



Effectiveness of Frequency Modulated Transcutaneous Electrical Nerve Stimulation (TENS) on Post Incision Pain Following Abdominal Surgery: A Prospective, Randomized, Placebo Controlled Study

Ajay Thakur¹, Preetham Rai² and Dhanesh KU¹

¹Nitte Institute of Physiotherapy, Nitte University, Mangalore, India-575018.

²Department of Surgery, KS Hegde Medical Academy, Nitte University, Mangalore, India-575018.

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ABSTRACT

To evaluate the effectiveness of modulated frequency transcutaneous electrical nerve stimulation (TENS) on relieving pain after abdominal surgery. The study population was those who underwent abdominal surgery. The subjects were randomly divided into two groups (treated with frequency modulated TENS and placebo TENS). Both the groups were treated with the usual analgesic routine. The subjects received the treatments for 30 minutes at every time and each subject will be assessed 5 consecutive days. Per day the subject received treatment twice daily after 4 and 8 hours of post surgery. Pain was evaluated using a standard 11-point visual analog scale (VAS) before the application of TENS and after application of TENS (24, 48, 72, 96, and 120) post operative hours. The study population comprised of 60 subjects aged between 25 to 50 years. To evaluate the effectiveness of modulated frequency VAS was measured five times and compared between the experimental and control group. There was a difference in median pain score over a period of time ($P < 0.001$) between the groups expect at base line ($P = 0.854$). This study revealed that there was a relief in pain between the subjects over a short span of time. Hence the TENS after abdominal surgery is beneficial for the subjects with abdominal surgery incision. Since, the treatment has no observable side effects, and the pain-reducing effect persisted for 5 days, it is advisable for the subjects.

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Introduction

Pain has been described as "an unpleasant experience which we associate with tissue damage or express in terms of tissue damage, or both."⁽¹⁾The International Association for the Study of Pain described pain as "An unpleasant sensory & emotional experience associated with actual or potential tissue damage, or described in terms of such damage". Transcutaneous Electrical Nerve Stimulation (T.E.N.S.) is a seemingly simple piece of therapeutic apparatus that is increasingly being used in the control and management of pain.⁽²⁾

Pain can be modified by cognitive manipulation, change of mood, or by various physical means, such as opiates, analgesics or other agents which act on the peripheral or central nervous systems. T.E.N.S. is a noninvasive technique of electrical stimulation of the peripheral nervous system. It has recently emerged as a distinct therapeutic modality in the control of both acute and chronic pain.

Transcutaneous electrical stimulation stimulates nerve fibers that send signals to the brain, which the thalamus interprets as pain. The impulses transmitted transcutaneously stimulate myelinated A fibers, which transmit proprioceptive ascendant information. These fibers are sensitive to interrupted biphasic and monophonic waves, such as those delivered by TENS. The effects of TENS follow the "Gate Theory" postulated by Melzack et al.³ in 1965, in which the superstimulation of type A fibers block the entrance of stimuli conducted by type C fibers in the gates of the gelatinous substance, the posterior horn of the spinal cord, and the transmission cells⁴.

Surgical procedures cause, inevitably, tissue damage, may it be by direct visceral manipulation, through the incision itself, and by the use of surgical retractors that help expose the surgical field. Pain after surgery causes discomfort to the patient, preventing the patient from relaxing, leading to shallow breathing, and hindering the patient's movements in bed.

Pain is an important negative influence in the postoperative evolution of abdominal surgeries, especially those in the upper abdomen, even using analgesic drugs. Transcutaneous electrical stimulation can be used in the postoperative hospital routine as adjuvant to conventional analgesia⁵.

Despite the availability of newer analgesic drugs and techniques, concerns remain regarding the side effect profiles of both opioid and nonopioid analgesic techniques. Intravenous (IV) patient-controlled analgesia (PCA) has become a widely accepted technique for the management of acute postoperative pain. However, opioid-related side effects often occur in the postoperative period, despite efforts to minimize the opioid dosage⁶. TENS can be an effective way of managing both acute and chronic pain on its own or when used in conjunction with other ways of relieving pain. TENS is said to have the advantage of being cheap, non toxic, non invasive and simple to use. TENS will not cure pain totally but it can help to reduce pain to a more acceptable level without side effects and so, making the life of patient more comfortable and easier.

The aim of this study was to determine the effectiveness of frequency modulated transcutaneous electrical stimulation (TENS) as an adjunct in decreasing patient's pain, allowing for

more effective physical therapy maneuvers in the postoperative period.

Methods:

The study was approved by Ethical committee of Nitte University, Mangalore and signed informed consent was obtained by all the patients. Sixty patients, who underwent abdominal surgery on the first postoperative day, and presented a pain score ≥ 3 on the visual analog scale (VAS), were randomly assigned to any of the 2 groups. The randomization occurred in the order, in which the patients were enrolled in the study according to the computer-generated randomization schedule prepared before commencement of the study. Before the treatment patients were explained well about TENS and the procedure. All the patients were advised that TENS treatment did not preclude the administration of analgesics. After the operation both the two groups of patients were given a standard medication using intravenous patient controlled analgesia (PCA), i.e. Tramadol.

Subjects were selected from the population group satisfying the inclusion criteria from the patients of the department of Surgery of K.S Hegde Charitable hospital, Mangalore, India.

Inclusion criteria were patients with upper abdominal surgery, Patients age 25 – 50 Years at the time of the study, Patients with post abdominal incisional pain, Pain score ≥ 3 measured by the visual analogic scale (VAS) on the first postoperative day, Both sex, Patient willingness to participate and the patients which were excluded were Cardio respiratory diseases, Patients aged above 50 Years, Hemoptysis, Abnormal skin sensation, Psychiatric illness.

TENS was given using Gem Stim combo apparatus; model GM320TE which is a battery operated TENS. To apply TENS, the type of incision was not taken into consideration.

Two sterile electrodes (first unit channel) were placed on one side of the incision and the other two electrodes (second unit channel), on the other side of incision. The electrodes were positioned 1 cm away from the suture line. The intensity was adjusted individually based on patient tolerance between 10–30 mA generating a perceptible tingling sensation without significant muscle contraction. Treatment was given for 20 minutes through 4 electrodes placed around the surgical incision twice after 4 and 8 hours after surgery. All subjects received 50 mg of Tramadol every 8 hours to control pain after surgery. Pain was assessed before the treatment i.e. before application of TENS on the first post operative day and after application of TENS 24, 48, 72, 96 and 120 post operative hours (POH_s) through a visual analogue scale (VAS).

Experimental Group: Modulated TENS

In this group 30 patients were given modulated TENS (4Hz-150Hz, Pulse width of 120 μ sec). Injectable Tramadol drug 50 mg IV, 8 hourly was given for 5 days for the management of post abdominal incisional pain.

Control Group: Control group

In this group 30 patients were given injectable Tramadol drug 50 mg IV, 8 hourly for 5 days without having intervention of TENS.

Results:

Statistical analysis was performed using IBM SPSS 21 and Medcalc 12 software's. All recorded data were taken for analysis including those of patients who were discharged.

The study population comprised of 60 subjects aged between 25 to 50 years. To evaluate the effectiveness of modulated frequency, pain score was measured five times and compared between the experimental and control group.

Table 1

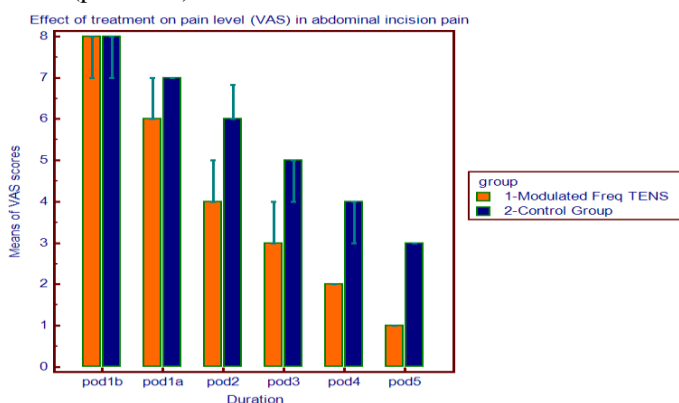
ANOVA						
		Sum of Squares	df	Mean Square	F	Sig.
POD1B	Between Groups	.017	1	.017	.034	.854
	Within Groups	28.167	58	.486		
	Total	28.183	59			
POD1	Between Groups	12.150	1	12.150	15.765	.000
	Within Groups	44.700	58	.771		
	Total	56.850	59			
POD2	Between Groups	43.350	1	43.350	51.487	.000
	Within Groups	48.833	58	.842		
	Total	92.183	59			
POD3	Between Groups	32.267	1	32.267	30.348	.000
	Within Groups	61.667	58	1.063		
	Total	93.933	59			
POD4	Between Groups	41.667	1	41.667	68.526	.000
	Within Groups	35.267	58	.608		
	Total	76.933	59			
POD5	Between Groups	54.150	1	54.150	130.681	.000
	Within Groups	24.033	58	.414		
	Total	78.183	59			

There was a difference in median pain score over a period of time ($P < 0.001$) between the groups expect at base line ($P = 0.878$).

Table 2. Mean pain scores for frequency modulated TENS and control group

Postoperative period	Group 1. Frequency Modulated TENS (n=10) Mean \pm SD	Group 2. Control Group (n=10) Mean \pm SD	P-value
POD 1 (Before TENS)	7.2 \pm 0.42	7.3 \pm 0.48	0.62
POD 1 (After TENS)	4.9 \pm 0.87	6.6 \pm 0.51	0.0001
POD 2 (After TENS)	4.1 \pm 0.87	5.6 \pm 0.51	0.0002
POD 3 (After TENS)	2.2 \pm 0.63	3.4 \pm 0.51	0.0002
POD 4 (After TENS)	1.7 \pm 0.48	3.1 \pm 0.56	0.0001
POD 5 (After TENS)	1.4 \pm 0.51	3.0 \pm 0.66	0.0001

The mean pain intensity did not differ between the groups on POD1, before he application of TENS, 7.2 \pm 0.42 for the active TENS group versus 7.3 \pm 0.48 for the control group. Following the assigned treatment, the mean score on the VAS in the active TENS group decreased significantly after TENS application compared to control group on POD1 ($p < 0.0001$), POD2 ($p < 0.0002$), POD3 ($p < 0.0002$), POD4 ($p < 0.0001$) and POD5 ($p < 0.0001$).



In the above graph when comparing the experimental and control group the differences before treatment of TENS on the 1st post operative day is compared to the 5th post operative day, there was a pain reduction on all the 5 post operative days as compared to the control group.

Discussion: Studies investigating frequency-modulated TENS are few. Ekstrom et al⁷ investigated the effect of peripheral nerve stimulation using frequencies modulating at 85 610 pps or 85620pps for 2-, 6-, or 15-second time periods. All modulated frequencies produced reductions in the C-fiber-evoked flexion reflex response. However, controlled studies on healthy participants exposed to experimentally induced pain failed to detect differences in hypalgesia between different settings of frequency-modulated interferential therapy and compared with constant-frequency interferential therapy^{8,9,10}

Desantana et al¹¹ reported that TENS alternating between 4 pps for 1 day and 100 pps for 1 day delayed opioid tolerance to repeated TENS application in rats when compared with 4 pps or 100 pps administered independently. Recently, a new TENS-like device has appeared with sequentially modulated frequency (1 to 39 Hz) and width (10 to 40ms). This frequency of rhythmic electrical modulation system has been shown to generate changes in the H-reflex amplitude over and above that seen with constant frequencies¹². The putative differential effects of constant, modulating, and alternating frequencies have been attributed to different mechanisms in the spinal cord. Wang et al¹³ re-ported that electro acupuncture that alternated between 2 pps and 100 pps, each lasting for 3 seconds, generated greater antinociceptive responses in rats than 2 pps and 100 pps applied simultaneously to the right and left hind legs, respectively.

There is some evidence that alternating (switching) frequency between preset upper and lower frequency limits affects nervous system response. Hamza et al.¹⁴ Reported that TENS alternating between 2 pps and 100 pps in a 3-second period produced greater postoperative morphine-sparing effects than either 2 pps or 100 pps frequencies alone. They used 100 women undergoing major gynecological procedures in 4 groups who were given free-access to patient-controlled analgesia (PCA) delivering 2 to 3 mg intravenous boluses of morphine with a lockout interval of 10 minutes.

The aim of this study was to investigate the effect of frequency modulated TENS on post incision pain following abdominal surgery. To this the effect of 4Hz -150Hz were investigated over a period of 5 days. Active frequency modulated TENS significantly reduced pain intensity when compared to the control group. To our knowledge, this is the first study to show the effectiveness of frequency modulated TENS in reducing pain on post incision pain following abdominal surgery.

Conclusions: This study revealed that there was a relief in pain between the subjects over a short span of time. Hence, TENS is beneficial for the subjects with abdominal surgery incision. Since, the treatment has no observable side effects, and the pain-reducing effect persisted for 5 days, it is advisable for the subjects.

References:

1. Merskey, H., Pain & Personality. In: Sternbach, R. (ED.), the psychology of pain, Raven press, New York, 1978:111-127.
2. Taylor, P., Hallet, M. and Flaherty, L., Treatment of osteoarthritis of the knee with transcutaneous electrical nerve stimulation. *Pain*, 1981; 11: 233-240.
3. Melzack R, Wall P — Pain mechanisms: a new theory. *Science*, 1965;150:971-979.
4. Robinson AJ, Snyder-Mackler L *Eletrofisiologia Clinica Eletroterapia e Teste Eletrofisiologico*, 2 ed., Porto Alegre, Artmed, 2002; 195-242.
5. Marin LI, Castro CES Estimulação elétrica nervosa transcutânea no controle da dor pos-laparotomia. Estudo preliminar. *Rev Bras Anestesiologia*, 1986; 36:207-214.
6. Baoguo Wang, Jun Tang, Paul F. White, Fanzea, Robert Naruse, Alexander Sloninsky, Robert Kariger, Julian Gold and Ronald H. Wander. Effect of the intensity of transcutaneous acupoint electrical stimulation on the postoperative analgesic requirement. *Anesth Analg*.1997; 85:406-13.
7. Ekstrom U, Sjolund BH: Is modulation the way to increase the efficacy of conventional TENS? An experimental study, in Dubner R, Gebhart G, Bond M, (eds): *Proceedings of the Vth World Congress on Pain*. Amsterdam, Elsevier Science Publishers, 1988, pp 583-589.
8. Johnson MI, Tabasam G: An investigation into the anal-gesic effects of different frequencies of the amplitude-mod-ulated wave of interferential current therapy on cold-induced pain in normal subjects. *Arch Phys Med Rehabil* 84:1387-1394, 2003.
9. Johnson MI, Tabasam G: A single-blind investigation into the hypoalgesic effects of different swing patterns of interferential currents on cold-induced pain in healthy volunteers. *Arch Phys Med Rehabil* 84:350-357, 2003.
10. Palmer ST, Martin DJ, Steedman WM, Ravey J: Alteration of interferential current and transcutaneous electrical nerve stimulation frequency: Effects on nerve excitation. *Arch Phys Med Rehabil* 80:1065-1071, 1999.
11. Desantana JM, Santana-Filho VJ, Sluka KA: Modulation between high- and low-frequency transcutaneous electric nerve stimulation delays the development of analgesic tol-erance in arthritic rats. *Arch Phys Med Rehabil* 89:754-760, 2008.
12. Barrella M, Toscano R, Goldoni M, Bevilacqua M: Frequency rhythmic electrical modulation system (FREMS) on H-reflex amplitudes in healthy subjects. *Eura Medicophys* 43:37-47, 2007
13. Wang Y, Zhang Y, Wang W, Cao Y, Han JS: Effects of syn-chronous or asynchronous electroacupuncture stimulation with low versus high frequency on spinal opioid release and tail flick nociception. *Exp Neurol* 192:156-162, 2005.
14. Hamza MA, White PF, Ahmed HE, Ghoname EA: Effect of the frequency of transcutaneous electrical nerve stimulation on the postoperative opioid analgesic requirement and recovery profile. *Anesthesiology* 91:1232-1238, 1999.