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# The Effect of TENS on Pain, Function, Depression, and Analgesic Consumption in the Early Postoperative Period with Spinal Surgery Patients

## *Postoperatif Erken Dönemde TENS Kullanımının Analjezik Tüketimi ve Analjeziklerle İlişkili Yan Etkiler Üzerine Etkisi*

Bilge KARA[1], Ferdi BASKURT[2], Serap ACAR[1], Didem KARADIBAK[1], Lugen CIFTCI[1], Serhat ERBAYRAKTAR[1], Ali Necati GOKMEN[1]

*[1]Dokuz Eylul University, School of Physical Therapy, Inciralti, Izmir, Turkey*
*[2]Suleyman Demirel University, Faculty of Health Sciences, Department of Physical Therapy and Rehabilitation, Isparta, Turkey*

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**Correspondence address: Bilge KARA** / E-mail: bparlak@deu.edu.tr

**ABSTRACT**

**AIM:** The aim of our study was to examine the effects of the use of Transcutaneous Electrical Nerve Stimulation (TENS) in patients who had undergone spinal surgery on pain, functionality, depression and consumption of analgesic agents.

**MATERIAL and METHODS:** Fifty-Four patients were randomized and placed into two groups, patient-controlled analgesia (PCA) plus TENS and only PCA. To assess the pain levels of the patients, the Visual Analog Scale (VAS) was used. In the assessment of their functional levels, the Timed Up and Go test (TUG) was utilized and in the assessment of their depression, the Beck Depression Inventory (BDI) was used. The measurements were performed before the operation and on the first and second postoperative days. The side effects were recorded from the analgesic agents.

**RESULTS:** During the first and second days after the operation, a decrease in the pain levels was noticed in the TENS group ($p<0.05$. In the TENS group, the consumption of analgesic agents also decreased and thus side effects were less frequent. From the viewpoint of functional and depression levels, no significant difference between the groups was noticed ($p>0.05$).

**CONCLUSION:** TENS was effective in reducing analgesic agent-related side effects and in reducing analgesic consumption. In addition, TENS also decreased activity related pain.

**KEYWORDS:** TENS, PCA, Pain, Analgesic consumption, Functional level, Depression

**ÖZ**

**AMAÇ:** Çalışmamızın amacı spinal cerrahi geçiren hastalarda TENS (Transcutaneous Electrical Nerve Stimulation) kullanımının ağrı, fonksiyonellik, depresyon ve analjezik ajanlar ile olan etkisini incelemektir.

**YÖNTEM ve GEREÇLER:** 54 hasta randomize olarak Patient-Controlled Analgesia (PCA) ve TENS ile sadece PCA olmak üzere iki gruba ayrılmıştır. Hastaların ağrı düzeyleri Vizüel Analog Skala (VAS) ile değerlendirilmiştir. Fonksiyonel düzeylerinin değerlendirilmesinde Timed Up and Go testi (TUG) kullanılmıştır. Depresyon düzeyleri Beck Depresyon Anketi ile ölçülmüştür. Tüm ölçümler operasyon öncesi ve operasyon sonrası birinci ve ikinci günlerde yapılmıştır. Analjezik tüketimine bağlı yan etkiler kaydedilmiştir.

**BULGULAR:** Operasyondan sonraki birinci ve ikinci günlerde, TENS grubu aktivitelerinde ağrı düzeylerinde anlamlı derecede azalma gözlenmiştir ($p<0,05$). TENS grubunda analjezik ajan kullanımı azalmış ve yan etkiler daha az gözlenmiştir. Fonksiyonel durum ve depresyon düzeyleri açısından gruplar arasında anlamlı derecede fark yoktur ($p>0,05$).

**SONUÇ:** TENS analjezik kullanımı ve ilaç kullanımına bağlı yan etkilerin oluşumunu önlemek açısından ağrı kontrolünde etkindir.

**ANAHTAR SÖZCÜKLER:** TENS, PCA, Ağrı, Analjezik tüketimi, Fonksiyonel düzey, Depresyon

## INTRODUCTION

Pain is described as an unpleasant sensory and emotional experience. Pain is also a potent trigger for the stress response, activating the autonomic nervous system and causing adverse effects on multiple organ systems (14). The severity of preoperative pain can also influence the development of postsurgical chronic pain syndromes (4,10,25). Untreated postoperative pain has been shown to produce a number of adverse effects, including impaired pulmonary functions. Improved management of postoperative pain has been shown to reduce the overall postoperative complication rate, the incidence of cardiovascular failure, and major infectious complications (4,6,8,17).

Current approaches to postoperative pain management include pharmacological agents (drugs) and a number of non-pharmacological agents. Patient-Controlled Analgesia (PCA) is one of the pharmacological agents used for postoperative pain control, and PCA equipment consists of an infusion pump electronically connected to a timing device. Success with PCA in a prior study led to a second larger study that compared self–administered, narcotic-dosing PCA with the more traditional time-sequence, fixed dosing of narcotics. Problems that may occur with PCA include allergic reactions to the medications and other adverse side effects, such as nausea, a dangerous drop in the rate and effectiveness of breathing and excessive sedation.

A variety of non-pharmacological strategies with minimal side effects have been used to treat pain during the postoperative period. One of these strategies is TENS which has been used extensively to control postoperative pain, but its effects are controversial (1,9,18,26). The majority of clinical studies testing the effectiveness of TENS on postoperative pain have used continuous conventional TENS with varying results. The use of electrical stimulators for pain control became common after 1965, when Melzack and Wall offered their gate control theory (13,22) for treating pain with TENS based on two fundamental methods. One method is presynaptic inhibition, in which thick afferent nerves (A-alpha, A-beta, A-gamma) are stimulated selectively, therefore stimulation transmission is blocked at the level of the medulla spinalis. The other method induces a painful impulse that stimulates A-gamma and C nerves lacking myelin. In this way endogenous opioid (endorphin) is released by inhibitor mechanisms active in the upper levels into the central nervous system. Additionally, recent evidence has suggested that TENS decreased hyperalgesia in the tissues surrounding surgical incisions (21). Hyperalgesia is characterized by a decrease in pain threshold and an increase in pain to suprathreshold stimuli.

A recent study has maintained that the main parameters that determine a good outcome in spinal surgery were achieving the patients' expectations or satisfaction with the results, pain, relief, alleviation of disability and social reintegration (22). Therefore, postoperative pain management aims not only to decrease pain intensity but also to increase patient comfort and improve postoperative outcomes. Inclusion of postoperative pain treatment in a multimodal approach of patient rehabilitation may thus improve recovery and shorten hospital stays. Additionally, uncontrolled postoperative pain may lengthen the return to normal activities (2,4,15). It is important to minimize the pain levels in patients in the postoperative period through physiotherapy and rehabilitation applications. In this way, returning to daily life activities and activities related to their occupation is faster after the operation.

In the literature, there are many studies on the relationship between TENS and analgesic consumption, but there is no study on the relationship between pain control and functional level in the early postoperative period. The aim of this study was therefore to assess TENS application performed after spinal surgery on the effect of pain, functionality, depression and analgesic consumption.

## MATERIAL and METHODS

Fifty-four patients, 28 female (51.9 %) and 26 male (48.1 %), who were scheduled for open lumbar discectomy at the University Hospital, Neurosurgery Department between November 2004 and April 2008 were included in the study. Exclusion criteria included patients with renal, hepatic or neuromusculoskeletal dysfunction, cardiac disease, history of allergy to opioids, and patients who experienced difficulty in communication. This study was approved by the local ethics committee, and informed consent was obtained from the patients before inclusion. The ethical committee for human research, University Hospital, Protocol Number was 425

### *Randomization*

A prospective randomized, single blind study was designed. A total of 54 patients were randomly allocated into two groups according to a computer- generated list. There was a control group (n = 29), which included PCA, and a second group (n = 25), which included both TENS and PCA.

## PROCEDURE

The patients were operated on by the same surgeon. PCA pump application was standardized for all the subjects, and the PCA pump was implemented by the same anesthesiology group after the operation. Additionally, a physician from the pain clinic performed the follow up for PCA pump applications in patients.

All patients received a PCA pump containing a standardized solution of meperidine (5 mg/mL). The operational aspects of the PCA pump (Abbott Life Care PCA Plus Infuser-Abbott Laboratories, North Chicago, IL, USA) and the TENS stimulator (four-channel, 14 mA continuous pulse, maximum 80 mA, 500 ohm power control, E704 T.E.N.S. applied with conventional mode, 150 ms, 6 Hz) were explained to the patients, and they were taught how to use the visual analogue scale pain score to evaluate pain intensity during the preoperative visit.

On arrival in the post-anesthesia care unit (PACU), the PCA device was connected to the patient's IV line and programmed

to deliver a 0.5 mg/kg loading dose of meperidine and 10 mg bolus doses of meperidine on demand, with a minimal lockout interval of 10 min and a maximal four-hour dose of 150 mg without any background infusion. If the patient required pain medication prior to initiating PCA therapy, meperidine (10 mg IV) was administered by the PACU nursing staff.

In the TENS group, a patient's postoperative analgesic care was supplemented with TENS, which was started when the patient arrived in the post surgical ward (second and third hours after surgery). TENS was administered twice for 30 to 40 minutes each time with a 3 to 4 hour rest interval between the TENS applications.

Similar to Hamza et al's1 and Chen et al's location of four cutaneous self-adhesive electrode pads, sized 16 cm2 (tens/ems, Promed GmbH, D-82490, Farchant, Germany) were attached on either side in a distance of 4 cm to the planned skin incision at dermatomal levels as illustrated in Figure 1. The frequency of stimulation was set in the standard TENS or high frequency TENS dense and disperse modes, with alternating electrical stimulation at 50 Hz and 100 Hz with a pulse width of 20 - 60 ms The intensity of stimulation depended on the treatment group and was increased until patient received a strong paraesthesia without muscle contraction (0 mA to 30 mA). All forms of electrical stimulation were applied using the TENS device.

PCA therapy was discontinued when the patient no longer required IV analgesic therapy. The TENS therapy was discontinued when the patients were able to control their pain with oral analgesic medication. The oral analgesic medication consisted of non-steroid anti-inflammatory drugs. Opioid-related side effects (e.g., postoperative nausea, vomiting, and pruritus) were treated according to a standardized protocol.

***Assessment***

The number of PCA demands (i.e., button presses), delivered bolus doses, opioid-related side effects, postoperative adverse effects such as dizziness, headache, drowsiness/sedation, and anxiety/restless were recorded.

***Pain***

A visual analog scale (VAS) for assessing current pain intensity was used for low back pain and consisted of a horizontal 100 mm line with the words 'no pain' at one end, and the words 'worst imaginable pain' on the other end. Before the operation and on the first and second days after the operation, patients' rest and activity pain were all recorded (3).

***Functional Level***

The timed Up and Go (TUG) test was used to measure the functional level of the patients. TUG test measurements were obtained by using an ordinary armchair (47 cm high) and stopwatch. Subjects were seated with their back against the chair, and they were instructed to stand up, walk three meters (to a mark on the floor), turn around, walk back to the chair and sit down. The task was to be performed at an ordinary comfortable speed. The stopwatch was started on the word 'go' and stopped as the subject sat down. The TUG time was measured in seconds. The person was allowed to wear his or her usual footwear and could use any assistive device they normally use. Timing began when the person started to rise from the chair and ended when he or she returned to the chair and sat down. The Timed Up and Go test was administered by a physiotherapist. The timed Up and Go test was repeated three times, and the best score was recorded. High scores were evaluated as unsatisfactory scores (19).

***Depression***

The Beck Depression Inventory (BDI) was developed and revised by Beck et al. and is composed of 21 items with multiple choices for the rating of the degree of symptoms, with scores ranging from 0 to 63. Each item consists of four statements presented in an ordered sequence to reflect an increasing intensity of experience. Each item is scored on a 0-3 scale, with 0 indicating absence of the symptom, and 3 indicating the most intense statement. The BDI requires minimal time and no special training to administer. The BDI has been used extensively in clinical diagnosis and research. A lower score represents a good result. In this study, the BDI was measured before and after the operation (12). The BDI scoring system is as follows:

An index score of < 9 is considered to be within the normal range;

A score of 10 to 15 shows minimal depressive symptomology;

A score of 16 – 31 indicates mild depression;

A score of 32 – 47 is indicative of moderate depression;

A score of 47 or above is considered severe depression.

***Analyses***

Descriptive statistics included frequency distribution of categorical variables and the mean and standard deviations for continuous variables. For the statistical analysis within groups, the Wilcoxon Signed Rank test was used, and for between groups, the Mann Whitney U test and chi-square test were used. The level of significance was $p < 0.05$. Statistical analysis was performed using the statistical package for social sciences (SPSS), version 11.0.

## RESULTS

Four patients were excluded from the study because they did not receive preoperative or postoperative measurements. Subjects' gender, age, body mass index, education level, smoking and alcohol consumption as well as other physical and demographic variables are given in Table I.

There were no statistically significant difference between the groups in relation to physical and demographical characteristics, and our groups' distributions were homogeneous.

Analgesic consumption in the TENS and control groups were evaluated 24 hours after the operation. It was found that analgesic consumption of the TENS group was lower than that of the PCA only group in the first 24 hours and in the total consumption. Patients in the PCA plus TENS group self-administered a PCA dose less than the patients in the control group; as a result, their analgesic need was rated as less (Table II). The analgesic consumption of the TENS group, number of button presses and additional need of analgesic were statistically and significantly different from the control group ($p < 0.05$) (Table II).

The patients' pain severity was assessed according to the VAS in activity preoperatively and postoperatively during the 1st and 2nd days after surgery: once in the morning and once in the afternoon. There were no statistically significant differences for preoperative pain between activity and rest. On the first day after operation, the TENS group showed no difference between the morning and afternoon pain measurements, but there were statistical and significant reductions in activity pain levels compared to the control group ($p<0.05$) (Table III). During the 2nd postoperative day, the TENS group's pain severity in the morning was significantly lower compared to the control group. However, there were no statistically significant differences between the two groups for pain in the afternoon measurement ($p > 0.05$) (Table III).

The timed up and go test results had lower scores in the TENS group than in the control group preoperatively. However, the TENS group patients had shorter times in the test than the control group on the 1st and 2nd postoperative days. Additionally, there were no statistically significant differences among preoperative and 1st and 2nd postoperative days according to the TUG test ($p>0.05$) (Table III).

When depression levels were evaluated at the preoperative period and at discharge from the hospital, it was noticed that the TENS group patients had less depressive symptoms than the control group patients. However, there were no statistically significant differences between the two groups ($p>0.05$) (Table III).

## DISCUSSION

TENS has been used to control postoperative pain following various surgical procedures (13,25,28). In this study, 54 patients who had spinal surgery were evaluated for pain, functionality, depression and analgesic consumption after TENS application.

**Table I:** Physical and Demographic Characteristics of the Subjects

| | TENS Group n=29 | Control Group n=25 | p |
|---|---|---|---|
| Gender (n) | | | |
| *Female* | 15 | 13 | 0.266 |
| *Male* | 10 | 16 | |
| Age (years) | 45.62 ± 10.59 | 47.60 ± 13.75 | 0.553 |
| BMI (kg/m$^2$) | 27.45 ± 4.21 | 26.91 ± 4.26 | 0.654 |
| Education Level (n) | | | |
| *Tertiary level* | 11 | 11 | |
| *Secondary school* | 8 | 6 | 0.822 |
| *Highest education* | 10 | 8 | |
| Occupation (n) | | | |
| *Actively working* | 16 | 13 | |
| *Unemployed/retired* | 2 | 6 | |
| *House wife* | 10 | 5 | 0.467 |
| *Student* | 1 | 1 | |
| Smoking (yes/no) | 13/16 | 14/11 | 0.413 |
| Alcohol consumption (yes/no) | 2/27 | 1/24 | 0.643 |

**Table II:** Postoperative Analgesic Requirements of the Patients

| | TENS Group n=29 | Control Group n=25 | p |
|---|---|---|---|
| Meperidine delivered in the first 24 hours | 86.33 ± 40.72 | 122.08 ± 43.93 | 0.004* |
| Meperidine delivered after 24 hours | 15.33 ± 24.45 | 41.25 ± 27.71 | 0.001* |
| Total meperidine consumption | 101.66 ± 61.33 | 163.33 ± 51.63 | 0.001* |
| PCA demand for the first 24 hours | 8.63 ± 4.07 | 12.20 ± 4.39 | 0.001* |
| PCA demand after 24 hours | 1.53 ± 2.44 | 4.50 ± 2.93 | 0.001* |

** p<0.05*

**Table III:** The Overall Clinical Score of Patients

| | TENS Group n=29 | Control Group n=25 | p |
|---|---|---|---|
| **PAIN (0-10)** | | | |
| Preoperative Rest | 4.79 ± 2.11 | 4.72 ± 2.17 | 0.986 |
| Activity | 8.03 ± 1.76 | 8.12 ± 1,94 | 0.743 |
| Postoperative 1st day | | | |
| Morning | | | |
| Rest | 2.44 ± 2.55 | 2.76 ± 2.00 | 0.226 |
| Activity | 3.20 ± 2.66 | 5.82 ± 2.51 | **0.001*** |
| Afternoon | | | |
| Rest | 2.20 ± 2.43 | 2.16 ± 1.74 | 0.655 |
| Activity | 2.90 ± 2.54 | 5.13 ± 2.18 | **0.001*** |
| Postoperative 2nd day | | | |
| Morning | | | |
| Rest | 1.09 ± 1.70 | 1.70 ± 1.55 | 0.226 |
| Activity | 1.57 ± 1.85 | 3.55 ± 2.35 | **0.001*** |
| Afternoon | | | |
| Rest | 1.00 ± 1.26 | 1.33 ± 2.30 | 0.094 |
| Activity | 1.00 ± 1.26 | 3.33 ± 2.51 | 0.005 |
| **Timed up & Go Test** (seconds) | | | |
| Preoperative | 11.62 ± 5.77 | 10.99 ± 2.78 | 0.573 |
| Postoperative 1st day | 16.47 ± 8.94 | 18.98 ± 9.32 | 0.187 |
| Postoperative 2nd day | 13.46 ± 7.13 | 15.25 ± 8.96 | 0.450 |
| **BACK Depression inventory** (BDI) | | | |
| Preoperative | 13.89 ± 8.00 | 15.76 ± 10.41 | 0.701 |
| Postoperative discharge day | 7.89 ± 5.95 | 12.92 ± 11.60 | 0.178 |

** p<0.05*

Study groups had homogenous distributions according to age, gender, body mass index, education level, occupation, cigarette smoking, alcohol consumption, and physical and demographical variables.

Pain associated with many surgical procedures is often treated inadequately. This shortcoming is unfortunate because acute postoperative pain can cause detrimental effects in multiple organ systems, including cardiovascular stress, autonomic hyperactivity, tissue breakdown (production of a catabolic state with suppression of anabolic hormones), increased metabolic rate, pulmonary dysfunction (most commonly after upper abdominal and thoracic surgery), increased blood clotting (hypercoagulability), fluid retention, dysfunction of the immune system, delayed return of bowel function (ileus), and the development of chronic pain syndromes after certain surgeries (e.g., phantom limb pain after amputation or post thoracotomy syndrome) (14).

Systematic reviews on TENS and postoperative pain commonly dichotomize complex trial data as either positive or negative, which may overlook clinically relevant effects (5,13,28). This practice has led to inconsistency in the interpretation of trial outcome by reviewers. For example, Conn et al. (7) reported that there were no differences between active and sham TENS in post appendectomy pain relief. In fact, Conn reported that patients in the active TENS group asked for less analgesia than those in the sham group. This result was statistically significant for the first 24-hour period and corresponded to the results of the proposed article. The review by Carroll et al. (5) judged this finding as a negative outcome based on the lack of differences in pain relief scores between the groups. However, the review

by Reeve et al. (21) judged the results from Conn et al. (7) as positive, possibly based on the finding that TENS significantly reduced the need for additional analgesics when compared to the sham group. .

There is a conflicting professional opinion on the use of TENS in acute postoperative pain. The recommendations of the Agency for Health Care Policy and Research for acute pain management state that TENS is 'effective in reducing pain and improving physical function', while an earlier report from the UK College of Anesthetists' on pain after surgery states that 'TENS is not effective as the sole treatment of moderate or severe pain after surgery' (16). Our study included the following groups: PCA with TENS application and PCA only. There was not a TENS only group.

Drug administration by patient-controlled analgesia (PCA) is common (8), and analgesic drugs were used as co-interventions in all available postoperative trials on TENS. Therefore, one of the aims of our study was to determine the effect of TENS application on analgesic consumption. It is important to emphasize that experimental studies of TENS effectiveness only provide support for partial pain relief, whereas analgesic drugs have the potential to produce complete pain relief. However, one problem with high doses of analgesic drugs is the undesirable side effects, such as depressed respiration, nausea, and sedation, reduced patient satisfaction (18). A clinically meaningful perspective is whether or not TENS can reduce analgesic consumption by PCA or analgesic request without significant increases in pain scores.

When the pain levels of our subjects were evaluated preoperatively and postoperatively, the TENS group, patients' pain levels during rest were significantly reduced compared to pain during activity. The fact that the pain level in activity was less demonstrated that the patients were more functional during their daily living activities. In addition, Erdoğan et al. (9) showed that TENS application reduced pain, improved pulmonary functions and reduced analgesic consumption. It has not been reported whether TENS is associated with side effects or intolerance, except for minimal discomfort. Similarly, we did not observe any side effects or intolerance related to TENS.

TENS is regarded as a relatively inexpensive, safe, non-invasive modality with few side effects to treat a variety of painful conditions. Technological advances have produced a wide range of stimulators with an even wider range of stimulation parameters for clinicians and patients to choose from (e.g., frequency, pulse amplitude, pulse duration, and electrode placement site) (24, 28,29).

The anesthesiologists' additional medication usage, the number of button presses and analgesic consumption on the first and second days after the operation were recorded. Additionally, it was indicated that after TENS group medication, the dizziness, vomiting and tiredness symptoms were less than in the control group. Furthermore, there were no adverse effects or negative results related to TENS application. The majority of clinical studies testing the effectiveness of TENS on postoperative pain have used continuous conventional TENS with varying results.

Meta-analysis studies have shown that 25-150 Hz for conventional TENS provided better pain relief than other indicated frequencies. We therefore applied 50-100 Hz conventional TENS in our study. TENS has long been used to reduce postoperative pain, and it has been found that TENS helps reduce acute postoperative pain (27). In one study, Rakel and Frantz (20) concluded that TENS reduced pain intensity during walking and deep breathing and increased walking function postoperatively when used as a supplement to pharmacological analgesia. Measuring physical mobility is very important to evaluate the functional results of the treatment.

In our study, we performed the TUG test to assess patients' functional status. The test was applied preoperatively and postoperatively on the first and the second days. Interestingly, there were no statistically significant results between the groups for the TUG test. Because there was no significant difference, the test results indicate that the patients had difficulty because of re-injury in the early postoperative period due to the fear of painful activity. This re-injury and fear of activity affected the subjects' functional status. These observations supported our theory that functional level might be affected by the fear of activity after

surgery. This makes sense, as psychological factors, such as the health locus of control anxiety and depression, have been shown to significantly affect PCA consumption and pain (23). However, although the results of the TENS group showed significant results with BDI for depression levels, there were no statistically significant improvements in mood. This outcome was troublesome because life dissatisfaction is associated with several poor health risk factors, such as the severity and symptoms of somatic disease, the use of medication, morbidity, mortality, premature work disability (9,11) and particularly, depressive symptoms (12,23).

All the performed treatments affected the patients' life satisfaction. To improve their life satisfaction, lower pain levels should be achieved after treatments. In connection with this, fewer medical agents should be used and functional levels must be increased earlier after medical intervention. As a result, patients will be able to return to their work and daily lives sooner.

## CONCLUSION

TENS application after operation reduced analgesic consumption, side effects (depending on the operation), and perception of pain level in the early postoperative period. TENS is therefore an effective application for side effects related to pain, analgesic consumption and medication.

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