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Comparing the Effects of Transcutaneous Electrical Nerve Stimulation (TENS) and Ultrasound Therapy (US) on Knee Osteoarthritis: A Case Study

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ABSTRACT

Background: Knee osteoarthritis (OA) is a widespread degenerative joint condition that affects individuals across various age groups, particularly in older adults. Effective management strategies, including physiotherapy interventions such as Transcutaneous Electrical Nerve Stimulation (TENS) and Ultrasound Therapy (US), are essential for alleviating symptoms like pain, stiffness, and functional limitations. However, limited research compares the combined effects of these modalities along with structured exercise on outcomes such as pain reduction, muscle strength, and functional improvement.

Objective: The current case study aims to assess the impact of TENS & US, combined with a consistent exercise regimen, on pain reduction, muscle strength, and Quality of Life in patient with knee OA.

Case Report: A 52-year-old female patient with chronic right knee pain underwent a four-week treatment protocol consisting of two phases: Phase 1 involved TENS therapy (Weeks 1-2), and Phase 2 involved US therapy (Weeks 3-4). Both phases were complemented by a uniform exercise program focused on strengthening, flexibility, and aerobic conditioning.

Results: Pain, measured using the Visual Analog Scale (VAS), decreased from 7/10 at baseline to 4/10 after TENS therapy and further reduced to 3/10 after US therapy. And pain decreased from 15/20 to 10/20 in TENS and 7/20 in US in Intermittent and Constant Osteoarthritis Pain: Knee Osteoarthritis (ICOAP). Muscle strength improved in both quadriceps and hamstrings, with an increase in strength from Grade 3 to Grade 4 in the quadriceps and Grade 4 to Grade 4+ in the hamstrings. Range of Motion (ROM): Flexion: 100° (right), 130° (left); Extension: 0° bilaterally. The SF-36 score, indicating the patient's functional capability and QOL, improved from 45/100 to 55/100 after TENS therapy and 45/100 to 65/100 after US therapy over the course of the study.

Discussion: The combination of TENS and US therapy provided significant benefits for pain relief, muscle strength, and functional recovery in this knee OA patient. TENS was effective in managing acute pain, allowing better engagement in rehabilitation exercises, while US therapy contributed to long-term functional improvements.

Conclusion: This case study suggests that a sequential approach combining TENS and US therapy, alongside a structured exercise program, can be an effective strategy for managing knee OA. More research with bigger sample sizes and longer follow-up

periods is necessary to validate these results and improve treatment guidelines.

Keywords: Knee osteoarthritis, Transcutaneous Electrical Nerve Stimulation (TENS), Ultrasound Therapy (US), Physiotherapy, Pain management, Muscle strength, Functional outcomes, Rehabilitation, Case study.

INTRODUCTION

Osteoarthritis (OA) is a chronic degenerative joint disorder which predominantly impacts weight-bearing joints, particularly in the elderly population and individuals engaged in repetitive physical activities[1]. Knee OA is the most prevalent form, with an estimated prevalence varying from 12% - 35% in wider population[2]. It is characterized by progressive cartilage degradation, joint pain, stiffness, swelling, and reduced functional capacity, all of which significantly impair quality of life. The condition is a leading cause of musculoskeletal disability worldwide, posing a considerable burden on healthcare systems and impacting individuals' ability to perform activities of daily living.

Management of knee OA often involves a multimodal approach encompassing pharmacological interventions, lifestyle modifications, and physiotherapy. Physiotherapy has a critical role in the conservative management of knee OA, concentrating on alleviating pain, boosting joint function, and improving overall well-being & QOL. Among the various treatment modalities available, Transcutaneous Electrical Nerve Stimulation (TENS) and Ultrasound Therapy (US) are widely utilized.

TENS is a non-invasive technique that delivers low-voltage electrical currents to the skin to modulate pain by stimulating peripheral nerves and activating endogenous pain control mechanisms[3]. It is particularly valued for its immediate pain-relieving effects, which can help patients initiate rehabilitation exercises with reduced discomfort. On the other hand, US applies high-frequency sound waves to the targeted tissues, producing mechanical and thermal effects that aid in tissue healing, reduce inflammation, and alleviate pain[4]. It is also hypothesized to stimulate cartilage repair, offering potential long-term benefits for joint health. Despite their extensive use, limited evidence exists comparing the relative efficacy of TENS and US in knee OA management. Furthermore, the interplay between these modalities and structured exercise programs has not been fully explored. This case study seeks to address this gap by evaluating and comparing the effects of TENS and US, when combined with an identical exercise regimen, on pain reduction, muscle strength, and functional 4 outcomes in a patient with knee OA. This research aims to provide insights into optimizing physiotherapy protocols for managing this pervasive condition.

CASE STUDY

History

A 52-year-old female patient, a housewife, reported with a chief complaint of chronic right knee pain persisting for two years. The pain was insidious in onset and progressively worsened over time. The patient reported aggravation of pain during prolonged standing, climbing stairs, and performing household chores, with a pain intensity of 7/10 on the Visual Analog Scale (VAS)[5] and 15/20 on Intermittent and Constant Osteoarthritis Pain: Knee Osteoarthritis (ICOAP)[6]. Morning stiffness lasting approximately 15 minutes was noted, with no history of trauma or significant comorbidities. She had been managing her symptoms with over-the-counter analgesics and occasional physiotherapy sessions, but reported minimal improvement.

Physical Examination

Observation: Mild swelling was observed around the right knee with no visible deformity.

Palpation: Tenderness over the medial joint line with mild warmth; no effusion detected.

Range of Motion (ROM): Flexion: 100° (right), 130° (left); Extension: 0° bilaterally.
Muscle Strength (MMT): Quadriceps: Grade 3 (right), Grade 5 (left); Hamstrings: Grade 4 (right), Grade 5 (left).
Activity Of Daily Living (ADLs): The patient reported difficulty with
(ADLs) such as squatting and ascending stairs[7]. SF-36 score: 45/100, indicating poor quality of life.

PROCEDURE

The treatment protocol included two phases over four weeks, maintaining a consistent exercise regimen throughout.

Phase 1: TENS Therapy (Weeks 1-2)
Frequency: Daily, five days per week.
Duration: 20 minutes per session.
Parameters:
Mode: continuous
Frequency: 100 Hz.
Intensity: Adjusted to the patient's tolerance level, ensuring comfort while achieving effective stimulation.
Placement: Electrodes were placed over the painful area around the right knee, targeting nerve pathways or optimal pain relief.

Phase 2: Ultrasound Therapy (Weeks 3-4)
Frequency: Daily, five days per week.
Duration: 10 minutes per session.
Parameters:
Frequency: 1 MHz for deep tissue penetration.
Intensity: 1.5 W/cm².
Mode: Continuous to maximize thermal and mechanical effects.
A coupling gel was applied to the area to facilitate effective sound wave transmission. The US probe was moved in a slow, circular motion to cover the entire knee joint, ensuring even treatment distribution.

Exercise Program (Weeks 1-4)
To complement the modalities and improve functional outcomes, a consistent exercise regimen was implemented throughout the four weeks:

1. Isometric Exercises:
Quadriceps sets: The patient was instructed to contract the quadriceps muscle, hold the contraction for 10 seconds, and relax.
Repetitions: 10 per session.

2. Dynamic Strengthening Exercises:
Straight leg raises: Performed in sets of 10 repetitions.
Mini-squats: Gradual progression was encouraged to avoid joint strain.

3. Stretching Exercises:
Hamstring and calf stretch: Each stretch was held for 20 seconds and repeated three times.

4. Aerobic Exercise:
Treadmill walking for 10 minutes per session at a low resistance level.
Treatment Combination
Week 1-2: TENS therapy with the prescribed exercise program.
Week 3-4: Ultrasound therapy with the same exercise program.

Outcome Measures
Pain intensity was evaluated using the Visual Analog Scale (VAS), a subjective tool for measuring pain level rated from 0(no pain) to 10(worst pain) and Intermittent & Constant Osteoarthritis Pain (ICOAP): knee version (constant pain), a measure of pain rated from 0(no constant knee pain) to 4(extreme pain) in each question among 5.
Baseline: The patient reported a pain level of 7/10 in VAS and 15/20 in ICOAP, indicative of moderate to severe pain that significantly interfered with daily activities.
Week 2 (Post-TENS): Pain reduced to 4/10 in VAS and 10/20 in ICOAP, reflecting a substantial improvement due to TENS' analgesic effects.
Week 4 (Post-US): Pain further decreased to 3/10 in VAS and 7/20 in ICOAP, indicating additional relief following US therapy.

Muscle Strength (MMT):
Muscle strength was evaluated using Manual Muscle Testing (MMT) for the quadriceps and hamstrings:
Baseline: Quadriceps (Grade 3, right; Grade 5, left), Hamstrings (Grade 4, right; Grade 5, left).
Week 2 (Post-TENS): Quadriceps strength improved to Grade 4 on the right side, while hamstring strength remained consistent at Grade 4.
Week 4 (Post-US): Quadriceps strength further increased to Grade 4+ on the right side, and hamstring strength improved to Grade 4+.
Social Functional Outcome (SF-36):
Functional status and QOL were examined using the SF-36 Health Survey[8], which

evaluates physical functioning, pain, and overall well-being.

Baseline: The patient scored 45/100, reflecting poor functional ability and diminished quality of life.

Week 2 (Post-TENS): The score increased to 55/100, showing improvement in pain management and functional capacity.

Week 4 (Post-US): The score further increased to 65/100, indicating enhanced physical functioning and better patient-perceived health.

DISCUSSION

This case study highlights the comparative effects of TENS and US on pain reduction, muscle strength, and functional outcomes in a patient with knee OA. During the first two weeks, TENS therapy provided significant pain relief, reducing the VAS score from 7/10 to 4/10. This improvement is likely attributable to the activation of pain-inhibitory pathways and the modulation of nociceptive signals [9]. TENS' rapid action in reducing pain enabled the patient to engage more effectively in her exercise regimen, laying a foundation for subsequent improvements in strength and mobility.

In the subsequent two weeks, US therapy further decreased pain to 3/10 and facilitated greater improvements in muscle strength and functional capacity. The thermal and mechanical effects of US may have enhanced blood circulation, reduced inflammation, and promoted tissue repair, thereby supporting better outcomes in muscle performance and joint mobility. The improvement in MMT from Grade 4 to Grade 4+ for both quadriceps and hamstrings during this phase reflects the role of US in enhancing neuromuscular performance. The SF-36 score showed marked improvement following US therapy, rising from 55/100 to 65/100, indicating enhanced quality of life and patient-perceived well-being.

The consistent exercise program throughout the treatment period likely contributed to improved muscle strength and functional outcomes. By maintaining the same exercises in both phases, this case study isolated the effects of TENS and US, demonstrating that US yielded superior benefits when used sequentially after TENS. This suggests a potential synergistic effect where TENS provides initial pain relief[10], allowing better adherence to exercises, while US offers additional therapeutic benefits for longer-term recovery.

However, it is essential to note that individual patient factors, such as adherence to the treatment protocol and the chronicity of OA, may influence outcomes. Additionally, while this study provides valuable insights, the findings are based on a single patient and may not be generalizable to all individuals with knee OA [11].

CONCLUSION

This case study demonstrates the complementary roles of TENS and US in managing knee OA. While both modalities effectively reduced pain and improved outcomes, US showed superior benefits in terms of functional recovery and patient-perceived quality of life. A sequential approach starting with TENS for immediate pain relief, followed by US for long-term functional improvements may optimize outcomes in knee OA management. Further research with larger sample sizes and longer follow-up periods is recommended to validate these findings and refine treatment protocols.

Declaration by Authors

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