eC **A commentary by Mengnai Li, MD, PhD,** is linked to the online version of this article at jbjs.org.

Focused Shockwave Treatment for Greater Trochanteric Pain Syndrome

A Multicenter, Randomized, Controlled Clinical Trial

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Background: Greater trochanteric pain syndrome (GTPS) is a condition of lateral hip pain. Its physiopathology remains unknown, and there is no consensus on optimal management. The aim of this study was to assess the effectiveness of electromagnetic-focused extracorporeal shockwave treatment (F-ESWT) in patients with GTPS.

Methods: This multicenter clinical trial included 103 patients with chronic GTPS randomly assigned to the treatment group, consisting of electromagnetic F-ESWT and a specific exercise protocol, or the control group, receiving sham F-ESWT and the same exercise protocol. Both groups were treated with 3 weekly sessions; the F-ESWT group received an energy flux density of 0.20 mJ/mm^2, whereas the control group received 0.01 mJ/mm^2. Patients were assessed at baseline and 1, 2, 3, and 6 months after treatment. A visual analogue scale (VAS) score for pain at 2 months was the primary outcome. The Harris hip score (HHS), Lower Extremity Functional Scale (LEFS), EuroQoL-5 Dimensions Questionnaire (EQ-5D), and Roles and Maudsley score were used as secondary outcomes. Complications were recorded.

Results: The mean VAS score decreased from 6.3 at baseline in both groups to 2.0 in the F-ESWT group versus 4.7 in the control group at 2 months; the 2-month score differed significantly between groups ($p < 0.001$). All secondary outcomes at all follow-up intervals were significantly better in the F-ESWT group, except for the LEFS score at 1 month after treatment ($p = 0.25$). No complications were observed.

Conclusions: F-ESWT in association with a specific exercise program is safe and effective for GTPS, with a success rate of 86.8% at 2 months after treatment, which was maintained until the end of follow-up.

Level of Evidence: Therapeutic Level I. See Instructions for Authors for a complete description of levels of evidence.

Greater trochanteric pain syndrome (GTPS) is a common condition of lateral hip pain, evocable by palpation and exacerbated by a side-lying position and physical exercise[1-4]. It has an incidence rate of 1.8 to 5.6 per 1,000 subjects per year, is more frequent between the ages 40 and 60 years, and has a female-to-male preponderance of 4: 1[1,3,5]. The relationship between GTPS and trochanteric bursitis[5-9], historically considered the same entity, has been reviewed in the literature, with treatments often targeting the bursitis[10,11]. The physiopathology of GTPS remains unknown; tendinopathy is the most frequent finding[2,3,6,12]. It has been associated with repetitive friction between the greater trochanter and the iliotibial band, causing microtrauma to the gluteal tendons at the insertion of the greater trochanter, leading to tendon degeneration[8]. Bird et al. demonstrated that the pathological findings in the gluteus medius and minimus tendons seen on magnetic resonance imaging (MRI) are important in defining GTPS and showed that trochanteric bursal distension was found in only 8.3% of patients[3]. Therefore, bursitis should be considered to represent an associated factor[6,8,9,13]. This change

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of paradigm renews the interest in the diagnostic and therapeutic approach to GTPS[14].

Recent systematic reviews of GTPS[10,14] and lower-limb tendinopathy[15,16] management have included the role of focused extracorporeal shockwave treatment (F-ESWT) and radial pressure waves[17,18], despite these being 2 different treatment modalities with varying levels of evidence[19]. Reviews on shockwave treatment recently confirmed the efficacy of F-ESWT for other tendinopathies[19-21]. Carlisi et al. demonstrated the effectiveness of piezoelectric F-ESWT in reducing the pain of GTPS at short and mid-term follow-up[22]. Seo et al. confirmed the positive effect of electrohydraulic F-ESWT for GTPS with a short-term success rate of 83.3%[23]. Both F-ESWT and radial pressure waves are effective therapeutic strategies for tendinopathies, with a grade-B level of recommendation for GTPS[19]. While radial pressure waves are suitable for treating large and superficial areas, F-ESWT technology allows the pressure waves to be concentrated deep inside the body[19], as in the case of gluteal tendons. The International Society for Medical Shockwave Treatment (ISMST) included GTPS in a list of clinical indications for F-ESWT based on evidence[24]. Biological patterns involved in the F-ESWT mechanism of action include anti-inflammation, neovascularization, anti-apoptosis, direct suppressive effects on nociceptors, chondroprotective effect, and tissue and nerve regeneration[19,25]. Several studies showed F-ESWT efficacy for tendinopathies[26,27]. Therefore, the aim of the study was to evaluate the effectiveness and safety of electromagnetic F-ESWT in patients with GTPS.

Materials and Methods

This multicenter, randomized, controlled clinical trial was registered in ClinicalTrials.gov (NCT03338465). It was conducted in 3 centers: 2 in Italy (Physical Medicine and Rehabilitation [PMR] Unit, Sant'Andrea Hospital, Sapienza University of Rome and Department of Orthopedics and Traumatology, Federico II University Hospital, Naples) and 1 in Spain (PMR Hospital Quirónsalud, Barcelona). The 140 consecutive patients referred to 1 of these 3 medical centers from November 2017 to January 2019 were screened for eligibility for enrollment in the study. The recruitment procedure included an initial screening visit, followed by a hip radiograph and a sonographic or magnetic resonance imaging (MRI) examination of the gluteal tendons and trochanteric bursa. Patients of either sex were eligible for inclusion if they (1) were ≥18 years old, (2) had unilateral pain in the greater trochanteric area for >3 months, (3) had pain while lying on the affected side, (4) had local tenderness on palpation of the greater trochanteric area, and (5) signed an informed consent form. The exclusion criteria were (1) signs, symptoms, and complementary studies indicating osteoarthritis, calcification, a tendon tear, or another cause of hip pain; (2) hip internal rotation of ≤20° or another range of motion of ≤10°; (3) previous hip surgery; (4) persistent low-back pain; (5) vascular, neurologic, or rheumatic disease; (6) neoplasia or local infection in the hip; (7) pregnancy; (8) severe coagulation disorders or anticoagulant therapy; (9) another nonoperative treatment for GTPS in the last 3 months, excluding analgesics and nonsteroidal anti-inflammatory drugs (NSAIDs); and (10) previous shockwave treatment.

Of 140 patients assessed for eligibility, 103 with GTPS were enrolled and randomly assigned, using the Excel (Microsoft) RAND function, into 2 groups. Patients, assessors, data managers, statisticians, and study monitors were blinded to the treatment group allocation.

Treatment

An F-ESWT device (Duolith SD1 Ultra; Storz Medical) was used. Patients were treated in the lateral decubitus position, using a coupling ultrasound gel and an ultrasonic guide to concentrate the shockwaves on the greater trochanter area of the gluteus tendons enthesis. No local anesthesia was applied. Both groups were treated with 3 weekly sessions. At each session, 2,000 impulses were applied with a frequency of 5.0 Hz. The F-ESWT group received an energy flux density (EFD) of 0.20 mJ/mm^2, whereas the control group received 0.01 mJ/mm^2 (the lowest EFD of the device). The presence of the typical sound of the F-ESWT instrument during the treatment of both groups ensured the blindness regarding the group allocation. All of the patients received the same home-specific exercise program[17,28-30], to perform once a day for 24 weeks (see Appendix).

Outcome Measures

Patients were assessed at baseline and 1, 2, 3, and 6 months after the last session by clinicians blinded to the group allocation. The difference in the score on a visual analogue scale (VAS) for pain, ranging from 0 (absence of pain) to 10 (unbearable pain) points[31,32], at 2 months after the last treatment session was the primary outcome. The secondary outcomes included:

1. Harris hip score (HHS), which evaluates hip disability using questions about pain and daily life activities in the previous week and hip function and range-of-motion assessments. The scores range from 100 (no disability) to 0 (maximum disability)[33].
2. Lower Extremity Functional Scale (LEFS), a self-report questionnaire measuring the patients' initial function, ongoing progress, and outcome with regard to the lower extremity. The score ranges from 80 (very high function) to 0 (very low function)[34-36].
3. EuroQoL-5 Dimensions Questionnaire (EQ-5D), which evaluates patients' quality of life. It consists of a 5-dimension subjective assessment, with each item providing the option to choose a level of severity, graduated from 1 (absence of problems) to 3 (extreme limitation)[37].
4. Roles and Maudsley (RM) treatment satisfaction scale, which assesses pain and limitation of activity with a 4-point system (1 = excellent result; 2 = significant improvement; 3 = somewhat improved; and 4 = poor, with symptoms identical or worse than before treatment). The RM score has been widely used when reporting results of shockwave treatment[18,23].

Ethical Approval

The study was approved by the Independent Ethics Committee of Sapienza University of Rome (number 5143, protocol 219SA_2018) and of the Grupo Hospitalario Quirónsalud in Barcelona (reference Trocánter-Ondas_39_1.2). The research was conducted in accordance with the World Medical Association Declaration of Helsinki.

Statistical Analysis

Continuous variables are given as the mean and standard deviation (SD), while categorical variables are given as the frequency and percentage. The normality distribution of data was determined for each variable using graphical methods and the Shapiro-Wilk test. An a priori power analysis was conducted based on the difference between groups with regard to the mean VAS at the 2-month follow-up (the primary outcome). Assuming an alpha error of 0.05, a power of 0.90, a mean difference between groups of 2.0 points in the 2-month VAS score with an SD of 2.5, and a dropout rate of 20%, the estimated number of patients needed to be studied per group was 42. The estimated difference in the mean VAS score of 2 points between groups was based on previous intervention studies[18,22].

The unpaired Student t test was used to compare the group means for the scores for the secondary outcomes at the various follow-up time points. The Fisher exact test was used for noncontinuous variables.

Data analysis was carried out based on the intention-to-treat (ITT) approach. The significance level was $p < 0.05$. All analyses were conducted with IBM SPSS Statistics for Windows, version 21.

Results

Of 140 patients screened, 103 were allocated and treated according to the randomization in the study protocol

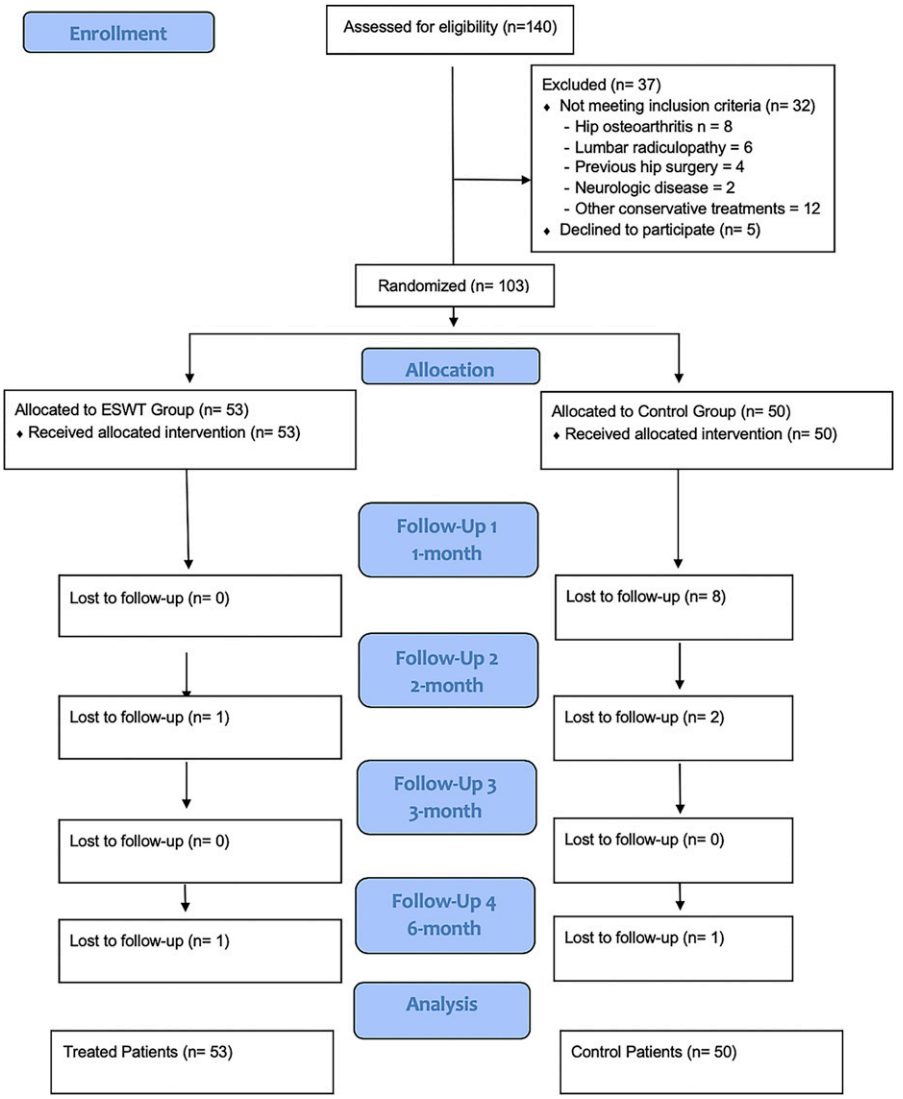

Fig. 1

CONSORT (Consolidated Standards of Reporting Trials) flowchart of enrollment and analysis.

TABLE I Baseline Characteristics of Randomized Patients

	F-ESWT (N = 53)	Control (N = 50)	P Value
Age* *(yr)*	57.1 ± 12.9	55.6 ± 11	0.52
Sex: female†	42 (79)	32 (64)	0.08
Side: right†	30 (57)	28 (56)	0.95
Diagnosis†			0.74
Tendinopathy	29 (55)	29 (58)	
Bursitis	10 (19)	11 (22)	
Tendinopathy + bursitis	14 (26)	10 (20)	
VAS*	6.3 ± 1.8	6.3 ± 1.4	0.67
HHS*	65.0 ± 13.5	65.9 ± 11.2	0.71
LEFS*	50.3 ± 15.7	49.6 ± 13.1	0.82
EQ-5D*	0.53 ± 0.3	0.6 ± 0.2	0.28

*The values are given as the mean and SD. †The values are given as the number with the percentage in parentheses.

(Fig. 1). No significant intergroup differences were found at baseline assessment (Table I). During the follow-up, 13 patients (2 in the F-ESWT group and 11 in the control group) dropped out before the end of the study. Their missing responses were imputed as the last observation carried forward, using an ITT approach.

No complications were observed.

Primary Outcome Measure

The mean VAS score at 2 months was significantly better in the F-ESWT group (2.0 ± 2.1) than in the control group (4.7 ± 2.1; $p < 0.001$). The average difference of 2.7 points reached the hypothesized estimate for the power analysis calculation.

Secondary Outcome Measures

Between-group analysis showed significant differences in all of the secondary outcomes at all follow-up times in favor of the F-ESWT group (Tables II, III, and IV). The only exception was the LEFS score at 1 month, which improved in both groups without a significant difference between them ($p = 0.25$).

HHS

The mean pretreatment HHS was 65.0 ± 13.5 for the F-ESWT group and 65.9 ± 11.2 for the control group ($p = 0.71$). The F-ESWT group had greater improvement in HHS than the control group ($p < 0.01$ at 1 month and $p < 0.001$ at the other time points) (Table II).

LEFS

The mean pretreatment LEFS score was 50.3 ± 15.7 for the F-ESWT group and 49.6 ± 13.1 for the control group ($p = 0.82$). The magnitude of the change in the LEFS score was significantly greater for the F-ESWT group, except at 1 month ($p = 0.25$ at 1 month; $p < 0.003$ for the other time points) (Table II).

EQ-5D

The mean pretreatment EQ-5D health status score was 0.53 ± 0.31 for the F-ESWT group and 0.56 ± 0.24 for the control group ($p = 0.28$). The magnitude of the change in the EQ-5D score was significantly greater for the F-ESWT group ($p < 0.025$ at 1 month and $p < 0.001$ for the other time points) (Table II).

RM Score

The mean RM score was significantly better for the F-ESWT group compared with the control group ($p < 0.001$ at each time

TABLE II HHS, LEFS, and EQ-5D

	Mean ± SD		
	F-ESWT	Control	P Value
HHS			
Baseline	65.0 ± 13.5	65.9 ± 11.2	0.71
1 mo	80.0 ± 12.4	73.5 ± 12.2	<0.01
2 mo	88.5 ± 11.2	77.6 ± 12.6	<0.001
3 mo	90.4 ± 10.3	78.0 ± 11.7	<0.001
6 mo	91.0 ± 10.3	79.4 ± 12.5	<0.001
LEFS			
Baseline	50.3 ± 15.7	49.6 ± 13.1	0.82
1 mo	57.3 ± 14.8	54.0 ± 13.7	0.25
2 mo	65.7 ± 12.7	56.5 ± 14.6	<0.001
3 mo	67.6 ± 12.0	60.6 ± 10.4	0.003
6 mo	68.1 ± 11.0	60.6 ± 12.4	0.002
EQ-5D			
Baseline	0.53 ± 0.31	0.56 ± 0.24	0.28
1 mo	0.72 ± 0.22	0.62 ± 0.18	0.025
2 mo	0.82 ± 0.17	0.66 ± 0.22	<0.001
3 mo	0.85 ± 0.14	0.68 ± 0.15	<0.001
6 mo	0.83 ± 0.14	0.69 ± 0.15	<0.001

TABLE III RM Scores

	Mean ± SD	P Value
1 mo		<0.001
ESWT	2.26 ± 0.79	
Control	2.96 ± 0.76	
2 mo		<0.001
ESWT	1.81 ± 0.81	
Control	2.64 ± 0.87	
3 mo		<0.001
ESWT	1.64 ± 0.79	
Control	2.45 ± 0.73	
6 mo		<0.001
ESWT	1.59 ± 0.85	
Control	2.53 ± 0.77	

TABLE IV Percentage Distribution of RM Scores

	Excellent or Good* (%)	Fair or Poor† (%)
1 mo		
F-ESWT	64.2	35.8
Control	21.7	78.3
2 mo		
F-ESWT	86.8	13.2
Control	38.7	61.3
3 mo		
F-ESWT	84.9	15.1
Control	54.5	45.6
6 mo		
F-ESWT	88.5	11.5
Control	53.4	46.6

*RM score of 1 or 2. †RM score of 3 or 4.

point) (Table III). The percentages of patients with an excellent result (an RM score of 1) or significant improvement (an RM score of 2) were significantly greater in the F-ESWT group compared with the control group at each time point (64.2% versus 21.7% at 1 month, 86.8% versus 38.7% at 2 months, 84.9% versus 54.5% at 3 months, and 88.5% versus 53.4% at 6 months; $p < 0.001$ for all) (Table IV).

Discussion

GTPS is a clinical condition whose exact pathogenesis is still unknown and for which optimal treatment protocols have not been defined[5]. Nonsurgical therapy is the mainstay of managing GTPS and includes NSAIDs, physiotherapy, therapeutic exercises, shockwaves, platelet-rich plasma, or corticosteroid injections[14,38]. Surgical treatment is generally reserved for recalcitrant cases for which nonoperative management has failed[11,39-43]. Shockwave treatment recently gained a relevant position as a nonoperative treatment[15,16]. Grimaldi et al. emphasized the dearth of scientific evidence for both surgical and nonoperative management of GTPS[44,45]. In a recent systematic review, Barratt et al. confirmed the lack of high-quality research regarding the nonoperative treatments for GTPS[14].

On the other hand, research has provided evidence supporting ESWT and radial pressure waves for lower-limb tendinopathy[15]. In 2009, 2 different studies demonstrated the effectiveness of radial pressure waves for GTPS in the short and long term[17,18]. In a randomized controlled clinical trial, Rompe et al. found, at 4 and 15 months of follow-up, that radial pressure waves provided better results than corticosteroid injections and home exercises for patients with GTPS[17]. In a case-control study, Furia et al. demonstrated that patients with GTPS treated with radial pressure waves had better outcomes at 1, 3, and 12 months than those treated with other nonoperative treatments[18]. In a recent retrospective study, Seo et al. showed the effectiveness of electrohydraulic low-energy F-ESWT (EFD = 0.10 mJ/mm^2) for pain relief in patients with GTPS but its long-term effect appeared to decrease with time[23]. A randomized clinical trial by Carlisi et al. showed piezoelectric F-ESWT for GTPS to be more effective than ultrasound therapy for reducing pain at short-term and mid-term follow-up[22].

To our knowledge, the current multicenter, prospective, randomized clinical trial is the first study to evaluate the effectiveness of a focused electromagnetic device for GTPS and the first to include sham F-ESWT as a control. Our study showed early pain reduction and improvement on functional, quality-of-life, and treatment-satisfaction scales from the first month and throughout the follow-up period. Sixty-four percent of patients in the F-ESWT group showed an excellent or good result at 1 month, with the result improving to 86.8% at 2 months, compared with 21.7% and 38.7% at 1 and 2 months, respectively, in the control group. The 2 previous trials of F-ESWT in GTPS[22,23] showed some differences in comparison with our study. Our sample size is superior to those in the studies by Seo et al.[23] and Carlisi et al.[22], which included 18 and 50 patients, respectively. We used 3 treatment sessions for each patient and the same EFD continuously during the entire session. In contrast, Seo et al. applied 600 shocks at 0.10 mJ/mm^2 and a variable number of sessions, depending on the patients' recovery, and surprisingly up to 12 sessions, which is not a standard protocol approved by DIGEST (the German ESWT society)[46] or the ISMST. Carlisi et al. compared piezoelectric F-ESWT—3 sessions of 1,800 pulses with the first 300 shocks at 0.05 mJ/mm^2 and the rest at 0.15 mJ/mm^2—with ultrasound therapy. We considered it important to demonstrate the short-term and mid-term effectiveness of F-ESWT as patients want pain to be alleviated as soon as possible. Moreover, the use of sham F-ESWT allowed us to confirm the effectiveness of F-ESWT by comparing it with a control group. Surprisingly, 80% of the patients with GTPS in the study by Carlisi et al. showed calcific tendinopathy around the trochanter on ultrasound evaluation, which highlights the importance of applying F-ESWT instead of radial pressure waves for GTPS. Calcific tendinitis, which requires high energy levels, was an exclusion criterion in our study.

Imaging techniques demonstrated an underlying bursitis as a cause of GTPS in 21 (20%) of our 103 patients (Table I), in contrast to the 8.3% rate of bursitis seen on MRI in the study by Bird et al.[3].

The better global results in our study were influenced by the application of medium energy levels to our patients (to guarantee higher effectiveness from our technology), compared with low energy levels in the study by Seo et al.[23] and very low energy levels in the study by Carlisi et al.[22]. According to the RM score, 86.8% of the patients in our F-ESWT group showed excellent or good results at 2 months compared with 38.7% in the control group at the same time point. F-ESWT would be expected to have long-term satisfactory results based on 2-year follow-up results in previous studies of shockwave therapy for tendinopathies[45-47]. Clarification of underlying pathogenic mechanisms may aid in the development of a better management strategy for GTPS. A correct GTPS differential diagnosis

may facilitate selection of patients who will benefit the most from F-ESWT.

There are several limitations of this study. The first is the lack of follow-up of >6 months after the intervention. Second, since the control group received 3 F-ESWT sessions at the lowest EFD of the equipment it could be considered a quasi-placebo group. Third, we lacked exact data on patients' compliance with the home exercise protocol. Fourth, although women were more likely to be in the treatment group, a sample size of 103 patients may be not large enough to detect important differences in responses to the intervention between the sexes.

Further research is necessary to confirm the long-lasting effectiveness of F-ESWT for GTPS.

Conclusions

F-ESWT associated with a specific exercise program is safe and effective for GTPS, with a success rate of 86.8% at 2 months after treatment, which was maintained until the end of follow-up. Future high-quality randomized clinical trials are needed to elucidate the optimal shockwave treatment parameters for tendinopathies and to determine their long-term efficacy for patients with GTPS.

Appendix

Supporting material provided by the authors is posted with the online version of this article as a data supplement at jbjs.org (http://links.lww.com/JBJS/F951). ■

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References

1. Williams BS, Cohen SP. Greater trochanteric pain syndrome: a review of anatomy, diagnosis and treatment. Anesth Analg. 2009 May;108(5):1662-70.

2. Fearon AM, Scarvell JM, Neeman T, Cook JL, Cormick W, Smith PN. Greater trochanteric pain syndrome: defining the clinical syndrome. Br J Sports Med. 2013 Jul;47(10):649-53. Epub 2012 Sep 14.

3. Bird PA, Oakley SP, Shnier R, Kirkham BW. Prospective evaluation of magnetic resonance imaging and physical examination findings in patients with greater trochanteric pain syndrome. Arthritis Rheum. 2001 Sep;44(9):2138-45.

4. Tortolani PJ, Carbone JJ, Quartararo LG. Greater trochanteric pain syndrome in patients referred to orthopedic spine specialists. Spine J. 2002 Jul-Aug;2(4):251-4.

5. Lustenberger DP, Ng VY, Best TM, Ellis TJ. Efficacy of treatment of trochanteric bursitis: a systematic review. Clin J Sport Med. 2011 Sep;21(5):447-53.

6. Long SS, Surrey DE, Nazarian LN. Sonography of greater trochanteric pain syndrome and the rarity of primary bursitis. AJR Am J Roentgenol. 2013 Nov;201(5):1083-6.

7. Schlesinger N, Dundeva-Baleva P, Abdel-Megid A, Borham A. THU0352 trochanteric bursitis: is there ultrasonographic evidence to suggest inflammation? Ann Rheum Dis. 2013 Jun 1;71(Suppl 3):275.

8. Ho GWK, Howard TM. Greater trochanteric pain syndrome: more than bursitis and iliotibial tract friction. Curr Sports Med Rep. 2012 Sep-Oct;11(5):232-8.

9. Silva F, Adams T, Feinstein J, Arroyo RA. Trochanteric bursitis: refuting the myth of inflammation. J Clin Rheumatol. 2008 Apr;14(2):82-6.

10. Reid D. The management of greater trochanteric pain syndrome: a systematic literature review. J Orthop. 2016 Jan 22;13(1):15-28.

11. Govaert LHM, van Dijk CN, Zeegers AVCM, Albers GHR. Endoscopic bursectomy and iliotibial tract release as a treatment for refractory greater trochanteric pain syndrome: a new endoscopic approach with early results. Arthrosc Tech. 2012 Aug 24;1(2):e161-4.

12. Connell DA, Bass C, Sykes CAJ, Young D, Edwards E. Sonographic evaluation of gluteus medius and minimus tendinopathy. Eur Radiol. 2003 Jun;13(6):1339-47. Epub 2002 Nov 23.

13. Mallow M, Nazarian LN. Greater trochanteric pain syndrome diagnosis and treatment. Phys Med Rehabil Clin N Am. 2014 May;25(2):279-89. Epub 2014 Mar 18.

14. Barratt PA, Brookes N, Newson A. Conservative treatments for greater trochanteric pain syndrome: a systematic review. Br J Sports Med. 2017 Jan;51(2): 97-104. Epub 2016 Nov 10.

15. Mani-Babu S, Morrissey D, Waugh C, Screen H, Barton C. The effectiveness of extracorporeal shock wave therapy in lower limb tendinopathy: a systematic review. Am J Sports Med. 2015 Mar;43(3):752-61. Epub 2014 May 9.

16. Korakakis V, Whiteley R, Tzavara A, Malliaropoulos N. The effectiveness of extracorporeal shockwave therapy in common lower limb conditions: a systematic review including quantification of patient-rated pain reduction. Br J Sports Med. 2018 Mar;52(6):387-407. Epub 2017 Sep 27.

17. Rompe JD, Segal NA, Cacchio A, Furia JP, Morral A, Maffulli N. Home training, local corticosteroid injection, or radial shock wave therapy for greater trochanter pain syndrome. Am J Sports Med. 2009 Oct;37(10):1981-90. Epub 2009 May 13.

18. Furia JP, Rompe JD, Maffulli N. Low-energy extracorporeal shock wave therapy as a treatment for greater trochanteric pain syndrome. Am J Sports Med. 2009 Sep; 37(9):1806-13. Epub 2009 May 13.

19. Moya D, Ramon S, Schaden W, Wang CJ, Guiloff L, Cheng JH. The role of extracorporeal shockwave treatment in musculoskeletal disorders. J Bone Joint Surg Am. 2018 Feb 7;100(3):251-63.

20. Reilly JM, Bluman E, Tenforde AS. Effect of shockwave treatment for management of upper and lower extremity musculoskeletal conditions: a narrative review. PM R. 2018 Dec;10(12):1385-403. Epub 2018 Jun 1.

21. Haupt G. Use of extracorporeal shock waves in the treatment of pseudarthrosis, tendinopathy and other orthopedic diseases. J Urol. 1997 Jul;158(1):4-11.

22. Carlisi E, Cecini M, Di Natali G, Manzoni F, Tinelli C, Lisi C. Focused extracorporeal shock wave therapy for greater trochanteric pain syndrome with gluteal tendinopathy: a randomized controlled trial. Clin Rehabil. 2019 Apr;33(4):670-80. Epub 2018 Dec 26.

23. Seo KH, Lee JY, Yoon K, Do JG, Park HJ, Lee SY, Park YS, Lee YT. Long-term outcome of low-energy extracorporeal shockwave therapy on gluteal tendinopathy documented by magnetic resonance imaging. PLoS One. 2018 Jul 17;13(7): e0197460.

24. International Society for Medical Shockwave Treatment. ISMST recommendations. 2018. Accessed 2020 Feb 11. https://www.shockwavetherapy.org/about-eswt/ismst-recommendations/

25. Notarnicola A, Moretti B. The biological effects of extracorporeal shock wave therapy (ESWT) on tendon tissue. Muscles Ligaments Tendons J. 2012 Jun 17;2(1):33-7.

26. Pakos E, Gkiatas I, Rakkas G, Papadopoulos D, Gelalis I, Vekris M, Korompilias A. Calcific deposit needling in combination with extracorporeal shock wave therapy (ESWT): a proposed treatment for supraspinatus calcified tendinopathy. SICOT J. 2018;4:45. Epub 2018 Oct 19.

27. Stasinopoulos D. Can extracorporeal shock-wave therapy be used for the management of lateral elbow tendinopathy? World J Methodol. 2018 Nov 29;8(3):37-9.

28. Rouzier P. The sports medicine patient advisor. Amherst, Mass: SportsMed Press; 1999.

29. Landry M. Brukner & Khan's clinical sports medicine. Physiother Can. 2014; 66(1):109-10.

30. Sociedad Española de Rehabilitacion y Medicina Fisica. SERMEF exercise program. Accessed 2019 Sep 5. http://www.sermef-ejercicios.org/webprescriptor/index.php?lang=&action=muestraSeleccionEjercicios&show=programa&cmd=delCesta&regionid=7

31. Haefeli M, Elfering A. Pain assessment. Eur Spine J. 2006 Jan;15(Suppl 1): S17-24. Epub 2005 Dec 1.

32. Heller GZ, Manuguerra M, Chow R. How to analyze the visual analogue scale: myths, truths and clinical relevance. Scand J Pain. 2016 Oct;13:67-75. Epub 2016 Jul 27.

33. Harris WH. Traumatic arthritis of the hip after dislocation and acetabular fractures: treatment by mold arthroplasty. An end-result study using a new method of result evaluation. J Bone Joint Surg Am. 1969 Jun;51(4):737-55.

34. Chow IHW, Cheing GLY. Comparison of different energy densities of extracorporeal shock wave therapy (ESWT) for the management of chronic heel pain. Clin Rehabil. 2007 Feb;21(2):131-41.

35. Rompe JD, Kirkpatrick CJ, Küllmer K, Schwitalle M, Krischek O. Dose-related effects of shock waves on rabbit tendo Achillis. A sonographic and histological study. J Bone Joint Surg Br. 1998 May;80(3):546-52.

36. Cacchio A, De Blasis E, Necozione S, Rosa F, Riddle DL, di Orio F, De Blasis D, Santilli V. The Italian version of the Lower Extremity Functional Scale was reliable, valid, and responsive. J Clin Epidemiol. 2010 May;63(5):550-7. Epub 2009 Nov 12.

37. EuroQol Group. EuroQol—a new facility for the measurement of health-related quality of life. Health Policy. 1990 Dec;16(3):199-208.

38. Kaux JF, Forthomme B, Goff CL, Crielaard JM, Croisier JL. Current opinions on tendinopathy. J Sports Sci Med. 2011 Jun 1;10(2):238-53.

39. Pretell J, Ortega J, García-Rayo R, Resines C. Distal fascia lata lengthening: an alternative surgical technique for recalcitrant trochanteric bursitis. Int Orthop. 2009 Oct;33(5):1223-7. Epub 2009 Feb 12.

40. Drummond J, Fary C, Tran P. The outcome of endoscopy for recalcitrant greater trochanteric pain syndrome. Arch Orthop Trauma Surg. 2016 Nov;136(11):1547-54. Epub 2016 Jul 12.

41. Zeman P, Rafi M, Skala P, Zeman J, Matějka J, Pavelka T. [Clinical results of endoscopic treatment of greater trochanteric pain syndrome]. Acta Chir Orthop Traumatol Cech. 2017;84(3):168-74.

42. Brinks A, van Rijn RM, Willemsen SP, Bohnen AM, Verhaar JAN, Koes BW, Bierma-Zeinstra SM. Corticosteroid injections for greater trochanteric pain syndrome: a randomized controlled trial in primary care. Ann Fam Med. 2011 May-Jun; 9(3):226-34.

43. Robertson-Waters E, Berstock JR, Whitehouse MR, Blom AW. Surgery for greater trochanteric pain syndrome after total hip replacement confers a poor outcome. Int Orthop. 2018 Jan;42(1):77-85. Epub 2017 Jul 28.

44. Grimaldi A, Mellor R, Hodges P, Bennell K, Wajswelner H, Vicenzino B. Gluteal tendinopathy: a review of mechanisms, assessment and management. Sports Med. 2015 Aug;45(8):1107-19.

45. Grimaldi A, Fearon A. Gluteal tendinopathy: integrating pathomechanics and clinical features in its management. J Orthop Sports Phys Ther. 2015 Nov;45(11): 910-22. Epub 2015 Sep 17.

46. Digest Guidelines for extracorporeal shockwave treatment. 2019. Accessed 2019 Nov 10. https://www.shockwavetherapy.org/fileadmin/user_upload/ISMST_Guidelines.pdf

47. Wang CJ, Yang KD, Wang FS, Chen HH, Wang JW. Shock wave therapy for calcific tendinitis of the shoulder: a prospective clinical study with two-year follow-up. Am J Sports Med. 2003 May-Jun;31(3):425-30.