Archives of Orthopaedic and Trauma Surgery (2019) 139:1763–1770
https://doi.org/10.1007/s00402-019-03262-z

ARTHROSCOPY AND SPORTS MEDICINE

Shock-wave therapy improved outcome with plantar fasciitis: a meta-analysis of randomized controlled trials

Hui Li[1] · Yuan Xiong[1] · Wu Zhou[1] · Yi Liu[1] · Jing Liu[1] · Hang Xue[1] · Liangcong Hu[1] · Adriana C. Panayi[2] · Bobin Mi[1] · Guohui Liu[1]

Received: 4 December 2018 / Published online: 21 August 2019

Abstract

Background Shock-wave therapy (SWT) has been widely applied and proven to be an effective treatment in ameliorating symptoms of plantar fasciitis (PF). Ultrasound therapy (UT) is another common treatment of PF, and several researches have documented its advantages when compared to corticosteroid injection. Despite this, few studies have focused on comparing the use of SWT and UT in the treatment of PF. The purpose of our meta-analysis is to evaluate whether SWT is better than UT in managing PF, both in terms of ameliorating pain and improving functionality.

Methods A systematic search of the literature was conducted to identify relevant articles that were published in Pubmed, Medline, Embase, the Cochrane Library, SpringerLink, Clinical Trials.gov and OVID from the databases' inception to October 2018. All studies comparing the efficacy of SWT and UT in terms of pain levels and functionality improvement were included. Data on the two primary outcomes were collected and analyzed using the Review Manager 5.3.

Results Five studies were included in the current meta-analysis. A significant difference in VAS score (MD = − 13.14, Cl − 14.07 to − 12.75 $P < 0.00001$, $I^2 = 100\%$) was noted between the SWT group and the UT group. No significant difference was seen in the AOFAS (MD = 3.19, Cl − 1.72 to 8.10 $P = 0.20$, $I^2 = 100\%$); FFI or PFPS score was not found significant difference either (SMD = − 1.17, Cl − 4.45 to 2.10 $P = 0.48$, $I^2 = 96\%$).

Conclusions The results from this meta-analysis highlight the effectiveness of both SWT and UT in the treatment of PF. Although inter-group differences were not significant, the VAS score was better improved in the SWT group, suggesting that SWT may be a superior alternative for the treatment of PF.

Keywords Plantar fasciitis · Shock wave · Ultrasound · Therapy

Abbreviations

SWT	Shock-wave therapy
UT	Ultrasound therapy

Hui Li and Yuan Xiong contributed equally to this work.

✉ Bobin Mi
mi19882@163.com

✉ Guohui Liu
liuguohui@medmail.com.cn

Hui Li
715525460@qq.com

Yuan Xiong
xiongyuanmed@163.com

Wu Zhou
494260189@qq.com

Yi Liu
liuyizsy@qq.com

Jing Liu
907732140@qq.com

Hang Xue
15871393021@163.com

Liangcong Hu
huliangcongtj@hust.edu.cn

Adriana C. Panayi
apanayi@bwh.harvard.edu

1 Department of Orthopedics, Union Hospital, Tongji Medical College, Huazhong University of Science and Technology, Wuhan 430022, China

2 The Division of Plastic Surgery, Brigham and Women's Hospital, Harvard Medical School, Boston, MA, USA

PF	Plantar fasciitis
VAS	Visual analog scale
HTI	Heel tenderness index
FFI	Foot function index
LQ	Laitinen questionnaire
PFPS	Plantar fasciitis pain and disability scale
AOFAS	American orthopaedic foot and ankle society
RMS	Roles-maudsley score
RCT	Randomized controlled trial

Introduction

Intractable heel pain is a common problem that affects middle-aged and elderly people [1]. And PF is a major cause of heel pain, which is responsible for a reduction in quality of life [2]. Many treatment modalities have been used in PF including orthoses [3, 4], stretching [5, 6], taping [7], extracorporeal shock wave therapy [8, 9], laser therapy [10], percutaneous injection [11] and drug medication [12]. SWT has been proven to be effective in achieving beneficial effects for this disorder, [13, 14] but there exist limitations, and an adequate choice of intense, pulse cycle, and modality is vital for the curative effect of SWT and it is not enough for some patients with intractable pain. Studies [15, 16] have reported that the therapeutic response to SWT depends on the intensity, pulse cycle and shock-wave modality. Ultrasound therapy (UT) is another common treatment of plantar fasciitis, and several researches [17–19] have documented its advantages over corticosteroid injection. Although both methods are useful for PF, few studies have focused on comparing the use of SWT and UT in the treatment of the condition and which treatment is better, if either, is still uncertain [20–24]. We aim to compare the efficacy between the SWT and UT, and it is hoped that the question will be resolved with our proposed meta-analysis.

Materials and methods

Search strategy

The databases searched were Pubmed, Medline, Embase, the Cochrane Library, SpringerLink, Clinical Trials.gov and OVID from inception to October 2018. The following search terms were used: plantar fasciitis or PF; shock-wave or SW, shock-wave therapy or SWT, ultrasound or US, and ultrasound therapy or UT.

Data selection

Inclusion eligibility was independently performed by two investigators who screened the title and abstracts of all articles. Disagreements were resolved with discussion between the authors. A third researcher was the adjudicator when the two investigators did not reach agreement. The inclusion criteria were: (1) studies were designed as RCTs; (2) participants were at least 18 years old; (3) studies compared SWT with UT; and (4) articles were written in the English language.

Data extraction

Two authors independently extracted the following data from each eligible study: study design, type of study population, age, number of participants and interventions. Any discrepancies in data extraction were resolved by a third investigator.

Quality and risk of bias assessments

The modified Jadad scale was used to assess the methodological quality of each study. A score of ≥ 4 indicated high quality. The Cochrane Handbook for reviews of interventions (Revman Version 5.3) was used to assess the risk of bias. Two independent authors subjectively reviewed all articles and assigned a value of "high", "low" or "unclear" based on the following items: selection bias, performance bias, detection bias, attrition bias, reporting bias and other bias. Any disagreements were resolved with discussion to reach a consensus. If a consensus could not be reached, a third investigator was consulted.

Statistical analysis

RevMan software was used to analyze the numerical data extracted from the included studies. For binary data, the risk ratios (RR) and 95% confidence intervals (CI) were assessed ($a = 0.05$ for the inspection standards). For continuous data, means and standard deviations (SD) were pooled to a weighted mean difference (WMD) and a 95% confidence internal (CI) in the meta-analysis. Heterogeneity was tested using the I^2 statistic. Studies with an I^2 statistic of 25–50% were considered to have low heterogeneity, those with an I^2 statistic of 50–75% were considered to have moderate heterogeneity and those with an I^2 statistic $> 75\%$ were considered to have high heterogeneity. When the I^2 statistic was $> 50\%$, sensitivity analyses were performed to identify any potential sources of heterogeneity. Statistical significance was indicated by a p value < 0.05.

Results

Description of studies and demographic characteristics

A total of 118 articles were identified as potentially relevant studies (Fig. 1). Following screening of titles and abstracts

($n = 69$) and removal of duplicates ($n = 27$) resulted in a total of 22 full publications. The 22 full manuscripts were assessed and a further 17 trials were excluded, leaving 5 trials eligible to be included in the meta-analysis. The demographic characteristics are summarized in Tables 1 and 2. All trials compared the effect of the SWT group versus the UT group.

Risk of bias in included studies

Assessment of the risk of bias is presented in Fig. 2. All trials included were randomized trial designs [20–24]. Four trials [20–22, 24] did not describe the methods of allocation concealment. Blinding of participants and personnel (performance bias) was unclear and incomplete outcome data (attrition bias) was high risk in two trials [20, 22]. One trial [23] had patients lost to follow-up.

SWT versus UT

From the five studies comparing SWT with UT, four studies used the VAS to assess the improved condition after treatment for pain and as shown in Fig. 3, SWT was found to be superior to UT when calculating the pooled effect size of VAS (MD = − 13.14, Cl − 14.07 to − 12.75 $P < 0.00001$, $I^2 = 100\%$). A sensitivity analysis failed to determine any one or two trials that might be causing the statistical heterogeneity. Further analysis of the different changes after

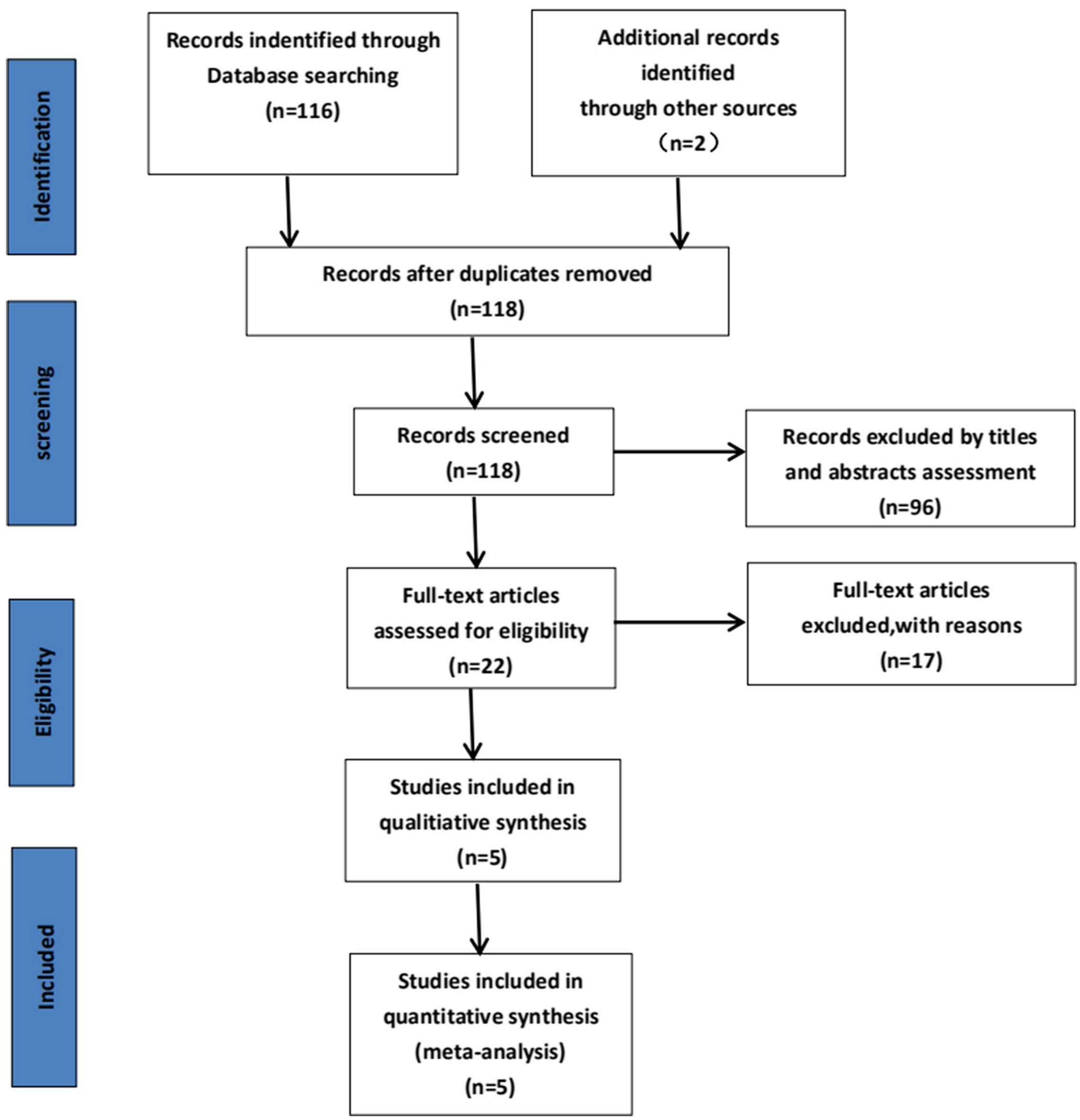

Fig. 1 Flowchart outlining the process of study identification, inclusion and exclusion

Table 1 Characteristics of the included studies

Study	Year	Country	Patients (*n*)		Age (years)		Average disease duration, month (week)		Study design	Quality score
			SWT	UT	SWT	UT	SWT	UT		
Krukowska J [20]	2016	Poland	27	20	51.40 ± 7.80	51.10 ± 8.60	≥ 4	≥ 4	RCT	7
Ulusoy A [21]	2017	Turkey	20	17	54.45 ± 6.90	50.95 ± 9.62	27.00 ± 29.79	17.30 ± 14.71	RCT	5
Bihter A [22]	2017	Turkey	18	18	50.00 ± 6.54	50.11 ± 9.29	≥ 12	≥12	RCT	6
Nipaporn K [23]	2015	Thailand	15	15	45.60 ± 1.07	45.00 ± 1.13	48.33 ± 9.79	50.01 ± 6.79	RCT	5
Cheing G [24]	2007	China	12	15	46.80 ± 10.30	48.80 ± 7.50	31.40 ± 50.40	31.40 ± 35.40	RCT	4

accepting treatment in AOFAS (both including pain and functional subscales) was performed and is shown in Fig. 4 (MD = 3.19, Cl − 1.72 to 8.10 $P = 0.20$, $I^2 = 100\%$). No significant difference was observed in this analysis and a sensitivity analysis also failed to determine any one or two trials that might be causing the statistical heterogeneity. In addition, two trials outcomes assessed by the FFI or PFPS score were also analyzed, and the result is displayed in Fig. 5 (SMD = significant difference 1.17, Cl significant difference 4.45 to 2.10 $P = 0.48$, $I^2 = 96\%$), and no significant difference in VAS score was noted between the SWT group and the UT group.

Discussion

As far as we know, either SWT or UT is the frequently used therapy for treatment of PF, in order to adequately compare the efficacy of SWT and UT, our study extracted the patients receiving steroid injections in the last 6 months or exercised regularly (stretching, aerobic exercises such as walking, running, swimming, etc.). When compared with surgery, SWT is associated with fewer adverse complications [25, 26]. Due to producing controlled micro-disruption of the plantar fascia, which preserving the gross structural integrity and biomechanics of the foot, the recovery time after SWT is short, and patients can generally continue their normal daily activities and working [27–30]. UT is another common treatment of PF, which is a mechanical wave with constant amplitude, width and pulse interval. Treatment with ultrasound induces changeable intra-cellular pressure, causes changes in the nervous conductivity, raises the threshold of pain, and contributes to muscle relaxation, which can accelerate metabolism and regenerative processes [31–33]. In the present meta-analysis, we synthesize the efficacy of SWT based on the comparison of UT, and it indicated that SWT displayed similar efficacy to UT in improving self-reported function, but better effect on relieving pain could be found in the treatment of PF.

We confirm that this research is the first meta-analysis looking at randomized controlled trails comparing the efficacy of SWT and UT, and prior to this analysis the outcome of SWT and UT as primary treatments of PF remained elusive. In 2017, Ulusoy A et al. [21] performed a randomized controlled trial, which showed that SWT was as useful as UT for improving symptoms of PF. However, Krukowska et al. [23] revealed that the fewer number of treatment sessions required by SWT compared to UT suggests that SWT has better analgesic efficacy. According to the previous literature, we cannot include a clear conclusion regarding the superiority between SWT and UT for the treatment of PF, and there are a few studies focused on comparing the use of SWT and UT in the treatment of the condition and which treatment is better. Thus, we hoped that the question will be resolved with our proposed meta-analysis and in our study, we found a moderately better outcome in the SWT group in terms of symptom and pain control in AOFAS score and FFI or PFPS scoring systems, although this difference was not statistically significant ($P > 0.05$). In addition, a significant difference in VAS score was noted between the SWT group and the UT group (MD = − 13.14, Cl − 14.07 to − 12.75 $P < 0.00001$, $I^2 = 100\%$), which encouraged us to believe that SWT is more effective in relieving pain for the treatment of PF.

We compared the AOFAS scores between the groups. The AOFAS clinical evaluation system includes pain and functionality terms. Our result indicates that SWT and UT are effective treatment methods but are not adequate in the rehabilitation of multiple factors such as pain and functionality. Moreover, from literature reading, using SWT or UT in combination with other physical therapy modalities might be more useful in the treatment of the PF and it is generally suggested that these modalities need to be combined depending on the condition of the patient to obtain success [34–36]. However, the fact that AOFAS score is neither validated nor reliable should be another weakness of our present study. It seemed that the statistical heterogeneity could be minimized using perfect blinding design; unfortunately, it was determined that methodological or clinical heterogeneity was still present and hard to deal with. The shock-wave preparations and ultrasound therapy, as well as intensity, pulse cycle, and interval were not uniform among the different trials. Several

Table 2 Characteristics of the five trials selected showing general information

Study	Year	Treatment Cycle (SWT/UT)	Treatment schedule		Assessment methods	Follow-up, week
			SWT	UT		
Krukowska J	2016	4/10	2000 strokes were applied with a frequency of 10 Hz and a capacity of 2.5 bar	Power setting was 1.5 W/cm^2, 80% fill factor, at a frequency of 1 MHz. The duration of a single treatment was 4 min, and the coupling substance used was paraffin oil	VAS, LQ	2
Ulusoy A	2017	3/15	The patients received 2000 shock waves with a 2.5-bar pressure, 10-Hz frequency during sessions into the areas of the painful heel	Continuous mode, base frequency of 1 MHz to produce a deeper penetration, power of 2 W/cm^2 into the areas of the painful heel	VAS, AOFAS; RMS; HTI	4
Bihter A	2017	3/7	A dose of 500 pulses, 3 Hz, 0.2 mJ/mm^2 applied to the whole heel area. Then, a dose of 1500 pulses, 8 Hz, 0.3 mJ/mm^2 was applied to the specified tender point palpated before the treatment	3.0 MHz frequency, power density 1 W/cm^2, and a pulsed wave duty cycle of 1/4 (impulse time/interval) for 8 min.	FFI; AOFAS	4
Nipaporn K	2015	6/18	A dose of 500 pulses, 10 Hz, 0.2 mJ/mm^2 applied to the whole heel area. Then, a dose of 1500 pulses, 8 Hz, 0.3 mJ/mm^2 was applied to the specified tender point palpated	3.0 MHz frequency, power density 0.5–1 W/cm^2, and a pulsed wave duty cycle of 1/4 (impulse time/interval) for 10 min	VAS; PFPS	24
Cheing G	2007	3/9	Treatment parameters were set at a frequency of 4 Hz with a total of 1000 impulses, and the intensity of the energy output varied from 0.23 to 0.37 mJ/mm^2	The treatment parameters were continuous ultrasound therapy, delivered at a frequency of 1 MHz, with an intensity of 1 W/cm^2. The choice of lower frequency (1 MHz) ultrasound was aimed to produce a deeper penetration as compared to a higher frequency (3 MHz).	VAS	3

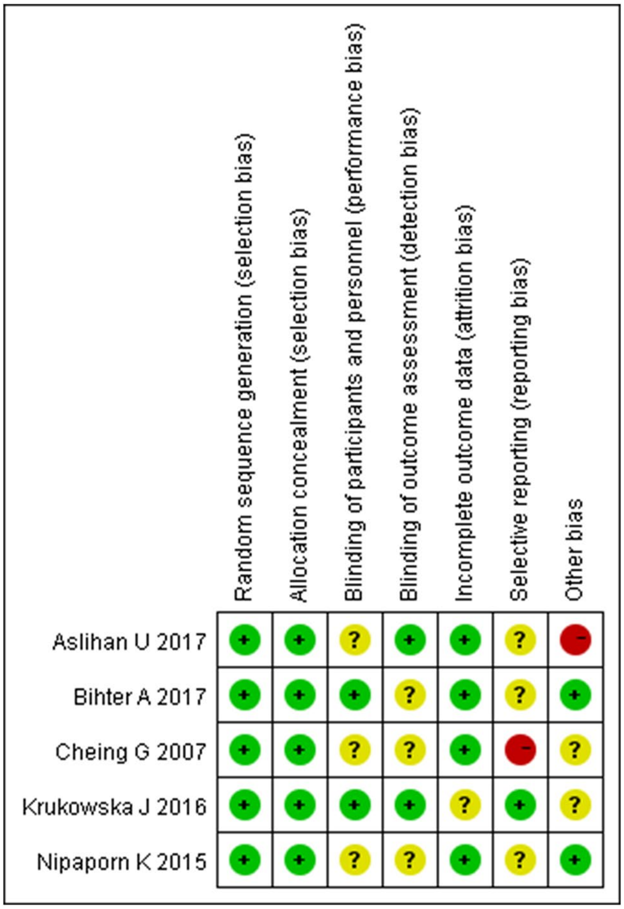

Fig. 2 Risk of bias summary

researches revealed that shock wave with or without high energy, and ultrasound with rich or poor treatment sessions could all cause varying degrees of clinical responses [19, 37, 38]. Furthermore, the variance of populations, duration time, and outcome scores also contributed to a high level of heterogeneity and diverse clinical outcomes [39, 40].

Just like other meta-analyses, our study is not devoid of limitations. First, the number of included trials with high quality was relatively small and it was impossible to retrieve all potentially eligible trials ideally. Secondly, the current meta-analysis focuses only on papers published in the English language. Inclusion of studies reported in other languages may influence heterogeneity and affect the current results. In addition, the variance of populations, pain duration, and outcome scores contributed to a high level of heterogeneity and diverse clinical outcomes. All these inconsistencies complicated data synthesis and increased the risk of incorrect results. In addition, the follow-up time was not consistent across studies. In summary, rigorously designed RCTs with larger sample sizes should be better designed to confirm the efficacy of SWT.

Conclusion

In this meta-analysis, we can find the effectiveness of both SWT and UT in relieving pain and improving self-reported function in the treatment of PF. Although inter-group differences were not significant, the VAS score showed higher

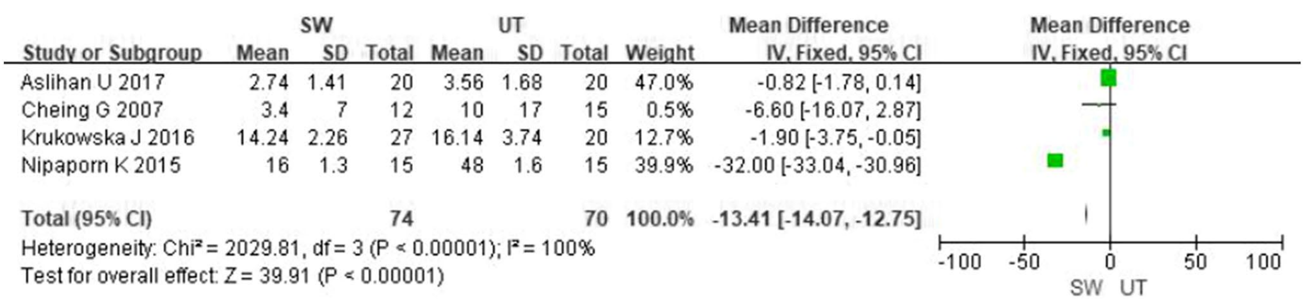

Fig. 3 Forest plot of VAS in the SWT group compared with the UT group

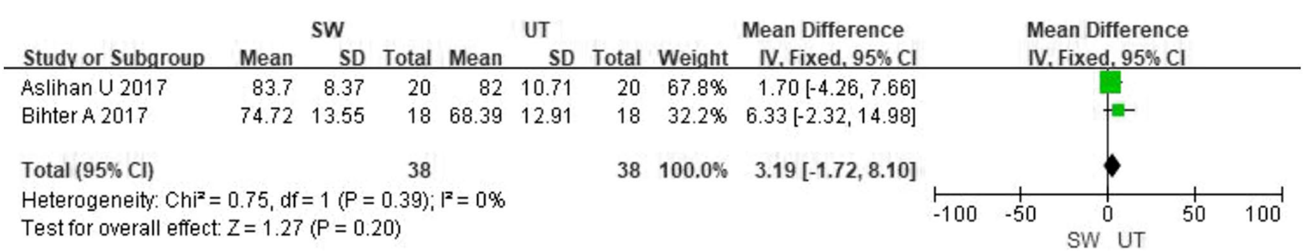

Fig. 4 Forest plot of AOFAS in the SWT group compared with the UT group

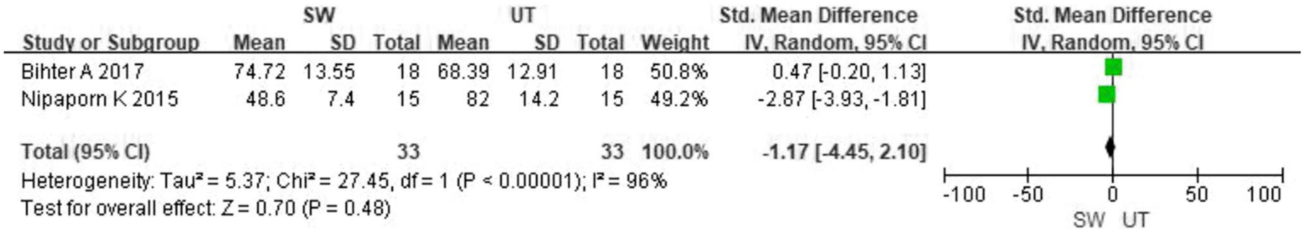

Fig. 5 Forest plot of FFI or PFPS in the SWT group compared with the UT

improvement in the SWT group; thus, SWT appears to be a better alternative for the management of PF. Further studies are needed to compare the efficacy of SWT and UT on long-term follow-up patients.

Acknowledgements This work was accomplished with the help of the library of Huazhong University of Science and Technology.

Author contributions YX and HX participated in the design of the study; BM and YL carried out data curation; JL and QW performed the statistical analysis; LC and QW carried out investigation; BM and CY carried out project administration; YS and WZ operated software; YX carried out supervision; LH and WZ carried out validation; YX and HX conceived the study, and participated in its design and coordination and helped to draft the manuscript; GL. YX and AP participated in the sequence alignment and drafted the manuscript. All authors read and approved the final manuscript.

Funding This study was supported by grants from the National Natural Science Foundation of China (No. 81772345). The funder had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Data availability Please contact author for data requests.

Compliance with ethical standards

Conflict of interest All the authors responsible for this work declare no conflict of interest.

References

1. Thomson CE, Crawford F, Murray GD (2005) The effectiveness of extracorporeal shock wave therapy for plantar heel pain: a systematic review and meta-analysis. BMC Musculoskelet Disord 6:19
2. Roxas M (2005) Plantar fasciitis: diagnosis and therapeutic considerations. Altern Med Rev 10:83–93
3. Gross MT, Byers JM, Krafft JL, Lackey EJ et al (2002) The impact of custom semirigid foot orthotics on pain and disability for individuals with plantar fasciitis. J Orthop Sports Phys Ther 32:149–157
4. Abbassian A, Kohls-Gatzoulis J, Solan MC (2012) Proximal medial gastrocnemius release in the treatment of recalcitrant plantar fasciitis. Foot Ankle Int 33:14–19
5. Powell M, Post WR, Keener J, Wearden S (1998) Effective treatment of chronic plantar fasciitis with dorsiflexion night splints: a crossover prospective randomized outcome study. Foot Ankle Int 19:10–18
6. DiGiovanni BF, Nawoczenski DA, Lintal ME, Moore EA et al (2003) Tissue-specific plantar fascia-stretching exercise enhances outcomes in patients with chronic heel pain. A prospective, randomized study. J Bone Joint Surg Am 85:1270–1277
7. Landorf KB, Radford JA, Keenan AM et al (2005) Effectiveness of low-dye taping for the short-term management of plantar fasciitis. J Am Podiatr Med Assoc 95(6):525–530
8. Böddeker R, Schäfer H, Haake M (2001) Extracorporeal shockwave therapy (ESWT) in the treatment of plantar fasciitis–a biometrical review. Clin Rheumatol 20(5):324–330
9. Buchbinder R, Ptasznik R, Gordon J et al (2002) Ultrasound-guided extracorporeal shock wave therapy for plantar fasciitis: a randomized controlled trial. JAMA 288(11):1364–1372
10. Basford JR, Malanga GA, Krause DA et al (1998) A randomized controlled evaluation of low-intensity laser therapy: plantar fasciitis. Arch Phys Med Rehabil 79(3):249–254
11. Kamel M, Kotob H (2000) High frequency ultrasonographic findings in plantar fasciitis and assessment of local steroid injection. J Rheumatol 27(9):2139–2141
12. Probe RA, Baca M, Adams R et al (1999) Night splint treatment for plantar fasciitis. A prospective randomized study. Clin Orthop Relat Res 368:190–195
13. Gollwitzer H, Saxena A, DiDomenico LA et al (2015) Clinically relevant effectiveness of focused extracorporeal shock wave therapy in the treatment of chronic plantar fasciitis: a randomized, controlled multicenter study. J Bone Jt Surg Am 97:701–708
14. Dizon JN, Gonzalez-Suarez C, Zamora MT et al (2013) Effectiveness of extracorporeal shock wave therapy in chronic plantar fasciitis: a meta-analysis. Am J Phys Med Rehabil 92:606–620
15. Sweeting D, Parish B, Hooper L et al (2011) The effectiveness of manual stretching in the treatment of plantar heel pain: a systematic review. J Foot Ankle Res 4:19–32
16. Gerdesmeyer L, Frey C, Vester J et al (2008) Radial extracorporeal shock wave therapy is safe and effective in the treatment of chronic recalcitrant plantar fasciitis results of a confirmatory randomized placebocontrolled multicenter study. Am J Sports Med 36(11):2100–2109
17. Cornwall MW, McPoil TG (1999) Plantar fasciitis: etiology and treatment. J Orthop Sports Phys Ther 29(12):756–760
18. Katzap Y, Haidukov M, Berland OM et al (2018) Additive effect of therapeutic ultrasound in the treatment of plantar fasciitis: a randomized controlled trial. J Orthop Sports Phys Ther 48:847–855
19. Li H, Lv H, Lin T (2018) Comparison of efficacy of eight treatments for plantar fasciitis: a network meta-analysis. J Cell Physiol 234:860–870
20. Krukowska J, Wrona J, Sienkiewicz M et al (2016) A comparative analysis of analgesic efficacy of ultrasound and shock wave therapy in the treatment of patients with inflammation of the

attachment of the plantar fascia in the course of calcaneal spurs. Arch Orthop Trauma Surg 136:1289–1296
21. Ulusoy A, Cerrahoglu L, Orguc S (2017) Magnetic resonance imaging and clinical outcomes of laser therapy, ultrasound therapy, and extracorporeal shock wave therapy for treatment of plantar fasciitis: a randomized controlled trial. J Foot Ankle Surg 56:762–767
22. Akinoglu B, Köse N, Kirdi N et al (2017) Comparison of the acute effect of radial shock wave therapy and ultrasound therapy in the treatment of plantar fasciitis: a randomized controlled study. Pain Med 18:2443–2452
23. Konjen N, Napnark T, Janchai S (2015) A comparison of the effectiveness of radial extracorporeal shock wave therapy and ultrasound therapy in the treatment of chronic plantar fasciitis: a randomized controlled trial. J Med Assoc Thai 98(Suppl 1):S49–S56
24. Cheing G, Chang H, Lo SK (2007) A comparison of the effectiveness of extracorporeal shock wave. Shock Waves 17:195–201
25. Roerdink RL, Dietvorst M, van der Zwaard B et al (2017) Complications of extracorporeal shockwave therapy in plantar fasciitis: systematic review. Int J Surg 46:133–145
26. Hammer DS, Adam F, Kreutz A et al (2005) Ultrasonographic evaluation at 6-month follow-up of plantar fasciitis after extracorporeal shock wave therapy. Arch Orthop Trauma Surg 125:6–9
27. Ibrahim MI, Donatelli RA, Schmitz C et al (2010) Chronic plantar fasciitis treated with two sessions of radial extracorporeal shock wave therapy. Foot Ankle Int 31:391–397
28. Ilieva EM (2013) Radial shock wave therapy for plantar fasciitis: a one year follow-up study. Folia Med 55:42–48 **(Plovdiv)**
29. Ogden JA, Alvarez RG, Levitt R (2001) Shockwave therapy for chronic proximal plantar fasciitis. Clin Orthop Relat Res 387:47–59
30. Rompe JD, Kirkpatrick CJ, Schwitalle M et al (1998) Dose-related effects of shock waves on rabbit tendon Achilles: a sonographic and histologic study. J Bone Jt Surg Br 80:546–552
31. Boerner E, Torun´-Kotarska E, Kusiciel-Lewandowska J (2009) The comparison of the efficiency of ultrasounds therapy of calcanean spur depending on therapeutic dose. Acta Bio-Opt Inf Med 15(3):230–233
32. Straburzyn´ska-Lupa A, Kornacka A (2005) Ultrasound therapy in the treatment of calcar pedis-own experiences. Ortop Traumatol Rehabil 7(1):79–86
33. Takla MKN, Rezk SSR (2018) Clinical effectiveness of multi-wavelength photobiomodulation therapy as an adjunct to extracorporeal shock wave therapy in the management of plantar fasciitis: a randomized controlled trial. Lasers Med Sci 34:583–593
34. Dogramaci Y, Kalaci A, Emir A et al (2010) Intracorporeal pneumatic shock application for the treatment of chronic plantar fasciitis: a randomized, double blind prospective clinical trial. Arch Orthop Trauma Surg 130:541–546
35. Molund M, Husebye EE, Hellesnes J et al (2018) Proximal medial gastrocnemius recession and stretching versus stretching as treatment of chronic plantar heel pain. Foot Ankle Int 39:1423–1431
36. Othman A, Ragab EM (2010) Endoscopic plantar fasciotomy versus extracorporeal shock wave therapy for treatment of chronic plantar fasciitis. Arch Orthop Trauma Surg 130:1343–1347
37. Weil LS, Roukis TS, Weil LS et al (2002) Extracorporeal shock wave therapy for the treatment of chronic plantar fasciitis: indications, protocol, intermediate results, and a comparison of results to fasciotomy. J Foot Ankle Surg 41(3):166–172
38. Ogden JA (2004) Extracorporeal shock wave therapy for plantar fasciitis: randomized controlled multicenter trial. Br J Sports Med 38:382
39. Zhang JY, Nie DB, Rocha JL et al (2018) Characterization of the structure, cells, and cellular mechanobiological response of human plantar fascia. J Tissue Eng 9:2041731418801103
40. Zhu F, Johnson JE, Hirose CB, Bae KT (2005) Chronic plantar fasciitis: acute changes in the heel after extracorporeal high-energy shock wave therapy-observations at MR imaging. Radiology 234:206–210

Publisher's Note Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.