



COMPARATIVE ANALYSIS OF EFFECTIVENESS OF ULTRASOUND-LASER AND TENS-LASER THERAPY IN KNEE OSTEOARTHRITIS MANAGEMENT

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ABSTRACT:

Background: Osteoarthritis (OA) is a degenerative joint disease that predominantly affects the geriatric population, leading to pain, functional limitations, and decreased range of motion. Physiotherapy modalities such as Transcutaneous Electrical Nerve Stimulation (TENS) and Low-Level Laser Therapy (LLLT) have been used for managing OA, but comparative studies of these modalities in combination with ultrasound are limited.

Objective: To determine the efficacy of Ultrasound-LASER (US+LASER) and TENS-LASER (TENS+LASER) therapies in managing knee osteoarthritis, focusing on improvements in the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) score, flexion range of motion (ROM), and Visual Analogue Scale (VAS) scores.

Methods: This quasi-experimental study included 40 patients with knee osteoarthritis, randomly assigned to two groups: Group A (US+LASER) and Group B (TENS+LASER). Group A received 5 minutes of ultrasound followed by 8 minutes of LASER therapy, while Group B received 20 minutes of TENS followed by 8 minutes of LASER therapy. Both groups performed specific knee osteoarthritis exercises during the treatment period. Data on WOMAC scores, flexion ROM, and VAS scores were collected at baseline and after four weeks of treatment. Statistical analysis was conducted using SPSS version 25.

Results: Group A showed a significant reduction in WOMAC scores from 71.05 ± 12.02 to 29.15 ± 8.37 , while Group B's scores decreased from 67.05 ± 12.66 to 47.25 ± 12.25 ($p < 0.001$). Flexion ROM improved from 83.50 ± 17.33 degrees to 119.50 ± 2.24 degrees in Group A and from 82.00 ± 12.40 degrees to 102.75 ± 10.06 degrees in Group B ($p < 0.001$). VAS scores decreased from 8.45 ± 1.43 to 1.95 ± 1.39 in Group A and from 8.40 ± 1.43 to 4.30 ± 1.08 in Group B ($p < 0.001$).

Conclusion: Ultrasound-LASER therapy is more effective than TENS-LASER therapy in reducing pain and improving knee function in patients with osteoarthritis. The study supports the use of Ultrasound-LASER therapy as a preferred treatment option for knee osteoarthritis due to its superior efficacy and time efficiency.

Keywords: Osteoarthritis, Knee Osteoarthritis, Ultrasound Therapy, Low-Level Laser Therapy, Transcutaneous Electrical Nerve Stimulation, WOMAC Index, Range of Motion, Pain Management, Physiotherapy Modalities, Non-Pharmacological Treatment

Introduction:

Osteoarthritis (OA) is a progressive joint disease characterized by the degeneration of cartilage and the underlying bone within a joint, leading to pain, stiffness, and functional limitations. It predominantly affects the geriatric population, contributing significantly to disability and impaired quality of life. Knee osteoarthritis, in particular, is a prevalent condition, affecting approximately 19% of individuals aged 45 and older, with its incidence increasing with age due to factors such as modern lifestyle and elevated body mass index (BMI) (1, 2). The clinical manifestations of knee OA include joint pain exacerbated by activity, prolonged sitting, or rest, as well as edema, reduced range of motion, and functional impairment. These symptoms result from complex pathophysiological processes, including inflammation of the joint capsule, bone marrow lesions, and decreased joint mobility, ultimately leading to functional disability and an increased risk of falls (3, 4, 5).

Effective management of knee OA aims to alleviate pain, improve joint function, and enhance the quality of life. Various non-pharmacological interventions, including weight loss, exercise, nutritional supplements, and surgical options, have been explored. Among these, physiotherapy modalities such as Transcutaneous Electrical Nerve Stimulation (TENS) and Low-Level Laser Therapy (LLLT) have gained prominence due to their non-invasive nature and potential therapeutic benefits. The U.S. Food and Drug Administration (FDA) has approved TENS as a drug-free technique for managing pain and stiffness associated with knee OA. TENS operates by delivering electrical impulses through the skin to stimulate larger-diameter afferent neurons, thereby activating descending pain inhibitory pathways and reducing the excitability of nociceptive neurons (6, 7). Additionally, TENS may enhance local blood flow and tissue healing through vasodilation and increased skin temperature, contributing to pain relief and functional improvement (8, 9).

LLLT, also known as low-power laser therapy, employs low-intensity lasers emitting light within the 540-830 nm wavelength range to modulate cellular activity and promote tissue repair. It has been widely used to manage pain in various musculoskeletal conditions, including knee OA. The therapeutic effects of LLLT are attributed to its ability to reduce inflammation, enhance cellular proliferation, and promote tissue regeneration. Despite its widespread use, the clinical outcomes of LLLT remain inconsistent, with some placebo-controlled studies reporting significant pain reduction in conditions such as cervical osteoarthritis and lateral epicondylitis (10, 11, 12). The synergistic use of LLLT with other modalities, such as ultrasound and TENS, has shown promise in enhancing therapeutic efficacy, yet comparative studies exploring these combinations are limited.

Ultrasound therapy, another modality used in physiotherapy, has been shown to facilitate tissue healing, improve blood circulation, and reduce inflammation through its mechanical and thermal effects. The application of continuous ultrasonic waves increases tissue temperature, promoting collagen synthesis and enhancing the extensibility of soft tissues. When combined with LLLT, ultrasound therapy may offer synergistic benefits by concurrently addressing pain and facilitating tissue repair. However, comprehensive comparative analyses evaluating the efficacy of combining ultrasound with LLLT versus TENS with LLLT in knee OA management are scarce (13, 14).

This study aims to bridge this research gap by conducting a comparative analysis of the effectiveness of Ultrasound-LASER (US+LASER) and TENS-LASER (TENS+LASER) therapies in managing knee OA. The primary objectives are to evaluate the improvements in the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) score and knee flexion range of motion (ROM) following each treatment protocol. The study hypothesizes that combining ultrasound with LASER will result in superior pain reduction and functional improvement compared to the combination of TENS with LASER. By providing robust evidence on the comparative efficacy of these treatment modalities, this research aims to inform clinical decision-

making and optimize therapeutic strategies for knee OA, ultimately enhancing patient outcomes (15, 16, 17).

Material & Methods

The study employed a quasi-experimental design to compare the effectiveness of Ultrasound-LASER (US+LASER) and TENS-LASER (TENS+LASER) therapies in managing knee osteoarthritis. The research was conducted at the Physiotherapy Department of Shalamar Hospital, Lahore, Pakistan, from September to December 2022. The study population consisted of patients diagnosed with knee osteoarthritis who were referred to the physiotherapy department. Subjects of either gender, aged between 45 and 72 years, were included. Participants were explained the two treatment modalities, and informed consent was obtained prior to enrollment.

For convenience and to ensure random allocation, participants were alternately assigned to the two groups based on their arrival at the department. The first knee osteoarthritis patient of each day was treated with Ultrasound-LASER (Group A), followed by the next patient with TENS-LASER (Group B), and so on. Group A received 5 minutes of ultrasound therapy followed by 8 minutes of LASER therapy. Ultrasound therapy was administered using a 5-cm-diameter applicator with continuous ultrasonic waves at a frequency of 1 MHz and an intensity of 1 W/cm². The ultrasound was applied to the lateral and medial aspects of the knee in a circular motion for 5 minutes on each side to ensure maximal energy absorption. LASER therapy was then administered using a 6-cm probe at a frequency of 30 Hz and a power of 5 W for 8 minutes, with the probe positioned vertically on the joint line while the patient was in a supine position with the knee at 30 degrees flexion.

Group B received 20 minutes of Transcutaneous Electrical Nerve Stimulation (TENS) therapy followed by 8 minutes of LASER therapy. TENS therapy involved placing electrodes on the lateral and medial sides of the knee joint lines, delivering stimulation at 100 Hz and a pulse width of 50-100 μ s based on the patient's tingling threshold. LASER therapy in this group was administered similarly to Group A. Both groups were instructed to perform specific knee osteoarthritis exercises, including straight leg raises, one-leg balancing, pillow squeezes, heel raises, quadriceps setting, quadriceps strengthening, and step-ups. These exercises were performed in three sets of ten repetitions each, with a three-minute break between sets. Treatment sessions were conducted thrice weekly for four weeks, with each session lasting 45 minutes.

Data collection involved obtaining demographic information and baseline measurements of the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), flexion range of motion (FROM), and Visual Analogue Scale (VAS) scores. These assessments were repeated at the end of the study. WOMAC index measures included pain, stiffness, and physical function, while FROM and VAS scores assessed knee joint flexion and pain intensity, respectively.

Ethical approval for the study was obtained from the institutional review board of Shalamar Hospital, and the study was conducted in accordance with the principles outlined in the Declaration of Helsinki. All participants provided written informed consent after being informed about the study's purpose, procedures, potential risks, and benefits.

Statistical analysis was performed using SPSS version 25. Numerical data such as WOMAC scores, flexion range of motion, and VAS scores were presented as mean \pm standard deviation (SD). Gender and group distributions were expressed as frequencies and percentages. The normality of the data was assessed, and independent sample t-tests were used to compare mean differences between groups. Paired sample t-tests were employed to determine pre- and post-treatment differences within each group. A p-value of 0.05 or less was considered statistically significant. The study aimed to provide robust evidence on the comparative efficacy of Ultrasound-LASER and TENS-LASER therapies in the management of knee osteoarthritis.

Results

A total of 40 participants were recruited for the study, with an equal distribution between Group A (Ultrasound-LASER) and Group B (TENS-LASER). The demographic characteristics of the

participants showed that 14 (35%) were male and 26 (65%) were female. Group A had a male-to-female ratio of 1:1.5, while Group B had a male-to-female ratio of 1:2.33. The mean age of participants in Group A was 57.10 ± 6.92 years, and in Group B, it was 55.60 ± 6.97 years. There was no statistically significant difference in age between the groups ($p=0.499$).

Table 1: Demographic Characteristics of Participants

Characteristic	Group A (US+LASER)	Group B (TENS+LASER)	Total (N=40)	p-value
Male	8 (40%)	6 (30%)	14 (35%)	
Female	12 (60%)	14 (70%)	26 (65%)	
Mean Age (years)	57.10 ± 6.92	55.60 ± 6.97	-	0.499

WOMAC Index, Flexion Range of Motion (FROM), and Visual Analogue Scale (VAS) Scores

The baseline WOMAC index scores for Group A and Group B were 71.05 ± 12.02 and 67.05 ± 12.66 , respectively, with no statistically significant difference between the groups ($p=0.312$). Post-treatment, Group A showed a significantly greater reduction in WOMAC scores (29.15 ± 8.37) compared to Group B (47.25 ± 12.25), with a p-value of <0.001 .

At baseline, the mean flexion range of motion was 83.50 ± 17.33 degrees for Group A and 82.00 ± 12.40 degrees for Group B, with no significant difference ($p=0.755$). Post-treatment, the mean flexion range of motion improved to 119.50 ± 2.24 degrees in Group A and 102.75 ± 10.06 degrees in Group B, with a statistically significant difference ($p<0.001$).

The baseline VAS scores were 8.45 ± 1.43 for Group A and 8.40 ± 1.43 for Group B. After treatment, the VAS scores decreased to 1.95 ± 1.39 in Group A and 4.30 ± 1.08 in Group B, with Group A showing a significantly greater reduction in pain ($p<0.001$).

Table 2: Comparison of WOMAC Index, Flexion Range of Motion (FROM), and VAS Scores Between Groups

Variable	Time	Group A (US+LASER)	Group B (TENS+LASER)	p-value
WOMAC Index	Pre	71.05 ± 12.02	67.05 ± 12.66	0.312
	Post	29.15 ± 8.37	47.25 ± 12.25	<0.001
Flexion Range of Motion (degrees)	Pre	83.50 ± 17.33	82.00 ± 12.40	0.755
	Post	119.50 ± 2.24	102.75 ± 10.06	<0.001
Visual Analogue Scale (VAS)	Pre	8.45 ± 1.43	8.40 ± 1.43	0.933
	Post	1.95 ± 1.39	4.30 ± 1.08	<0.001

Within-Group Improvements

Significant improvements were observed within both groups from pre- to post-treatment. In Group A, the WOMAC score decreased from 71.05 ± 12.02 to 29.15 ± 8.37 ($p<0.001$), flexion range of motion increased from 83.50 ± 17.33 degrees to 119.50 ± 2.24 degrees ($p<0.001$), and VAS score reduced from 8.45 ± 1.43 to 1.95 ± 1.39 ($p<0.001$). In Group B, the WOMAC score decreased from 67.05 ± 12.66 to 47.25 ± 12.25 ($p<0.001$), flexion range of motion increased from 82.00 ± 12.40 degrees to 102.75 ± 10.06 degrees ($p<0.001$), and VAS score reduced from 8.40 ± 1.43 to 4.30 ± 1.08 ($p<0.001$).

Table 3: Within-Group Improvements

Variable	Time	Group A (US+LASER)	Group B (TENS+LASER)	p-value
WOMAC Index	Pre	71.05 ± 12.02	67.05 ± 12.66	<0.001
	Post	29.15 ± 8.37	47.25 ± 12.25	<0.001
Flexion Range of Motion (degrees)	Pre	83.50 ± 17.33	82.00 ± 12.40	<0.001
	Post	119.50 ± 2.24	102.75 ± 10.06	<0.001
Visual Analogue Scale (VAS)	Pre	8.45 ± 1.43	8.40 ± 1.43	<0.001
	Post	1.95 ± 1.39	4.30 ± 1.08	<0.001

In conclusion, the results indicate that Ultrasound-LASER therapy is significantly more effective than TENS-LASER therapy in reducing pain, improving knee function, and enhancing the range of motion in patients with knee osteoarthritis. These findings suggest that combining ultrasound with LASER therapy may offer superior clinical benefits for managing knee osteoarthritis compared to combining TENS with LASER therapy.

Discussion:

The findings from this study indicated that Ultrasound-LASER therapy was significantly more effective than TENS-LASER therapy in managing knee osteoarthritis. Specifically, Group A (Ultrasound-LASER) demonstrated a greater reduction in the WOMAC score, a larger improvement in the flexion range of motion, and a more substantial decrease in VAS scores compared to Group B (TENS-LASER). These results align with previous studies that have highlighted the benefits of combining different physiotherapy modalities to enhance therapeutic outcomes in osteoarthritis management.

The superior efficacy of Ultrasound-LASER therapy can be attributed to the synergistic effects of ultrasound and laser treatments. Ultrasound therapy increases tissue temperature, enhances blood flow, and promotes collagen synthesis, leading to improved tissue healing and reduced inflammation. When combined with LASER therapy, which promotes cellular repair and reduces pain through photobiomodulation, the overall therapeutic effect is amplified. This finding is consistent with studies by Huang et al. (2015), who reported significant pain reduction and functional improvement in knee osteoarthritis patients treated with low-level laser therapy (LLT) (1).

In contrast, TENS therapy primarily provides pain relief by stimulating large-diameter afferent neurons and activating descending pain inhibitory pathways. While TENS effectively manages pain, it does not have the same tissue healing and anti-inflammatory effects as ultrasound. Consequently, the combination of TENS with LASER, although beneficial, did not achieve the same level of improvement in functional outcomes as Ultrasound-LASER therapy. This observation corroborates findings from previous studies, which suggested that while TENS is effective for pain management, its impact on joint function and tissue repair is limited (6, 7, 8).

A critical aspect of this study was the time efficiency of the treatments. The Ultrasound-LASER therapy sessions were shorter and more efficient than the TENS-LASER sessions, making them a more practical option in clinical settings. The shorter duration of Ultrasound-LASER sessions (13 minutes compared to 28 minutes for TENS-LASER) not only enhances patient throughput but also improves compliance and satisfaction, particularly in busy clinical environments.

The strengths of this study include its robust methodology, random allocation of participants, and comprehensive outcome assessments. However, several limitations should be considered. The lack of a control group receiving standard care or placebo limits the ability to attribute improvements solely to the interventions. Additionally, the small sample size and short follow-up period constrain the generalizability and long-term applicability of the findings. Future studies should include larger sample sizes, control groups, and extended follow-up periods to validate these results and provide more comprehensive insights into the long-term benefits and potential side effects of these therapies.

Furthermore, the study did not explore the impact of varying the parameters of Ultrasound, TENS, and LASER treatments, such as intensity, frequency, and duration, which could provide valuable information on optimizing these therapies for individual patient needs. Investigating these variables in future research could enhance the understanding of how best to utilize these modalities for maximum therapeutic benefit.

The study also highlighted the need for individualized treatment approaches in managing knee osteoarthritis. Given the variability in patient responses to different therapies, personalized treatment plans that consider the specific needs and conditions of each patient could improve

outcomes. Integrating advanced diagnostic tools to assess the severity and progression of osteoarthritis could further refine treatment strategies and optimize patient care.

In conclusion, while both Ultrasound-LASER and TENS-LASER therapies were effective in managing knee osteoarthritis, Ultrasound-LASER therapy offered superior efficacy in reducing pain and improving function in a more time-efficient manner. These findings support the use of Ultrasound-LASER therapy as a preferred treatment option for knee osteoarthritis and highlight the need for further research to optimize and validate these therapeutic approaches. The study contributes to the growing body of evidence supporting the use of combined physiotherapy modalities in osteoarthritis management and underscores the importance of personalized, evidence-based treatment strategies to enhance patient outcomes.

Conclusion:

In conclusion, while both Ultrasound-LASER and TENS-LASER therapies are effective in managing knee osteoarthritis, Ultrasound-LASER offers superior efficacy in reducing pain and improving function in a more time-efficient manner. These findings support the use of Ultrasound-LASER therapy as a preferred treatment option for knee OA and highlight the need for further research to optimize and validate these therapeutic approaches.

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