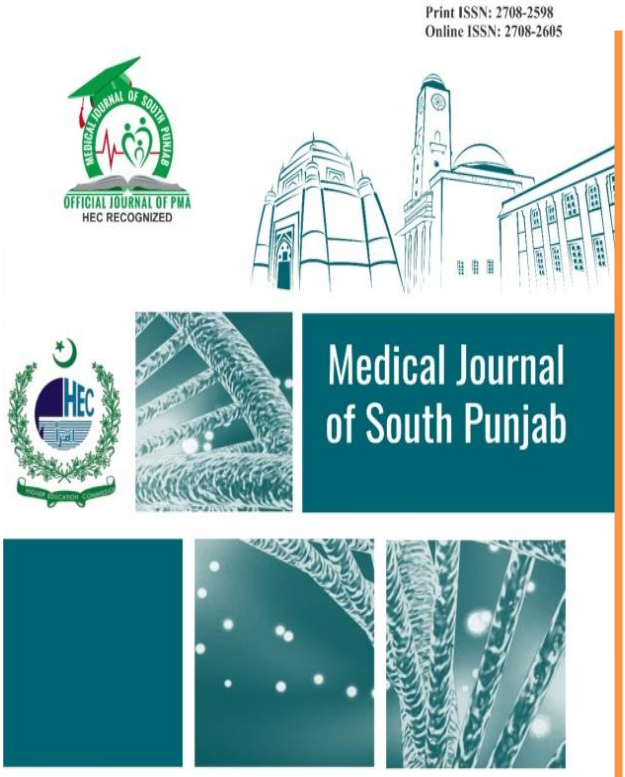
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Effectiveness of extracorporeal shockwave therapy versus therapeutic ultrasound in patients with moderate knee osteoarthritis

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Authors and Affiliation:

Rana Muhammad Arslan[1*], Sajid Rashid[2], Muhammad Hassan Sajid[3], Ayyan Ahmad[4]
[1-3]TIMES University Multan, Pakistan
[4]Laeeque Rafiq Hospital, Multan, Pakistan
Corresponding Author Email:
ranaarslan2020@gmail.com

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Effectiveness of extracorporeal shockwave therapy versus therapeutic ultrasound in patients with moderate knee osteoarthritis

Rana Muhammad Arslan[1*], Sajid Rashid[2], Muhammad Hassan Sajid[3], Ayyan Ahmad[4]
[1-3]TIMES University Multan, Pakistan
[4]Laeeque Rafiq Hospital, Multan, Pakistan
Corresponding Author Email: ranaarslan2020@gmail.com

ABSTRACT

Objective: To compare the effectiveness of ESWT and TUS on pain, stiffness and functional status in patients with moderate KOA.

Methodology: The participants were both male and female, aged between 41 to 65 years, diagnosed with moderate KOA. The participants were recruited at two study sites. One was "Laeeque Rafiq Hospital" and second was the "Barki Advance Physiotherapy Center". The participants were then randomized into three groups using a lottery method. The Group A received ESWT and followed a standardized KOA exercise program twice weekly, Group B received TUS and followed a standardized KOA exercise program three times per week, and Group C (control group) followed only standardized KOA exercise program without any electrotherapy interventions for three sessions per week. The intervention period consisted of four weeks. The assessment measures were done at baseline (before the start of interventions and after four-week intervention period. Outcome measures Numeric Pain Rating Scale (NPRS) and Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC). Data were analyzed using SPSS version 25.0 and Microsoft Excel software. We used Kruskal-Wallis test for between groups analysis and Wilcoxn test for within group analysis, with a p-value < 0.05 considered statistically significant. The study reported that all groups demonstrated statistically significant within-group improvements in NPRS and WOMAC scores after four-week treatment period.

Results: After 4 weeks of treatment the NPRS showed statistically significant difference between three groups with $p = 0.001$ indicating that all interventions produced similar improvements in NPRS scores but the WOMAC scores showed no statistically significant difference among the three groups in post-treatment scores ($H = 0.669$, $df = 2$, $p = 0.716$).

Conclusion: The present study revealed that ESWT, TUS and exercise protocol can be used as effective methods to improve pain and physical function in managing moderate KOA. However, the outcomes with ESWT were slightly better in relieving pain compared to TUS and the control group. Therefore, ESWT may be considered an effective and beneficial treatment option for pain management in patients with moderate KOA, while TUS and exercise therapy also remain useful conservative treatment approaches.

Keywords: Osteoarthritis, knee pain, therapeutic ultrasound, extracorporeal shockwave therapy, and randomized controlled trial.

1. INTRODUCTION

Osteoarthritis (OA) is a painful joint disorder in which there is degeneration to articular cartilage, subchondral bone reshaping, inflammation of the synovium and osteophytes formation. The most common joint affected by OA is the knee joint.[1] Knee osteoarthritis (KOA) typically manifests as pain, swelling, stiffness, crepitus, reduced range of motion, functional impairment, deformity and instability. It represents one of the highly prevalent causes of joint pain, disability, and reduced quality of life among adults worldwide.[2] According to the World Health Organization (WHO), more than 500 million people are currently living with OA worldwide, with KOA accounting for approximately 80% of the disease burden. It is estimated that around 10 to 15% of individuals above the age of 60 suffer from KOA.[3] It has serious public health consequences since KOA is one of the major reasons why people go on sick leave, retire early, or become less productive. [4]

Lack of access to proper rehabilitation facilities, lack of knowledge, and late diagnoses worsen the consequences of the disease in underdeveloped nations like Pakistan. Studies conducted to assess the prevalence of KOA reveal that about 25% to 30% of the adult population aged over 40 suffer from KOA.[5] KOA is commonly classified using the Kellgren-Lawrence (K-L)

grading system[6] based on radiographic findings. Therapies for treating KOA can be generally divided into pharmaceutical interventions, non-pharmaceutical treatments, and surgical interventions. Some of the common drug treatments include NSAIDs, acetaminophen, steroid medications, and hyaluronic acid supplements. Despite the fact that they could help alleviate pain temporarily, they could lead to side effects, be quite expensive, or have a limited period of effectiveness. Arthroscopic debridement, osteotomy, and total knee arthroplasty belong to the list of common surgery techniques used when the disease has progressed significantly.

In the case of non-pharmacological methods of treatment, physical therapy forms the basis of treatment for KOA. It usually aims at relieving pain, improving joint function, increasing mobility and restricting the progression of the condition. Many physical therapy treatments have proven very effective in treating KOA. Examples include therapeutic ultrasound (TUS), transcutaneous electrical muscle stimulation (TENS), exercise therapy and heating techniques, etc.[7,8] Recently, extracorporeal shockwave therapy (ESWT) has gained significant attention due to their non-invasive nature and potential to provide pain relief and improve joint function. [9] Out of the various physiotherapy treatments for the pain and improvement of function in KOA, TUS is the most commonly used. Recently, ESWT has become an effective modality for musculoskeletal rehabilitation. It uses high-energy acoustic waves to stimulate target tissues mechanically, thereby inducing biological effects. Originally developed for the treatment of kidney stones (lithotripsy), ESWT has become a useful treatment for a number of musculoskeletal disorders including plantar fasciitis, tendinopathies, and calcific shoulder tendinitis, and now osteoarthritis.[10] Proposed mechanisms of ESWT in KOA include stimulation of angiogenesis and neovascularization in periarticular tissues, improving blood supply and tissue metabolism.[10]

The conflicting nature of evidence available on both treatments when compared against one another, especially in mild to moderate KOA patients has made it difficult for physiotherapists to use one option clearly. So, a comparison between the two treatment modalities is needed to be carried out to find out which of the two modalities has superior results.

2. METHODOLOGY

This study is a randomized controlled trial (RCT) and is complaint with CONSORT reporting guidelines.[11] The study centers were Laeeque Rafiq Hospital, Multan and Barki Advance Physiotherapy Center, Multan. Ethical approval was taken from the study sites owners/managers before recruiting participants. We recruited patients diagnosed with moderate knee osteoarthritis according to Kellgren–Lawrence (K–L) Radiographic Grading Scale.[12] Thestudyspan was of almost 6 months. The recruitment of the patients started on 21st November, 2025 after the synopsis approval and ended on 30th April, 2026. Sample was calculated by G-Power calculator. This study recruited 132 participants, 44 participants in each group. Participants who met the inclusion criteria for the study at both of our study sites were allocated in different groups selected via lottery method sampling. We recruited bothmales and females, agedfrom40 to 65yearsold havingmoderate knee osteoarthritisfrom at least 6 weeks. Exclusion criteria was patients with mild or severe knee osteoarthritis, having previous histories of knee joint surgery, history of intra-articular knee joint fracture,or recent knee joint injury, presence of neurological symptoms including radiating pain, numbness, or lower limb tingling, people with cancer, osteoporosis, or rheumatoid arthritis among other systemic diseases, patients taking various physical therapy treatments for knee pain or participating in other clinical interventions at the time of the study and patients taking opiods.

The data collection tools were Numeric Pain Rating Scale (NPRS) and Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC). A total of 132 participants aged between 40 to 65 years were randomly recruited during this investigation. Participants for the study were screened for selection using K-L grading for mild KOA.[12] All the participants of the study received information about the research aims together with potential risks and study advantages. Then, the participants gave written consent to join the study. Patients were randomly allocated tothree groups via lottery method sampling technique using sealed envelopes.Research investigators assessed each participant at baseline (before starting intervention)using the standardized questionnaires and scales, and at the end of four-week intervention periodinordertotrackpatient improvement. Complete confidentiality and privacy protection of participant was maintained during the entire course of the study. The patientsfulfillingtheinclusioncriteriawererando mizedintothree groups.GroupA (ESWT), Group B (TUS) and Group C (Control) with the help of sealed envelope using lottery method. Group A received ESWT along with standard KOA exercise protocol andGroupBreceivedTUS along with standard KOA exercise protocol and Group C (control group) received only standard KOA exercise protocol.Thepatients in Group A giventwosessions perweek and the patients in group B and C received three sessions per week for four weeks. The participants of each group were assessed at baseline before giving interventions and after four weeks of the treatment for all outcome measures (pain and functional status). Total patients recruited were 132. Out of these only 120 patients completed the four-week treatment period. Data were analyzed using combination SPSS-version 25.0 and Microsoft Excel Software. As the data were not normallydistributed, we used non-parametric tests (including Kruskal-Wallis test for between groups analysis and Wilcoxn test for within group analysis). Written informed consent were taken from the participants before the start of the study.

3. RESULTS

This study recruited total 132 participants. The age distribution revealed that the majority of the participants belonged to the age group of 51–60 years (55.3%), followed by 41–50 years (23.5%), while 21.2% participants were between 61–65 years of age. These findings indicate that moderate knee osteoarthritis was more prevalent among middle-aged and older adults, particularly in the 51–60 years age category. Among the total 132 participants, 75 (56.8%) were males and 57 (43.2%) were females. The findings demonstrate a slightly higher participation of males compared females. Participants were equally distributed among the three groups with 44 participants (33.3%) in each group, namely Group A (ESWT), Group B (TUS), and Group C (Control).

It was reported that all three groups demonstrated improvement in WOMAC pain, stiffness, and functional scores after four weeks of intervention. The ESWT group showed reduction in WOMAC pain from 14.05 ± 2.07 to 10.55 ± 1.96. The TUS group improved from 13.93 ± 1.67 to 9.88 ± 2.06. The control group improved from 13.97 ± 1.80 to 9.68 ± 2.01. Similarly, WOMAC stiffness and functional scores also improved across all groups after treatment. These findings indicate that all interventions contributed positively toward reducing symptoms and improving functional abilities in patients with moderate knee osteoarthritis.

At baseline, there was no statistically significant difference between the three groups regarding NPRS score ($p = 0.818$), showing that all groups were comparable before treatment. After four weeks, statistically significant difference was observed between the groups ($p = 0.001$), indicating that all interventions produced similar improvements in NPRS score.

Table 1: Kruskal-Wallis test between Group A (ESWT), Group B (TUS) and Group C (Control) analysis of NPRS Score.

	Group	N	Mean rank	p value

Baseline NPRS Score	A (ESWT)	42	61.76	
	B (TUS)	41	57.83	
	C (Control)	37	62.03	
	Total	120		0.818
Post-Treatment NPRS Score	A (ESWT)	42	79.07	
	B (TUS)	41	48.39	
	C (Control)	37	52.84	
	Total	120		0.0001

In table 2, the Kruskal–Wallis test was performed to compare the overall WOMAC scores among the three study groups (ESWT, TUS, and control) at baseline and post-treatment. At Baseline, regarding WOMAC scores there was no statistically significant difference among the three groups at baseline (H = 1.219, df = 2, p = 0.544). This indicates that the groups were comparable in terms of overall WOMAC scores before the intervention. Similarly, the WOMAC scores showed no statistically significant difference among the three groups in post-treatment overall WOMAC scores (H = 0.669, df = 2, p = 0.716). This indicates that the post-treatment WOMAC scores did not differ significantly among the three groups.

Table 2: Kruskal-Wallis test between Group A (ESWT), Group B (TUS) and Group C (Control) analysis of WOMAC Score.

	Group	N	Mean rank	p value
Baseline WOMAC Score	1.0	42	61.51	
	2.0	41	63.99	
	3.0	37	55.49	
	Total	120		.544
Post-treatment WOMAC Score	1.0	42	63.82	
	2.0	41	57.67	
	3.0	37	59.86	
	Total	120		.716

In table 3, The ESWT group demonstrated a statistically significant reduction in pain intensity after four weeks, with NPRS decreasing from 5.74 ± 1.19 to 3.48 ± 1.15 (p = 0.001).

Table 3: Wilcoxon sign rank test within each group analysis of NPRS

Variables		Mean ± SD	Median IQR	p value
NPRS Group A	Baseline	5.74 ± 1.19	6 (2)	0.001
	After 4 weeks	3.48 ± 1.15	3 (1)	
NPRS Group B	Baseline	5.59 ± 1.30	6 (3)	0.001
	After 4 weeks	2.39 ± 0.73	3 (1)	
NPRS Group C	Baseline	5.76 ± 1.21	6 (3)	0.001
	After 4 weeks	2.76 ± 1.58	2 (1)	

This indicates that ESWT effectively reduced pain in patients with moderate knee osteoarthritis. The TUS group also showed significant improvement in pain intensity, with NPRS reducing from 5.59 ± 1.30 to 2.39 ± 0.73 (p = 0.001). These findings suggest that therapeutic ultrasound significantly reduced knee pain after treatment. Similarly, the control group exhibited statistically significant improvement in NPRS scores from 5.76 ± 1.21 to 2.76 ± 1.58 (p = 0.001). This demonstrates that the standard exercise protocol was also effective in reducing pain.

Table 4: Wilcoxon sign rank test within each group analysis of WOMAC

Variables		Mean ± SD	Median IQR	p value
WOMAC Group A	Baseline	61.57 ± 10.09	59 (17)	0.001
	After 4 weeks	45.38 ± 7.99	44 (14)	
WOMAC Group B	Baseline	62.24 ± 9.16	59 (15)	0.001
	After 4 weeks	44.17 ± 7.43	42 (9)	
WOMAC Group C	Baseline	59.92 ± 8.08	58 (12)	0.001
	After 4 weeks	44.59 ± 8.20	43 (13)	

As shown in table 4, a statistically significant improvement in WOMAC score was observed in the ESWT group after four weeks (p = 0.001). Mean WOMAC score improved from 61.57 ± 10.09 at baseline to 45.38 ± 7.99 after treatment, indicating improved pain, stiffness, and functional status. The TUS group also demonstrated statistically significant improvement in WOMAC scores from 62.24 ± 9.16 to 44.17 ± 7.43 (p = 0.001), showing effectiveness of therapeutic ultrasound in improving symptoms and physical function. And the control group also showed significant

improvement in WOMAC score from 59.92 ± 8.08 to 44.59 ± 8.20 (p = 0.001). This indicates that exercise therapy alone also contributed positively toward symptom management.

4. DISCUSSION

This study was conducted to compare the effectiveness of ESWT and TUS in patients diagnosed with moderate KOA. The primary objective was to determine whether ESWT and TUS provided additional benefits in reducing pain intensity and improving physical function compared with exercise therapy alone. The participants were randomly allocated into three groups, with 44 participants initially assigned to each group. The main findings of this study revealed no significant differences in baseline NPRS scores (H = 0.402, p = 0.818) or baseline WOMAC scores (H = 1.219, p = 0.544). These findings indicate that the three groups were statistically comparable before the commencement of treatment. The methodological strength of the present study was its recruitment from two different clinical settings in Multan, Pakistan. These included Laeeque Rafiq Hospital, a 200-bedded non-profit private Hospital, and Barki Advance Physiotherapy Center, a private physiotherapy facility. Recruiting participants from two different healthcare settings provided an opportunity to include patients with varying clinical and healthcare backgrounds. Another methodological strength was the use of a random allocation procedure involving sealed, opaque envelopes prepared by an independent third party who was not associated with the investigator or the participating clinical facilities. The envelopes contained allocation labels for Group A (ESWT), Group B (TUS), and Group C (control). This procedure was intended to minimize selection bias and maintain allocation concealment. Furthermore, the study was conducted in accordance with the relevant principles of the CONSORT guidelines for RCTs, supporting transparent reporting of the research methodology and participant flow.

The improvement observed in the ESWT group may contribute to reduced pain sensitivity and improved musculoskeletal function.[13–15] Previous research by Chen et al. 2014 also reported beneficial effects of ESWT in patients with KOA, supporting its potential role as a non-invasive treatment modality in musculoskeletal rehabilitation. The findings of the present study are therefore consistent with previous evidence suggesting that ESWT may provide meaningful pain relief in patients with KOA.[16] Similarly, the TUS group demonstrated a statistically significant reduction in NPRS scores, decreasing from 5.59 ± 1.30 at baseline to 2.39 ± 0.73 after four weeks of intervention (p = 0.001). This finding suggests that therapeutic ultrasound was also associated with a substantial reduction in pain intensity. The findings are consistent with previous research by Jia et al. 2022, which suggested that therapeutic ultrasound may provide beneficial effects in reducing pain and improving joint-related outcomes in patients with knee osteoarthritis. The significant improvement observed in the present study further supports the potential usefulness of TUS as an adjunctive intervention in conservative KOA management. However, its effectiveness should be interpreted in relation to the treatment protocol, ultrasound parameters, duration of intervention, and the characteristics of the participants.[17]

Although all three groups demonstrated significant within-group improvements in pain intensity, the between-group analysis revealed an important difference in treatment outcomes. At baseline, the Kruskal–Wallis test showed no statistically significant difference among the three groups (p = 0.818). However, after four weeks of intervention, a statistically significant difference was observed in NPRS scores among the groups (H = 20.790, df = 2, p < 0.001). The mean ranks of post-treatment NPRS scores were 79.07 for the ESWT group, 48.39 for the TUS group, and 52.84 for the control group. Since lower NPRS scores represent less pain, the higher mean rank in the ESWT group indicates that participants in this

group generally reported higher pain scores following treatment compared with the other two groups. Conversely, the TUS group demonstrated the lowest mean rank, suggesting comparatively lower post-treatment pain scores.

This finding is particularly important because it indicates that statistically significant within-group improvements do not necessarily translate into equal treatment effectiveness between groups. Although ESWT, TUS, and strengthening exercises were all associated with reduced pain[18–20], the overall between-group comparison suggests that the extent of improvement differed among the interventions. However, the Kruskal–Wallis test identifies only an overall difference among the three groups and does not establish which specific pairs of groups differ significantly. Therefore, post-hoc pairwise comparisons with appropriate adjustment for multiple testing are required before concluding that ESWT was significantly different from both TUS and the control group.

The findings nevertheless suggest that the choice of physiotherapy intervention may influence the magnitude of pain reduction in patients with moderate KOA. Further studies with larger sample sizes and longer follow-up periods may help establish whether the observed differences in pain outcomes are maintained over time.

5. CONCLUSION

The present study revealed that ESWT, TUS and exercise protocol can be used as effective methods to improve pain and physical function in subjects suffering from moderate KOA. All the groups after four weeks intervention period showed a significant within-group decrease in the NPRS and WOMAC index scores for ESWT, TUS and control group. However, the outcomes with ESWT were slightly better in relieving pain compared to TUS and the control group. Therefore, ESWT may be considered an effective and beneficial treatment option for pain management in patients with moderate KOA, while TUS and exercise therapy also remain useful conservative treatment approaches.

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