS = American Orthopedic Foot and Ankle Association; FFI = Foot Function Index; SWT = shock wave therapy; US=ultrasound therapy

We found the one leg stance test values to increase in all groups after treatment, indicating an improvement in one leg stance balance. When all three groups were compared with each other, there was no difference between the one leg stance test values. In addition, the values of the forward functional reach test were found to increase. This could be due to the increased time of balance while standing on one leg and the decrease in pain. There are no studies comparing US and SWT treatments and evaluating one leg stance balance in PF patients. In a single case study, a 61-year-old patient suffering from PF for 10 years was reported to obtain relief in functional activity with in- creased standing on one leg duration after eight sessions of iontophoresis therapy and a home exercise program [32].

Reviews of other studies in patients with PF generally indicate that a single treatment modality is inadequate in PF treatment and a combination of multiple treatment modalities should be used. It has also been determined a single type of exercise therapy is not enough in the treatment of PF. In parallel with this knowledge, we found that pain intensity decreased more in the SWT and exercise group and there was less improvement in the group that received only exercise treatment.

This study has several limitations. The biggest limitation was the duration of the study. The study needs to be longer to determine the long-term effects of US and SWT treatment and to compare them in a better way. The other limitation is that we could not make a control group without treatment as it would not be ethical. This caused us to apply these exercises in the study groups in order to prevent a difference, and we were therefore unable to evaluate the effectiveness of the SWT and US treatments by themselves.

Conclusion

In conclusion, the results of this study provide evidence that US treatment and SWT treatment are effective methods to reduce pain and increase functionality in PF when combined with exercises. On the other hand, US therapy was found to be superior to SWT treatment in reducing pain in PF. There was less improvement in the group receiving only exercise therapy when compared with the two other groups.

If the patient's complaints about pain are at the fore- front, treatment could consist of a combination of US and exercise therapy. If there is a pain together with pathologies that disrupt the patient's biomechanical sequence, the combination of SWT and exercise therapy could be preferred. Our result could be useful in the management of PF. However, studies on larger series comparing SWT and US treatment with longer follow-up are needed.

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