

Extracorporeal shock wave therapy versus dry needling for piriformis syndrome: A randomized clinical trial

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ABSTRACT

Objectives: This study aimed to compare the efficacy of extracorporeal shock wave therapy (ESWT) and dry needling (DN) in treating piriformis syndrome (PS).

Patients and methods: This randomized controlled trial included 48 patients with PS between February 3, 2024, and August 23, 2024. The patients were randomized into DN and ESWT groups. The ESWT group received three sessions of ultrasound-guided ESWT, and the DN group received three sessions of ultrasound-guided DN. Static stretching exercises were given to both groups. Clinical evaluations were assessed with the visual analog scale (VAS), Oswestry Disability Index (ODI), and Lower Extremity Functional Scale (LEFS) at baseline and one and three months after treatment.

Results: Forty-four patients completed the study, with 23 patients (18 females, 5 males; mean age: 49.6±8.9 years; range, 33 to 70 years) in the ESWT group and 21 patients (16 females, 5 males; mean age: 50.4±9.2 years; range, 33 to 64 years) in the DN group. In both groups, there was a significant improvement in VAS pain, ODI, and LEFS scores at one and three months of follow-up compared to baseline ($p<0.001$). However, no significant difference was observed in VAS, ODI, and LEFS scores between the groups ($p>0.05$).

Conclusion: In this study, the combination of DN and stretching exercise, as well as ESWT and stretching exercise, was effective in terms of pain relief and functionality in patients with PS during a three-month follow-up period. These two treatment methods can be effectively used in patients with PS. Extracorporeal shock wave therapy can be considered as an alternative treatment method, particularly in patients with needle phobia.

Keywords: Dry needling, extracorporeal shock wave therapy, pain management, piriformis muscle syndrome, sciatica.

Piriformis syndrome (PS) is a neuromuscular disorder that leads to buttock or thigh pain as a result of compression of the sciatic nerve by the piriformis muscle. The sciatic nerve is closely related to the piriformis muscle and usually exits inferior to the muscle in the greater sciatic notch.^[1] The etiology of PS has not been clarified. However, myofascial pain syndrome, trauma, anatomical anomalies, and activities that create a high level of demand on the muscle may increase the tension of the muscle.^[2] The estimated incidence of PS has been reported to be between 12.2% and 27%.^[2] In another study, it was reported that PS constituted 17.2% of patients with

low back pain as a presenting symptom.^[3] There is no definite gold standard method for the diagnosis of PS. Piriformis syndrome is diagnosed by combining clinical findings with physical examination maneuvers that create pressure on the sciatic nerve and reviewing possible differential diagnoses.^[4,5]

There is no optimal treatment option in the management of PS. Lifestyle modifications and conservative treatment form the basis of treatment. Surgical treatment may also be considered in cases resistant to conservative treatment and in anatomical anomalies.^[4] Treatment aims to decrease the

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tension in the piriformis muscle and to strengthen the hip abductors, external rotators, and hip extensors.^[5] Minimally invasive treatments such as local anesthetics, corticosteroids, botulinum toxin injections, and dry needling (DN) can be added to these conservative treatments.^[4,6-9] Minimally invasive procedures applied in treatment have been performed under imaging guidance in recent years to increase procedure accuracy and avoid possible complications.^[7,10,11]

Dry needling therapy is administered using a fine needle and reduces muscle tension and pain while increasing muscle range of motion and muscle strength.^[12] Previous literature has shown that DN can be used in PS therapy.^[8,11,13] Extracorporeal shock wave therapy (ESWT), which consists of sonic waves characterized by rapid pressure increase and high peak pressure, is widely used in musculoskeletal system pathologies such as myofascial pain syndrome, and its use is increasing. It has been shown to accelerate healing and reduce pain in muscle pathologies.^[14,15] However, its use as an indication for PS has not been widely emphasized in the literature, although studies have indicated that it may be effective for PS.^[7,16,17]

In the current literature, to our knowledge, there is no study directly comparing the efficacy of DN and ESWT in PS. This study aimed to evaluate the effects of these two regenerative treatment methods applied without any pharmacological intervention on pain and functionality in PS.^[12,18]

PATIENTS AND METHODS

This randomized controlled trial included patients with PS who presented to the Department of Physical Medicine and Rehabilitation of the İstanbul Training and Research Hospital with thigh or buttock pain between February 3, 2024, and August 23, 2024. Two experienced clinicians evaluated the participants and diagnosed PS according to previously defined criteria. According to these criteria, the presence of localized pain aggravated by sitting, tenderness around the ischial tuberosity, and at least one of the following maneuvers that increase piriformis muscle tension: hip FAIR (flexion-abduction-internal rotation), pace test (resisted abduction of both thighs in the seated position), tonic external rotation of hip test, heel-contralateral knee maneuver test, Freiberg maneuver (forceful internal rotation of the extended thigh in the supine position), or Beatty test (active abduction of the affected thigh in the side-lying position) was required.^[1,8] Patients who

met the inclusion criteria, had unilateral PS, were over 18 years of age, and had symptoms for more than three months were included in the study.^[1,8] The exclusion criteria included disc pathologies as determined by radiological imaging, hip joint and soft tissue pathologies, recent history of trauma, history of lumbar and hip surgery, history of rheumatological disease, history of polyneuropathy, history of sciatic nerve injury, history of malignancy, opioid-derived analgesia or corticosteroid intervention for pain in the last month, patients receiving another treatment during the study, and patients with contraindications for DN treatment (e.g., coagulopathy, local or systemic infection) or ESWT treatment (e.g., coagulopathy, local or systemic infection, pacemaker, and malignancy).^[19,20] Written informed consent was obtained from all participants. The study protocol was approved by the İstanbul Training and Research Hospital Clinical Research Ethics Committee (Date: 22.12.2023, Decision No: 347, 2011-KAEK-50, 22.12.2023). This study was conducted in accordance with the principles of the Declaration of Helsinki.

In this study, a total of 65 patients were diagnosed with PS, but 17 patients were excluded, as they met the exclusion criteria (previous injection, n=3; concomitant lumbar disc pathologies, n=11; total hip replacement, n=1; history of polyneuropathy, n=2). Forty-eight patients fulfilling the inclusion criteria were included in this study and allocated into two groups according to a random number table (Figure 1). Randomization was performed by a clinician who was not familiar with the study protocol.

At the beginning of the study, participants' age, sex, body mass index (BMI), and symptom duration were recorded. The pain levels of the patients in the sitting position within the last 24 h were evaluated by a 10-cm Visual Analog Scale (VAS). The physical functions of the patients were assessed using the Oswestry Disability Index (ODI) and Lower Extremity Functional Scale (LEFS). Oswestry Disability Index is an assessment scale that evaluates the functional disability caused by low back pain with patient-reported results.^[21] The ODI consists of 10 items and each item is scored between 0 and 5. Turkish validity and reliability of the ODI was demonstrated by Yakut et al.^[22] Lower Extremity Functional Scale is a patient-reported assessment scale used to evaluate lower extremity function.^[23] It consists of 20 items, and each item is scored between 0 and 4. The Turkish

validity and reliability of the LEFS were previously demonstrated by Citaker et al.^[24] The evaluation scales were evaluated in both groups before the start of treatment and one and three months after the end of treatment. In our study, outcome assessors were blinded to participants' group allocations, and evaluations were based solely on standardized questionnaire forms completed by the participants, minimizing potential observer bias.

Patients were assigned to the DN group and the ESWT group according to the randomization method. In the DN group, DN treatment of the piriformis muscle was performed in three sessions, once a week, under ultrasound guidance by a clinician with approximately six years of experience in musculoskeletal system pain management. Dry needling was performed under sterile conditions after the piriformis muscle was visualized by ultrasound with the patient in prone position. A low-frequency (2-6 MHz) transducer (Clarius ultrasound multipurpose scanner, C3; Clarius, Burnaby, BC, Canada) was used to visualize the piriformis muscle. The ultrasound probe was placed to visualize the iliac process and gluteus maximus muscle; the probe was then shifted distally to visualize the piriformis muscle over the sciatic notch (Figure 2). The patient's knee joint was flexed, and the movement of the piriformis muscle was

ultrasonographically monitored by internal and external rotation of the hip.^[11] The relationship of the sciatic nerve with the piriformis muscle was determined. Then, a sterile acupuncture needle (0.30×60-mm needle; SEIRIN J type, Kyoto, Japan) was inserted through the skin with the in-plane technique. After needle insertion, the guide was removed, and the needle was guided into the muscle. Then, local twitch response was tried to be obtained by using the in-and-out needling technique.^[8]

Patients in the ESWT group received three sessions of ESWT over three consecutive weeks, one session per week. Before the procedure, 120° flexion, 30° adduction, and 50° external rotation positions were given to the hip joint while the patient was lying on the side to lengthen the piriformis.^[9] After placing the ESWT connection gel into the piriformis muscle under ultrasound guidance, the correct pressure was applied to the skin and performed as follows: three sessions of ESWT (MASTERPLUS MP100; STORZ MEDICAL, Tokyo, Japan) at an energy density of 4.0 bar and a frequency of 2000 shocks/min at 5 Hz.^[7]

Both patient groups were taught static stretching exercises consisting of flexion, adduction, and internal rotation of the hip to be performed at home for 10 repetitions twice a day by the therapist, and the participants were expected to perform these exercises

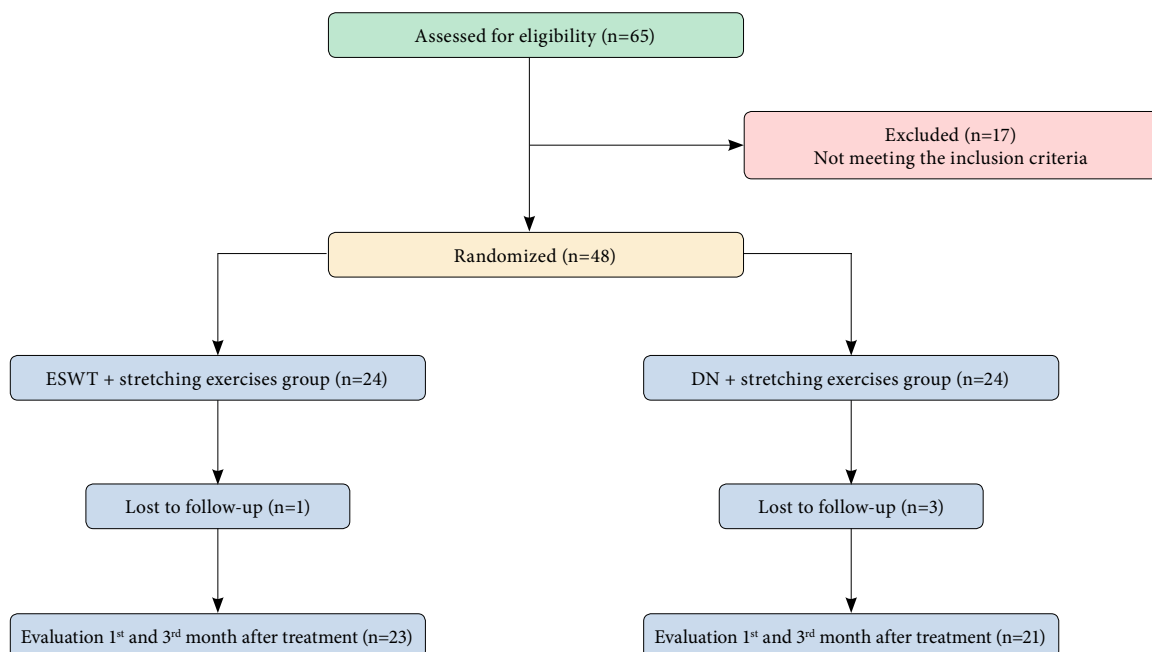


Figure 1. Flowchart illustrating the inclusion and randomization process.

ESWT: Extracorporeal shock wave therapy; DN: Dry needling.

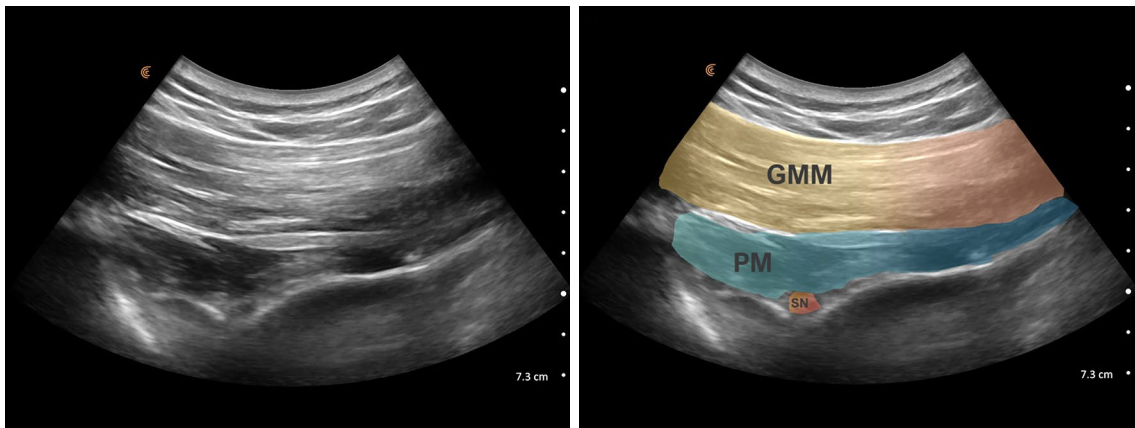


Figure 2. Imaging of the piriformis muscle above the sciatic notch in the longitudinal plane using a low-frequency (2-6 MHz) convex probe and its relationship with the sciatic nerve.

GMM: Gluteus maximus muscle; PM: Piriformis muscle; SN: Sciatic nerve.

during the study.^[11] The accuracy of the participants' exercise performance was verified during the weekly sessions, and the exercises were demonstrated again when necessary.

Statistical analysis

The sample size of this study was calculated (alpha value =0.05, power =0.80, effect size =0.6) using G*Power version 3.1.5 software (Heinrich-Heine Universität Düsseldorf, Düsseldorf, Germany) considering the studies in the literature.^[8,11] It was planned to enroll 19 patients for each group, but considering the possible dropout from the study, a total of 48 patients were planned to be enrolled.

Statistical analyses were carried out using IBM SPSS version 22.0 software (IBM Corp., Armonk, NY, USA). The Kolmogorov-Smirnov/Shapiro-Wilk test, kurtosis and skewness values, and histogram plots were used to assess normal distribution. When presenting descriptive analyses, mean \pm standard deviation (SD) and median (interquartile range) values were given for quantitative variables. Categorical variables were analyzed using the chi-square test. Independent variables were compared with the Student's t-test. Repeated measures analysis of variance were used to determine changes over time by each group. Bonferroni correction was applied to prevent type 1 errors in multiple comparisons when analysis of variance showed significant differences. Cohen's effect sizes (d) were used for the measurements. When interpreting the effect size (Cohen's d), small ($d < 0.2$), medium ($d = 0.2-0.5$), and large ($d > 0.8$) were considered.^[25] A p-value < 0.05 was considered statistically significant. The researcher

performing the statistical analyses was blinded to the study groups.

RESULTS

Of the 48 patients initially included in the study, one patient in the ESWT group and three patients in the DN group dropped out of the study during follow-up. Finally, 44 patients, 23 (18 females, 5 males; mean age: 49.6 ± 8.9 years; range, 33 to 70 years) in the ESWT group and 21 (16 females, 5 males; mean age: 50.4 ± 9.2 years; range, 33 to 64 years) in the DN group, completed the study. The mean BMI was 25.3 ± 5.1 and 24.0 ± 4.9 for the ESWT and DN groups, respectively. The mean pain duration was 7.6 ± 4.2 and 7.8 ± 3.7 months for the ESWT and DN groups, respectively. No significant difference was observed between the treatment groups in terms of sex, age, BMI, and pain duration ($p > 0.05$; Table 1).

The VAS pain score showed a significant improvement in both groups at one and three months of follow-up compared to baseline ($p < 0.001$). However, VAS score at one and three months did not show significant difference between the groups ($p > 0.05$). No significant difference was observed between the treatment groups in terms of ODI and LEFS at any timepoint ($p > 0.05$; Table 2).

The ODI and LEFS scores evaluating the functionality of the patients showed significant improvement in both groups compared to baseline at one and three months of follow-up ($p < 0.001$). However, ODI and LEFS scores at one and three months did not differ significantly within the groups ($p > 0.05$). There was no significant difference between

TABLE 1
Comparison of demographic data between the ESWT and DN groups

	ESWT group (n=23)			DN group (n=21)			p
	n	%	Mean±SD	n	%	Mean±SD	
Age (year)			49.6±8.9			50.4±9.2	0.580*
Sex							0.598**
Male	5	23.8		5	23.8		
Female	18	76.2		16	76.2		
Body mass index (kg/m ²)			25.3±5.1			24.0±4.9	0.445*
Disease duration (mo)			7.6±4.2			7.8±3.7	0.750*

ESWT: Extracorporeal shock wave therapy; DN: Dry needling; SD: Standard deviation; * Student's t test; ** Chi-square test.

TABLE 2
Comparison of VAS, ODI, and LEFS scores within- and between-groups

	ESWT group			DN group			Between groups difference			
	Mean±SD	Median	Q1-Q3	Mean±SD	Median	Q1-Q3	Mean	95% CI	p	d
VAS-0	7.8±1.4	8.0	7.0-9.0	8.0±1.1	8.0	7.0-8.5	-0.22	-1.02; 0.59	0.632*	1.33
VAS-1	4.1±2.8	4.0	2.0-6.0	4.4±2.0	5.0	3.0-6.0	-0.39	-1.87; 1.09	0.455**	2.46
VAS-3	3.7±3.1	3.0	1.0-7.0	3.9±2.2	3.0	2.0-6.5	-0.25	-1.91; 1.39	0.594*	2.75
P†		<0.001‡¶			<0.001‡¶					
ODI-0	43.9±16.2	42.0	33.0-60.0	45.9±16.5	46.0	34.0-60.0	-2.13	-12.12; 7.86	0.741**	16.38
ODI-1	25.0±17.9	20.0	10.0-40.0	22.4±11.5	20.0	15.5-27.0	2.51	-6.57; 11.60	0.724*	15.09
ODI-3	23.0±17.9	18.0	8.8-46.0	20.5±12.2	20.0	8.8-29.0	2.48	-6.81; 11.77	0.953*	15.36
P†		<0.001‡¶			<0.001‡¶					
LEFS-0	37.9±13.0	34.0	29.0-50.0	38.2±13.2	43.0	26.0-45.5	-2.13	-12.12; 7.86	0.741**	16.38
LEFS-1	53.0±16.5	56.0	40.0-69.0	50.0±11.9	50.0	41.0-58.0	2.51	-6.57; 11.60	0.724*	15.09
LEFS-3	55.3±17.6	60.0	38.0-72.0	52.3±16.1	60.0	37.0-65.0	2.48	-6.81; 11.77	0.953*	15.36
P†		<0.001‡¶			<0.001‡¶					

VAS: Visual Analog Scale; ODI: Oswestry disability index; LEFS: Lower extremity functional scale; ESWT: Extracorporeal shock wave therapy; DN: Dry needling; 0: Baseline; 1: Post-treatment 1st month; 3: Post-treatment 3rd month; d: Cohen's effect size; CI: Confidence interval; * Mann-Whitney U-test; ** Student's t test; † Friedman's test; ‡ Significant difference between 0 and 1 p<0.001, Wilcoxon Signed-Rank test; ¶ Significant difference between 0 and 3 p<0.001, Wilcoxon Signed-Rank test.

the groups in terms of ODI and LEFS at baseline, one month, and three months ($p>0.05$; Table 2). The mean difference, confidence interval, and effect sizes between the groups at baseline and follow-up periods are presented in Table 2.

No significant difference was found when the treatment-related changes in VAS, ODI, and LEFS scores over time were compared between the treatment groups ($p>0.05$; Table 3). The mean difference, confidence intervals, and effect sizes of treatment-related changes within groups are presented in Table 3.

Depending on the treatments used, this study showed no side effects or complications during the study period.

DISCUSSION

In this study, we compared the efficacy of DN and ESWT treatments added to stretching exercises for patients with PS. Both groups showed significant improvement in pain (VAS) and functional scores (LEFS and ODI) at one and three months of follow-up compared to baseline. However, no significant difference was observed in treatment-related changes in VAS, ODI, and LEFS scores between the groups.

Patients with PS experience moderate to severe disability in their daily lives with prolonged sitting habits such as sitting on rough surfaces and crossing legs. Activities such as prolonged walking may also cause tension in the piriformis muscle and aggravate the symptoms.^[1] In PS, the goal is to increase the

TABLE 3
Comparison of the changes in pre- and posttreatment scores between groups

	ESWT group		Within groups	DN group		Within groups	Between groups
	Mean±SD	95% CI	d	Mean±SD	95% CI	d	<i>p</i>
VAS							
Change baseline-1 st month	3.6±2.6	2.57; 4.81	2.58	3.5±2.1	2.55; 4.49	2.14	0.972*
Change baseline-3 rd month	4.1±2.9	2.79; 5.37	2.98	4.0±2.6	2.84; 5.24	2.64	0.953*
Change 1 st month-3 rd month	0.3±1.2	-0.14; 0.92	1.23	0.5±1.6	-0.23; 1.28	1.66	0.707**
ODI							
Change baseline-1 st month	18.8±17.4	11.30; 26.42	17.49	23.5±19.2	14.73; 32.29	18.77	0.431*
Change baseline-3 rd month	20.8±17.9	13.07; 28.57	17.92	25.4±21.2	15.74; 35.12	21.34	0.638**
Change 1 st month-3 rd month	1.9±5.4	-0.39; 4.31	5.45	1.9±8.2	-1.82; 5.68	5.49	0.387*
LEFS							
Change baseline-1 st month	-15.0±12.5	-20.45; -9.63	12.51	-11.7±9.1	-15.88; -7.54	9.17	0.390*
Change baseline-3 rd month	-17.3±13.6	-23.2; -11.44	13.64	-14.0±13.2	-20.12; -8.06	13.25	0.698*
Change 1 st month-3 rd month	-2.3±6.6	-5.16; 0.55	6.62	-2.4±12.4	-8.04; 3.28	12.45	0.888**

ESWT: Extracorporeal shock wave therapy; DN: Dry needling; CI: Confidence interval; VAS: Visual Analog Scale; ODI: Oswestry disability index; LEFS: Lower extremity functional scale; d: Cohen's effect size; * Student's t test; ** Mann-Whitney U-test.

muscle's extensibility by reducing tension, thereby reducing nerve compression. If we consider the tension in the piriformis muscle as the main problem, Nakanishi et al.^[16] reported that ESWT treatment applied in a case with PS provided a decrease in piriformis stiffness.

Extracorporeal shock wave therapy has been reported to be effective in the treatment of entrapment neuropathy in previous studies.^[26,27] In support of this, Nakanishi et al.^[16] also reported a decrease in sciatic nerve cross-sectional area with ESWT in a case of PS. However, ESWT has also been shown to be effective in conditions involving muscle tissue, such as myofascial pain syndrome and spasticity.^[28,29] In fact, the efficacy of ESWT in PS, which is a neuromuscular disorder, shown in this study was consistent with the literature. Another point noted in this study was that ESWT was applied after the location of the muscle was determined using ultrasonography. Huang et al.^[17] reported that ultrasound-guided ESWT was more effective than conventional ESWT on clinical and electrophysiological results in patients with PS. This study, unlike ours, used real-time ultrasonography.

Extracorporeal shock wave therapy increases angiogenesis by increasing vascular endothelial growth factor levels and regulating nitric oxide synthesis, regulates protein biosynthesis, and may

provide cell proliferation. In addition, it reduces pain by acting directly on nerve fibers and reduces calcium deposits in musculoskeletal structures. With all these effects, ESWT may provide favorable results such as tissue regeneration and improvement of pain.^[18,30] However, although the effects of ESWT on muscle tissue are not sufficiently understood. It has been shown in a rat study that ESWT applied after acute muscle injury increases the size of regeneration fibers, myonuclear content, and mitotic activity in muscle.^[31]

Ahadi et al.^[7] compared the efficacy of ESWT with corticosteroid and local anesthetic injection in patients with PS. They evaluated the pain levels of the patients at the beginning and at the end of the treatment at one, four, eight, and 12 weeks. They showed a significant improvement in pain scores in the ESWT group at one week after treatment, but no significant improvement was observed in the injection group. Both groups showed significant improvement in pain scores at the end of the 12-week follow-up. In our study, similarly, significant improvement in pain scores was recorded in both groups. In the role limitation due to physical problems scores, which are subgroups of the 36-item Short-Form Health Survey evaluating quality of life, they found a significant difference between the groups in favor of ESWT at four weeks after treatment. However, they found no significant difference between the two groups in

terms of other subgroups and total score and showed significant improvement compared to baseline in both groups. In this study, we observed notable enhancement in the ODI and LEFS scores of both groups, which assessed the functional condition of the patients. The type of ESWT and the number of sessions used in this study were radial ESWT and three sessions, similar to our study.

In their study of patients with PS, Huang et al.^[32] divided the patients into three different treatment groups. One group received only physical therapy modalities, the other group received stretching exercises in addition to physical therapy modalities, and the third group received ESWT in addition to physical therapy modalities and stretching exercises. They observed more improvement in hip movements, timed up-and-go test, H response latency, and pain scores during follow-up in the ESWT group. The results they obtained in the ESWT group were consistent with the results shown in our study.

The trigger points present in myofascial pain syndrome may cause compression findings in the neighboring nerve. It has been reported that the symptoms and signs observed in PS may be due to compression of the sciatic nerve by trigger points in the muscle.^[13,33] Considering muscle tension in PS, DN has been shown to decrease muscle tension and increase range of motion.^[12,34] Dry needling is a minimally invasive, easy-to-learn, inexpensive, and low-complication-risk treatment widely used in musculoskeletal disorders such as myofascial pain syndrome.^[35] Tabatabaiee et al.^[8] showed in their study in patients with PS that DN applied in three sessions was effective on pain 72 h and one week after treatment. Fusco et al.^[36] applied eight to 12 sessions of DN for 10 days under ultrasound guidance in three patients with PS in their case series and reported that DN was effective in improving symptoms in these patients with PS at the six-month follow-up. The results obtained in our study were consistent with these studies.

Guner and Ozcete^[11] divided their study participants into two groups: one group received only stretching exercises, while the other group received only DN. Both groups showed significant improvement in pain and functional scores at one and three months after treatment compared to baseline values. However, there was no statistically significant difference between the groups in terms of these parameters. In their study, they used a 22-gauge spinal needle, unlike in our study. A study

on needle selection stated that needle diameter may be a determining factor on treatment results.^[37] Although controversial, the study emphasizes that thinner needles cause less trauma to the muscle tissue, resulting in less pain after treatment; however, thicker needles may produce a more permanent response. Therefore, needle selection can be made by considering the patient's pain threshold and clinical status. When we look at the literature, needling sessions in PS are in different numbers. Although there is no clear information about the optimal number of sessions in patients with PS in the literature, three sessions of needling are recommended by some authors.^[13]

In this study, no significant differences were found in VAS, ODI, and LEFS scores between groups during follow-up. Luan et al.^[38] randomized patients with myofascial trigger points in the upper trapezius muscle to receive ESWT and DN. According to the results of that study, both DN and ESWT were found to be effective in myofascial trigger point management. However, no significant difference was found between the groups in the follow-ups performed at one and three months. Similarly, in another study, the effectiveness of ESWT and DN treatments applied to myofascial trigger points in patients with chronic neck pain was compared.^[39] No significant differences were found in the comparisons of outcome measures between groups during the follow-up period. Considering our findings and the data in the literature, it can be concluded that ESWT and DN treatments may lead to similar results in reducing muscle tension. However, these findings should be confirmed by other randomized controlled trials in the future.

This study had some limitations. First, it was limited to a relatively small sample size. Second, factors that may have affected response to treatment, such as psychological conditions and sleep disorders, were not evaluated. Third, there was a lack of a control group that did not receive treatment. Fourth, ESWT was ultrasound-assisted and not ultrasound-guided. In the future, studies comparing the combination of these two treatment modalities with ESWT alone or DN therapy alone and examining the effectiveness of the number of sessions are needed.

In conclusion, this was, to our knowledge, the first study to compare the efficacy of DN and ESWT treatments. In this study, the combination of DN and stretching exercise, as well as ESWT and stretching exercise, was effective in terms of pain relief and

functionality in patients with PS during a three-month follow-up. These two treatment methods can be effectively used in patients with PS. Extracorporeal shock wave therapy can be considered an alternative treatment method, particularly in patients with needle phobia.

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REFERENCES

- Hopayian K, Danielyan A. Four symptoms define the piriformis syndrome: An updated systematic review of its clinical features. *Eur J Orthop Surg Traumatol* 2018;28:155-64. doi: 10.1007/s00590-017-2031-8.
- Jankovic D, Peng P, van Zundert A. Brief review: Piriformis syndrome: Etiology, diagnosis, and management. *Can J Anaesth* 2013;60:1003-12. doi: 10.1007/s12630-013-0009-5.
- Kean Chen C, Nizar AJ. Prevalence of piriformis syndrome in chronic low back pain patients. A clinical diagnosis with modified FAIR test. *Pain Pract* 2013;13:276-81. doi: 10.1111/j.1533-2500.2012.00585.x.
- Boyajian-O'Neill LA, McClain RL, Coleman MK, Thomas PP. Diagnosis and management of piriformis syndrome: An osteopathic approach. *J Am Osteopath Assoc* 2008;108:657-64. doi: 10.7556/jaoa.2008.108.11.657.
- Probst D, Stout A, Hunt D. Piriformis syndrome: A narrative review of the anatomy, diagnosis, and treatment. *PM R* 2019;11:S54-63. doi: 10.1002/pmrj.12189.
- Fanucci E, Masala S, Sodani G, Varruciu V, Romagnoli A, Squillaci E, et al. CT-guided injection of botulinic toxin for percutaneous therapy of piriformis muscle syndrome with preliminary MRI results about denervative process. *Eur Radiol* 2001;11:2543-8. doi: 10.1007/s003300100872.
- Ahadi T, Yousefi A, Sajadi S, Yousefi N, Babaei-Ghazani A. Comparing radial extracorporeal shockwave therapy and corticosteroid injection in the treatment of piriformis syndrome: A randomized clinical trial. *J Bodyw Mov Ther* 2023;33:182-8. doi: 10.1016/j.jbmt.2022.09.020.
- Tabatabaiee A, Takamjani IE, Sarrafzadeh J, Salehi R, Ahmadi M. Ultrasound-guided dry needling decreases pain in patients with piriformis syndrome. *Muscle Nerve* 2019;60:558-65. doi: 10.1002/mus.26671.
- Gulledge BM, Marcellin-Little DJ, Levine D, Tillman L, Harrysson OL, Osborne JA, et al. Comparison of two stretching methods and optimization of stretching protocol for the piriformis muscle. *Med Eng Phys* 2014;36:212-8. doi: 10.1016/j.medengphy.2013.10.016.
- Fishman SM, Caneris OA, Bandman TB, Audette JF, Borsook D. Injection of the piriformis muscle by fluoroscopic and electromyographic guidance. *Reg Anesth Pain Med* 1998;23:554-9. doi: 10.1016/s1098-7339(98)90080-3.
- Guner D, Ozcete ZA. Evaluation of the efficacy of ultrasound-guided dry needling therapy and exercise in piriformis muscle syndrome. *Cureus* 2023;15:e43804. doi: 10.7759/cureus.43804.
- Cagnie B, Dewitte V, Barbe T, Timmermans F, Delrue N, Meeus M. Physiologic effects of dry needling. *Curr Pain Headache Rep* 2013;17:348. doi: 10.1007/s11916-013-0348-5.
- Bağcier F, Tufanoğlu FH. A new treatment modality in piriformis syndrome: Ultrasound guided dry needling treatment. *Agri* 2020;32:175-6. doi: 10.14744/agri.2019.92170.
- De la Corte-Rodríguez H, Román-Belmonte JM, Rodríguez-Damiani BA, Vázquez-Sasot A, Rodríguez-Merchán EC. Extracorporeal shock wave therapy for the treatment of musculoskeletal pain: A narrative review. *Healthcare (Basel)* 2023;11:2830. doi: 10.3390/healthcare11212830.
- Liao CD, Xie GM, Tsauo JY, Chen HC, Liou TH. Efficacy of extracorporeal shock wave therapy for knee tendinopathies and other soft tissue disorders: A meta-analysis of randomized controlled trials. *BMC Musculoskelet Disord* 2018;19:278. doi: 10.1186/s12891-018-2204-6.
- Nakanishi S, Tsutsumi M, Kawanishi K, Wada M, Kudo S. Effects of radial extracorporeal shockwave therapy on piriformis syndrome: A single-case experimental design. *Cureus* 2024;16:e61873. doi: 10.7759/cureus.61873.
- Huang MH, Chen TW, Chen CH, Lee CL. Effects of ultrasound-guided extracorporeal shockwave therapy on the rehabilitation of patients with piriformis syndrome. *Ultrasound Med Biol* 2017;43:S203-4.
- Simplicio CL, Purita J, Murrell W, Santos GS, Dos Santos RG, Lana JFSD. Extracorporeal shock wave therapy mechanisms in musculoskeletal regenerative medicine. *J Clin Orthop Trauma* 2020;11:S309-18. doi: 10.1016/j.jcot.2020.02.004.
- Danazumi MS, Yakasai AM, Ibrahim AA, Shehu UT, Ibrahim SU. Effect of integrated neuromuscular inhibition technique compared with positional release technique in the management of piriformis syndrome. *J Osteopath Med* 2021;121:693-703. doi: 10.1515/jom-2020-0327.
- Rhim HC, Singh M, Maffulli N, Saxena A, Leal C, Gerdemeyer L, et al. Recommendations for use of extracorporeal shockwave therapy in sports medicine: An international modified Delphi study. *Br J Sports Med* 2025;59:1287-301. doi: 10.1136/bjsports-2024-109082.

21. Fairbank JC, Couper J, Davies JB, O'Brien JP. The Oswestry low back pain disability questionnaire. *Physiotherapy* 1980;66:271-3.
22. Yakut E, Düger T, Oksüz C, Yörükan S, Ureten K, Turan D, et al. Validation of the Turkish version of the Oswestry Disability Index for patients with low back pain. *Spine (Phila Pa 1976)* 2004;29:581-5. doi: 10.1097/01.brs.0000113869.13209.03.
23. Binkley JM, Stratford PW, Lott SA, Riddle DL. The Lower Extremity Functional Scale (LEFS): Scale development, measurement properties, and clinical application. North American Orthopaedic Rehabilitation Research Network. *Phys Ther* 1999;79:371-83.
24. Citaker S, Kafa N, Hazar Kanik Z, Ugurlu M, Kafa B, Tuna Z. Translation, cross-cultural adaptation and validation of the Turkish version of the Lower Extremity Functional Scale on patients with knee injuries. *Arch Orthop Trauma Surg* 2016;136:389-95. doi: 10.1007/s00402-015-2384-6.
25. Fritz CO, Morris PE, Richler JJ. Effect size estimates: Current use, calculations, and interpretation. *J Exp Psychol Gen* 2012;141:2-18. doi: 10.1037/a0024338.
26. Raissi GR, Ghazaei F, Forogh B, Madani SP, Daghighzadeh A, Ahadi T. The effectiveness of radial extracorporeal shock waves for treatment of carpal tunnel syndrome: A randomized clinical trial. *Ultrasound Med Biol* 2017;43:453-60. doi: 10.1016/j.ultrasmedbio.2016.08.022.
27. Öztürk Durmaz H, Tuncay F, Durmaz H, Erdem HR. Comparison of radial extracorporeal shock wave therapy and local corticosteroid injection effectiveness in patients with carpal tunnel syndrome: A randomized controlled study. *Am J Phys Med Rehabil* 2022;101:685-92. doi: 10.1097/PHM.0000000000001891.
28. Ramon S, Gleitz M, Hernandez L, Romero LD. Update on the efficacy of extracorporeal shockwave treatment for myofascial pain syndrome and fibromyalgia. *Int J Surg* 2015;24:201-6. doi: 10.1016/j.ijisu.2015.08.083.
29. Yang E, Lew HL, Özçakar L, Wu CH. Recent advances in the treatment of spasticity: Extracorporeal shock wave therapy. *J Clin Med* 2021;10:4723. doi: 10.3390/jcm10204723.
30. Lv F, Li Z, Jing Y, Sun L, Li Z, Duan H. The effects and underlying mechanism of extracorporeal shockwave therapy on fracture healing. *Front Endocrinol (Lausanne)* 2023;14:1188297. doi: 10.3389/fendo.2023.1188297.
31. Zissler A, Steinbacher P, Zimmermann R, Pittner S, Stoiber W, Bathke AC, et al. Extracorporeal shock wave therapy accelerates regeneration after acute skeletal muscle injury. *Am J Sports Med* 2017;45:676-84. doi: 10.1177/0363546516668622.
32. Huang CF, Chen TW, Li CF, Hsiao YH, Chen CH, Huang MH. The preliminary results of extracorporeal shockwave therapy in patients with piriformis syndrome. *RPS* 2018;46:37-45.
33. Suputtitida A. Update of extracorporeal shockwave therapy in myofascial pain syndrome. *Int Phys Med Rehab J* 2017;1:82-6.
34. Tabatabaei A, Ebrahimi Takamjani I, Sarrafzadeh J, Salehi R. Could dry needling change the kinematics of gait in individuals with piriformis muscle syndromes? Secondary analysis of a randomized controlled trial. *J Bodyw Mov Ther* 2024;37:323-7. doi: 10.1016/j.jbmt.2023.11.058.
35. Kalichman L, Vulfsons S. Dry needling in the management of musculoskeletal pain. *J Am Board Fam Med* 2010;23:640-6. doi: 10.3122/jabfm.2010.05.090296.
36. Fusco P, Di Carlo S, Scimia P, Degan G, Petrucci E, Marinangeli F. Ultrasound-guided dry needling treatment of myofascial trigger points for piriformis syndrome management: A case series. *J Chiropr Med* 2018;17:198-200. doi: 10.1016/j.jcm.2018.04.002.
37. Wang G, Gao Q, Li J, Tian Y, Hou J. Impact of needle diameter on long-term dry needling treatment of chronic lumbar myofascial pain syndrome. *Am J Phys Med Rehabil* 2016;95:483-94. doi: 10.1097/PHM.0000000000000401.
38. Luan S, Zhu ZM, Ruan JL, Lin CN, Ke SJ, Xin WJ, et al. Randomized trial on comparison of the efficacy of extracorporeal shock wave therapy and dry needling in myofascial trigger points. *Am J Phys Med Rehabil* 2019;98:677-84. doi: 10.1097/PHM.0000000000001173.
39. Manafnezhad J, Salahzadeh Z, Salimi M, Ghaderi F, Ghojzadeh M. The effects of shock wave and dry needling on active trigger points of upper trapezius muscle in patients with non-specific neck pain: A randomized clinical trial. *J Back Musculoskelet Rehabil* 2019;32:811-8. doi: 10.3233/BMR-181289.