

# Comparative Evaluation of the Effects of Short-Wave Diathermy, Ultrasound, and TENS on Pain and Physical Functions in Knee Osteoarthritis

Diz Osteoartritinde Kısa Dalga Diatermi, Ultrason ve TENS'in Ağrı ve Fiziksel Fonksiyon Üzerindeki Etkilerinin Karşılaştırılması

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## ABSTRACT

**Objective:** Short-wave diathermy (SWD), ultrasound (US), and Transcutaneous Electrical Nerve Stimulation (TENS) are commonly used agents in physical therapy treatments. This study aimed to evaluate the therapeutic effects of these physical therapy agents in women with bilateral knee osteoarthritis (OA).

**Methods:** Three equal groups of 60 women diagnosed with knee OA of age 45-65 years based on their treatment regimens were created: SWD (group 1), US (group 2), and TENS (group 3). These patients had stages 2 and 3 knee OA with reference to the Kellgren-Lawrence Classification System. The evaluations were performed using the visual analog scale (VAS) and Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) and the physical function tests at the time points of pre-treatment, post-treatment, and 1-month follow-up duration.

**Results:** There were not any significant difference among the groups in terms of age, height, weight, body mass index, duration of pain, and radiological staging of OA. All 3 physical therapy agents were effective in terms of pain and physical functions. Better results were obtained in terms of the VAS and WOMAC scores at post-treatment and at 1-month follow-up when compared to that at pre-treatment assessment. However, comparison of the results of all 3 physical therapy agents showed that TENS treatment was more effective in relieving pain. Although no significant difference was noted among the groups in terms of the physical functions, SWD was more effective in terms of the scores of repeated sit-to-stand test and 20 m walk tests, while US was more effective in terms of the straight-line walk test scores.

**Conclusion:** Treatment with the physical therapy agents was effective in alleviating the physical functions. In addition, TENS was found to be more effective in alleviating pain.

**Keywords:** Short wave diathermy, ultrasound, TENS, pain, physical functions

## ÖZ

**Amaç:** Kısa dalga diatermi (KKD), ultrason (US) ve Transkutanöz Elektriksel Sinir Stimülasyonu (TENS) tedavide yaygın olarak kullanılan fizik tedavi ajanlarıdır. Çalışmamızın amacı bilateral diz osteoartriti (OA) olan kadınlarda bu fizik tedavi ajanlarının terapötik etkilerini karşılaştırmaktır.

**Yöntemler:** Çalışmaya KKD (grup 1), US (grup 2) ve TENS (grup 3) tedavisi alan 45-65 yaşları arasında diz OA tanısı alan 60 kadın dahil edildi. Her grupta eşit sayıda hasta vardı. Bu hastalarda Kellgren-Lawrence sınıflamasına göre evre 2 ve 3 diz OA tanısı mevcuttu. Tedavi öncesi, tedavi sonrası ve 1. ay kontrollerde vizüel analog skala (VAS), Western Ontario vs Mc Master Universities Osteoarthritis Index (WOMAC) ve fiziksel fonksiyon testlerine göre değerlendirmeler yapıldı.

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## ÖZ

**Bulgular:** Gruplar arasında yaş, boy, kilo, vücut kitle indeksi, ağrı süresi ve OA'nın radyolojik evrelemesi açısından anlamlı fark yoktu. Her üç fizik tedavi ajanının da fiziksel fonksiyonlar üzerine etkili olduğu bulundu. Tedavi sonrası ve 1 aylık kontrollerde VAS ve WOMAC sonuçları açısından tedavi öncesine göre daha iyi sonuçlar elde edildi. Bununla birlikte, her üç fizik tedavi ajanının sonuçları karşılaştırıldığında TENS'nin ağrı tedavisi açısından daha etkili olduğu belirlendi. Gruplar arasında fiziksel fonksiyonlar açısından anlamlı bir fark olmamasına rağmen SWD'nin tekrarlı otur-kalk testi ve yirmi metre yürüme testleri açısından daha etkili olduğu ve US'nin düz çizgi yürüme testi açısından daha etkili olduğu bulundu.

**Sonuç:** Fizik tedavi ajanlarının fiziksel fonksiyonlar üzerinde etkili olduğu tespit edildi. Ek olarak, TENS'nin ağrı üzerinde daha etkili olduğu bulundu.

**Anahtar kelimeler:** Kısa dalga diyatermi, ultrason, TENS, ağrı, fiziksel fonksiyonlar

## INTRODUCTION

Osteoarthritis (OA) may affect several joints, especially the weight-bearing joints (1). The knee is the most commonly affected joint in OA. The prevalence of OA is 12%-35% in the general population (2,3). OA causes pain, joint swelling, stiffness, instability, and muscle weakness in the joints. These undesirable effects together decrease the quality of life of the patients. The aim of treatment in this situation is targeted at reducing the pain and joint stiffness, maintaining or regaining the joint range of motion and muscle strength, and reducing the dependency on daily living activities. Different physical therapy agents are frequently used for this purpose, including the most common used ones of short-wave diathermy (SWD), Transcutaneous Electrical Nerve Stimulation (TENS), and ultrasound (US) (4).

SWD is an electrotherapeutic modality applied in the treatment of knee OA. In this treatment module, the application of continuous electromagnetic radiation increases the tissue temperature, which in turn induces vasodilatation, reduces muscle spasms, accelerates the cellular activity, and elevates the pain threshold (5).

High-frequency sound waves are applied to the affected tissues during US therapy. US therapy enhances soft tissue healing, decreases the inflammatory response, increases the blood flow, increases the metabolic activity, and decreases pain (6).

The efficiency of different electrical characteristics of TENS is to selectively activate different types of fiber. The aim of conventional TENS is to selectively activate A $\beta$  afferents, producing segmental analgesia (7).

There are different theories about the mechanism of TENS. Most researchers agree that this device is effective in relieving pain using the 2 mechanisms of gate control and secretion of endorphins (8).

In this prospective study, we investigated the effects of SWD, US, and TENS treatments on the pain and physical functions. Accordingly, we evaluated the effects of SWD, US, and TENS treatments on the pain and physical functions in patients with OA.

## METHODS

The patients receiving SWD, US, and TENS treatments with the diagnosis of knee OA were reviewed prospectively during February 2008-2009. The scores of complete visual analogue scale (VAS),

Western Ontario and McMaster University Osteoarthritis Index (WOMAC), lift test, pick-up test, repeated sit-to-stand test, sock test, stair ascending and descending test, straight-line walking, timed up & go test, and 20 m walk test of 20 patients from each group were analyzed at pre-treatment, post-treatment, and 1-month follow-up.

Ethics committee approval was obtained from the Local Ethics Committee of the İstanbul Physical Therapy and Rehabilitation Training and Research Hospital in January 2008. Written informed consent, approved by our institutional review board, was obtained from all patient.

Female patients aged 45-65 years with bilateral knee OA were included in the study. Patients with a history of previous knee joint surgery, intra-articular injection, and lower back or hip pain in addition to knee pain were excluded from the study. Bilateral knee OA was diagnosed with reference to the American College of Rheumatology criteria. These patients had stages 2 or 3 knee OA according to the Kellgren-Lawrence Classification System. Twenty patients each were grouped as follows: group 1: patients receiving SWD treatment, group 2: patients receiving US therapy, and group 3: patients receiving TENS treatment (9).

SWD was applied for 15 min, US (1 MHz, 1.5 W/cm<sup>2</sup> dose) for 5 min, and TENS for 20 min in each session. Each patient received a total of 15 sessions of the prescribed treatment.

In each group, isometric quadriceps strengthening exercise was applied as a home program. Patients performed this exercise program for 3 months, thrice a day for 1 h at each session.

Evaluations were made in terms of recording the scores of VAS, WOMAC, and physical function tests at the pre-treatment, post-treatment, and 1-month follow-up (10).

Physical functions were evaluated using the lift test, pick-up test, repeated sit-to-stand test, sock test, stair ascending and descending test, stair ascending and descending test, straight-line walking, timed up & go test, and 20-m walk test (11-13).

## Statistical Analysis

SPSS for Windows 13.0 package program was applied for statistical analysis. Chi-square test was used to compare the demographic ratios among the groups, and the analysis of variance test was

applied to compare the means among the groups. Mann-Whitney-U test or Wilcoxon test were used to compare the non-parametric tests. Statistical significance was accepted as  $p < 0.05$ .

## RESULTS

No significant difference was found among the groups in terms of age, height, weight, body mass index, duration of pain, and radiological staging of OA ( $p > 0.05$ ) (Table 1).

### SWD Treatment Group

**VAS score:** Post-treatment value was significantly lower than the pre-treatment value ( $p = 0.001$ ). At the 1-month follow-up, the VAS score was significantly lower than that at the post-treatment assessment ( $p = 0.001$ ) (Table 2).

**Physical functional tests:** The post-treatment and 1-month follow-up values were significantly better than the pre-treatment value ( $p < 0.001$ ). There was no significant difference between the values of 1-month follow-up and that at post-treatment ( $p > 0.05$ ) (Table 2).

**WOMAC pain:** The post-treatment value was significantly lower than the pre-treatment one ( $p = 0.001$ ). At the 1-month follow-up, the WOMAC Pain score was significantly lower than the post-treatment score ( $p = 0.003$ ) (Table 2).

**WOMAC stiffness:** The post-treatment value was significantly lower than the pre-treatment score ( $p = 0.002$ ). At the 1-month follow-up, the WOMAC Stiffness score was significantly lower than the post-treatment score ( $p = 0.02$ ) (Table 2).

**WOMAC physical function:** The post-treatment and 1-month follow-up values were significantly lower than the pre-treatment value ( $p < 0.001$ ). No significant difference was noted between the 1-month follow-up and post-treatment assessment ( $p = 0.41$ ) (Table 2).

**WOMAC total:** The post-treatment value was significantly lower than the pre-treatment one ( $p = 0.002$ ). At the 1-month follow-up, the WOMAC total score was significantly decreased than that at post-treatment assessment ( $p = 0.003$ ) (Table 2).

**Table 1. Comparison of groups in terms of age, height, weight, BMI, duration of pain, and radiological grading**

	Group 1 SWD	Group 2 US	Group 3 TENS	p
Age (year)	55.15±6.61	54.75±6.12	55.20±5.32	0.87
Height (cm)	158.30±6.82	162.00±6.68	160.45±5.35	0.22
Weight (kg)	78.35±12.70	79.45±14.39	75.55±10.14	0.30
BMI (kg/cm <sup>2</sup> )	29.66±9.25	30.80±5.53	29.57±5.06	0.66
Duration of pain (month)	23.20±13.92	16.26±9.34	18.30±10.05	0.31
Kellgren-Lawrence	-	-	-	0.31
Grade 2	10	8	16	-
Grade 3	30	32	24	-

BMI: body mass index. SWD: short-wave diathermy, US: ultrasound, TENS: Transcutaneous Electrical Nerve Stimulation

**Table 2. Pre-treatment, post-treatment, and 1-month follow-up values of the patients treated with SWD**

Group 1 (SWD)	Pre-treatment	Post-treatment	First month follow-up
VAS	7.45±0.99	5.40±1.09	4.60±1.09
Lift test	11.40±2.13	13.05±2.23	12.70±2.17
Pick-up test	2.15±0.67	1.75±0.78	1.76±0.67
Repeated sit-to-stand test (sn)	16.46±3.68	13.83±3.80	13.17±3.82
Sock test (0-3)	2.25±0.71	1.80±0.69	1.80±0.69
Stair ascending test (sn)	13.79±4.06	11.06±4.08	10.31±3.88
Stair descending test (sn)	13.72±4.33	11.23±4.50	11.15±4.32
Straight-line walking (sn)	16.38±5.24	14.51±5.24	14.44±5.17
Timed up & go test (sn)	12.31±3.22	9.91±2.75	9.92±2.65
Twenty meter walk test (sn)	20.36±4.26	18.12±3.18	17.61±2.86
WOMAC pain	14.80±2.82	10.85±2.66	10.00±2.90
WOMAC stiffness	5.10±1.11	3.70±1.30	3.25±1.25
WOMAC physical function	50.70±4.90	38.80±8.28	39.50±9.29
WOMAC total	70.60±6.07	54.85±11.37	51.75±11.67

SWD: short-wave diathermy, VAS: visual analog scale, WOMAC: Western Ontario and McMaster Universities Osteoarthritis Index

## US Treatment Group

**VAS score:** The post-treatment value was significantly lower than the pre-treatment one ( $p < 0.001$ ). No significant difference was noted between the 1-month follow-up and post-treatment assessment ( $p = 0.058$ ) (Table 3).

**Physical functional tests:** In the tests other than the lift test and repeated sit-to-stand test, the values at post-treatment and at 1-month follow-up were significantly better than that at pre-treatment assessment ( $p < 0.001$ ). No significant difference was noted between the 1-month follow-up and that at post-treatment ( $p > 0.05$ ) (Table 3).

**Lift test:** Post-treatment and 1-month follow-up values were significantly better than that the pre-treatment values ( $p < 0.001$ ). However, at the 1-month follow-up, the lift test score was significantly lower than that at post-treatment ( $p = 0.011$ ) (Table 3).

**Repeated sit-to-stand test:** The post-treatment and 1-month follow-up values were significantly better than that the pre-treatment value ( $p < 0.001$ ). However, at the 1-month follow-up, the repeated sit-to-stand test score was significantly lower than that at post-treatment assessment ( $p = 0.038$ ) (Table 3).

**WOMAC pain, stiffness, physical function and total score:** The post-treatment and 1-month follow-up values were significantly better than the pre-treatment values ( $p < 0.001$ ). No significant difference was noted between the 1-month follow-up and at post-treatment assessment ( $p > 0.05$ ) (Table 3).

## TENS Treatment Group

**VAS score:** The post-treatment value was significantly lower than the pre-treatment value ( $p < 0.001$ ). No significant difference was noted between the 1-month follow-up and post-treatment values ( $p = 0.052$ ) (Table 4).

**Physical functional tests:** In the straight-line walking test, the post-treatment and 1-month follow-up values were significantly better than the pre-treatment value ( $p < 0.001$ ). No significant difference was noted between the 1-month follow-up and post-treatment values ( $p > 0.05$ ) (Table 4).

**Straight-line walking test:** The post-treatment and 1-month follow-up values were significantly better than the pre-treatment value ( $p < 0.001$ ). However, at the 1-month follow-up, the straight-line walking test score was significantly lower than at the post-treatment assessment ( $p = 0.04$ ) (Table 4).

**WOMAC pain:** The post-treatment and 1-month follow-up values were significantly better the pre-treatment value ( $p < 0.001$ ). No significant difference was noted between the 1-month follow-up value and the post-treatment value ( $p = 0.19$ ) (Table 4).

**WOMAC stiffness, physical function and total score:** The post-treatment value was significantly lower than the pre-treatment value ( $p < 0.001$ ). At the 1-month follow-up, the WOMAC total score was significantly decreased than that at the post-treatment assessment ( $p = 0.001$ ) (Table 2).

## Comparison of the Groups

The VAS and WOMAC Pain scores after TENS treatment and at 1-month follow-up were better when compared to that after SWD and US treatments ( $p < 0.05$ ). SWD was found to be more effective in terms of repeated sit-to-stand test and 20 m walk tests after the treatment and at 1-month follow-up ( $p < 0.05$ ). US was most effective at 1-month follow-up in terms of the straight-line walk test scores ( $p < 0.001$ ). No significant difference was noted among the groups in terms of other parameters.

**Table 3. Pre-treatment, post-treatment, and 1-month follow-up values of the patients treated with SWD**

Group 2 (US)	Pre-treatment	Post-treatment	First month follow-up
VAS	7.25±0.91	4.50±1.10	4.20±0.95
Lift test	11.30±2.34	13.65±2.36	12.75±2.44
Pick-up test	1.85±0.71	1.10±0.44	1.05±0.39
Repeated sit-to-stand test (sn)	15.14±2.81	12.30±2.34	12.54±2.45
Sock test (0-3)	2.16±0.75	1.00±0.45	0.95±0.39
Stair ascending test (sn)	11.72±3.29	9.05±2.83	9.63±2.65
Stair descending test (sn)	11.33±2.59	9.30±2.15	9.50±2.15
Straight-line walking (sn)	18.27±5.74	16.23±4.28	15.88±4.33
Timed up & go test (sn)	11.22±2.39	8.91±2.08	9.26±2.27
Twenty meter walk test (sn)	19.31±4.92	17.30±6.06	16.30±7.57
WOMAC pain	13.65±2.20	9.95±2.41	9.65±2.25
WOMAC stiffness	5.20±1.50	3.55±1.09	3.30±0.97
WOMAC physical function	48.68±5.68	37.25±8.03	36.65±7.14
WOMAC total	67.75±9.17	51.00±10.84	49.60±9.25

SWD: short-wave diathermy, US: ultrasound, VAS: visual analog scale, WOMAC: Western Ontario and McMaster Universities Osteoarthritis Index

**Table 4. Pre-treatment, post-treatment, and 1-month follow-up values of the patients treated with TENS**

Group 3 (TENS)	Pre-treatment	Post-treatment	First month follow-up
VAS	7.35±0.67	3.98±0.67	4.06±0.48
Lift test	13.60±2.64	14.80±3.05	14.75±3.59
Pick-up test	1.75±0.63	1.10±0.44	1.00±0.45
Repeated sit-to-stand test (sn)	14.67±2.38	12.30±2.34	11.43±2.45
Sock test (0-3)	1.65±0.58	1.00±0.45	1.05±0.39
Stair ascending test (sn)	9.75±3.03	9.05±2.83	8.41±2.49
Stair descending test (sn)	9.53±3.62	9.30±2.15	9.50±2.15
Straight-line walking (sn)	17.37±4.52	16.27±5.74	15.54±3.86
Timed up & go test (sn)	9.69±1.89	8.91±2.08	7.76±1.43
Twenty meter walk test (sn)	18.80±3.96	17.30±6.06	17.17±3.40
WOMAC pain	14.15±2.25	8.95±2.41	9.06±1.78
WOMAC stiffness	5.30±1.17	3.55±1.09	3.50±0.94
WOMAC physical function	48.40±6.72	37.25±8.03	33.95±8.88
WOMAC total	68.10±7.30	51.00±10.84	47.05±10.50

TENS: Transcutaneous Electrical Nerve Stimulation, VAS: visual analog scale, WOMAC: Western Ontario and McMaster Universities Osteoarthritis Index

## DISCUSSION

Our results revealed that the evaluated physical therapy agents were effective in the treatment of pain and physical functions. However, in terms of pain treatment, TENS was more effective than other agents. In terms of physical functions, SWD was more effective in terms of repeated sit-to-stand test and 20 m walk tests. According to the straight-line walk test, US is more effective.

SWD, US, and TENS are commonly used physical therapy agents applied in the treatment of knee OA. However, the effect of these physical therapy agents on joint pain remains unclear. These treatment approaches increase the temperature of the tissues on application as well as an increase in the blood flow to the tissues. As the blood flow increases, the tissue perfusion and metabolic activity also increase, and muscle relaxation is achieved (5-7). Another mechanism is called the gate control theory (5,6,14). TENS has also been reported to modulate the pain control pathway by inducing endogenous opioid secretion (15).

These physical therapy agents reduce inflammation at the joints as well as reduce the pain. The decrease in synovitis was demonstrated by a decrease in US -measured synovial tissue thickness after the treatment. Reduction in inflammation reduces pain and positively affects the range of motion of the joints (16).

Some past studies have shown that SWD, US, and TENS can reduce the pain in patients with knee OA, albeit they are insufficient in terms of the physical functions alone (16-19). It has been emphasized that exercise therapies are more important in terms of physical functions (20).

Different results on the effect of physical therapy agents on the physical functions have been reported in the literature. SWD, US, and TENS increase the compliance of patients with exercise therapy, but some studies claim that US is not as effective as SWD

and TENS (21,22). On the other hand, some past studies assert that US with SWD is an effective treatment modality in the treatment of knee OA and neither are superior to each other (23,24). In another study, physical therapy agents were reported to have increased the walking distance during the treatment, although this distance decreased at the end of the treatment. In the present study, it was determined that exercise programs applied during and post-treatment could increase the walking distance during the treatment duration and prevent a decrease in the walking distance after the treatment application (21). Therefore, it is recommended to apply these physical agents together with exercise therapies for the treatment of knee OA (17,21).

In all 3 physical therapy modalities tested in this study, we found that the pain complaints decreased significantly after the treatment and at 1-month follow-up when compared to that before the treatment. On the other hand, although they were reported to be inadequate in terms of physical functions, in our study, we achieved better outcomes in terms of the scores of the physical function parameters. Furthermore, the tested physical functions did not decrease at the 1-month follow-up assessment.

### Study Limitations

The absence of any control group in this study as well as the absence of medium and long-term results challenges the strengths of the study.

## CONCLUSION

TENS, US, and SWD are effective interventions for the treatment of pain and physical functions in the treatment of knee OA and can thus be safely preferred as the treatment approaches. Further studies need to be conducted to investigate their effectiveness in the treatment of other joint OA.

**Ethics Committee Approval:** Ethics committee approval was obtained from the Local Ethics Committee of the İstanbul Physical Therapy and Rehabilitation Training and Research Hospital in January 2008.

**Informed Consent:** Written informed consent, approved by our institutional review board, was obtained from all patient.

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