

Application of Transcutaneous Electrical Stimulation in Tinnitus Treatment

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Abstract

Aim

Tinnitus is a common auditory condition in otolaryngology practice. Subjective tinnitus is characterized by the perception of sound in the absence of an external source and is a chronic condition. (1–2) In this study, we aimed to investigate the regulatory effects of TENS in the treatment of tinnitus, where electromagnetic induction plays a significant role in the pathophysiology.

Materials and Methods

The study was conducted between September 2023 and February 2024 at the XXX Training and Research Hospital Otolaryngology clinic with 80 patients diagnosed with subjective tinnitus. TENS was applied to the patients using the device C2 paravertebral level. Patients were evaluated using the Tinnitus Handicap Inventory (THI), Beck Depression Scale-Turkish Version, and Visual Analog Scale (VAS), and the results between groups were compared. The normal distribution of data was assessed using histograms, Q-Q plots, and the Shapiro-Wilk test.

Results

The study group consisted of 18 male and 22 female patients. The control group consisted of 16 male and 24 female patients. The average age of the study group was 59, and the control group's average age was 52. VAS and THI scores showed statistically significant improvements. ($p < 0.001$, $p = 0.045$) (Table 2) There was improvement in the Beck Anxiety Scale, but it was not statistically significant. No significant improvement was observed in the Beck Depression Scale.

Conclusion

Tinnitus significantly reduces the quality of life of patients. In our study, TENS therapy has been found to be an effective and safe new treatment approach for reducing the discomfort and negative impact on daily activities caused by tinnitus.

Introduction

Tinnitus is a common auditory condition in otolaryngology practice. It is generally classified into subjective and objective tinnitus. Objective tinnitus results from muscle contractions or blood flow, while subjective tinnitus is characterized by the perception of sound in the absence of an external source and is a chronic condition. (1-2) Epidemiological studies worldwide indicate that approximately 10% to 15% of adults experience tinnitus, and about 20% of these individuals require clinical intervention. (3)

The pathophysiological mechanism of tinnitus is complex and not well-defined. Current hypotheses suggest that tinnitus is triggered by interactions between altered cochlear input and disrupted central auditory processing. (4) Another hypothesis for the etiology of tinnitus is that changes in the neural networks within both auditory and non-auditory systems may contribute to the condition.

The use of electrical currents to alter physiological responses has been known since the 1800s, and has been employed in the treatment of chronic pain, electrical stimulation of inflammation, edema, joint dysfunction, neurodegenerative diseases, cardiovascular conditions, and spinal disorders.(5-6) As pain and tinnitus are subjective symptoms that can be masked or change over time, they are considered similar conditions.(7) Transcutaneous electrical nerve stimulation (TENS) is a non-pharmacological, safe, and non-invasive neuromodulation technique.(5-8) Electrical stimulation for the treatment of tinnitus remains an intriguing therapeutic approach.

In this study, we aimed to investigate the regulatory effects of TENS in the treatment of tinnitus, where electromagnetic induction plays a significant role in the pathophysiology.

Materials and Methods

The study was conducted between September 2023 and February 2024 at the XXX Hospital Otolaryngology clinic with 80 patients diagnosed with subjective tinnitus. Inclusion criteria were patients aged between 18–75 years, with a complaint of unilateral or bilateral subjective tinnitus for more than 6 months, and those who consented to the informed volunteer consent form. This study applied the principles of the Declaration of Helsinki and local laws. Written informed consent forms were obtained from the participants included in the study. Exclusion criteria included patients with chronic otitis, Meniere's disease, a history of head trauma, oncology-related diseases, pregnant women, pacemaker users, and those with severe heart conditions. TENS was applied to the patients using the device (Intellect TENS-(E)77720 Chattanooga USA) with 2 cm² electrodes placed in the mastoid region and posterior cervical C2 paravertebral level. The stimulation was set to 20–30 Hz with a pulse duration of 180 microseconds and an amplitude intensity of 10–30 mA, producing a slight tingling sensation without discomfort. The sessions were conducted for 30 minutes, three times a week, for a total of 9 sessions over 3 weeks. The control group consisted of tinnitus patients who only received medical treatment. Patients were evaluated using the Tinnitus Handicap Inventory (THI), Beck Depression Scale-Turkish Version, and Visual Analog Scale (VAS), and the results between groups were compared. The normal distribution of data was assessed using histograms, Q-Q plots, and the Shapiro-Wilk test. For dependent data, the Wilcoxon test was used, and for independent data, the Mann-Whitney U test was used. The relationship between categorical data was evaluated using the chi-square test. A p-value < 0.05 was considered statistically significant.

Results

The study group consisted of 18 male and 22 female patients.(Table 1) The control group consisted of 16 male and 24 female patients. The average age of the study group was 59, and the control group's average age was 52. VAS and THI scores showed statistically significant improvements.($p < 0.001$, $p = 0.045$)(Table 2) There was improvement in the Beck Anxiety Scale, but it was not statistically significant. No significant improvement was observed in the Beck Depression Scale.

Table 1
Gender Distribution

Variables		Groups		p
		Control n = 40	Patient n = 40	
		n(%)	n(%)	
Gender	Male	16(40)	18(45)	0.821
	Female	24(60)	22(55)	

Table 2
VAS and THI Scores

VAS Score (pre-TENS)	Groups		p
	27.5(8–50)	38(6–49)	< 0.001
VAS Score (post-TENS)	25.5(5–50)		
THI Score (pre-TENS)	44(0-100)	57(2–96)	0.045
THI Score (post-TENS)	48(4-100)		

Discussion

Electrical stimulation for tinnitus treatment is an interesting method. TENS is one of the most important interventions in electrical stimulation. Its non-invasive nature and safety make it an increasingly preferred option among clinicians. Recent clinical studies suggest that patients with tinnitus may benefit from nerve stimulation. (5–7) It has been reported that after cochlear implantation, a decrease in tinnitus symptoms is a beneficial side effect. (8) Experimental studies partially demonstrate the therapeutic effects of TENS in alleviating tinnitus. (9) However, the exact mechanism of action for this method remains unclear, and several hypotheses exist. One hypothesis suggests that TENS reduces tinnitus by increasing cochlear blood flow. Another hypothesis posits that TENS reduces spontaneous nerve discharge in the peripheral network of the cochlea's basilar membrane through hyperpolarization induced by positive current. (10) The gate control theory suggests that non-nociceptive and nociceptive fibers from the periphery converge in the same region and that activation of non-nociceptive fibers suppresses the signals from nociceptive fibers, thereby blocking pain. (11–12) In a way, electrical stimulation through TENS may disrupt or block the nerve pathways that increase or misinterpret signals that lead to tinnitus, reducing its symptoms. This phenomenon is referred to as the neuromodulatory

effect of TENS. Another theory is that electrical stimulation of the C2 dermatome increases the activation of the dorsal cochlear nucleus, which provides inhibition on the central nervous system's somatosynchronous pathway, potentially reducing tinnitus. (13) Therefore, suppression of tinnitus through electrical stimulation from various regions within the mastoid, eardrum, and cochlea has been clinically tested since the 1960s and 1970s. (14–15) These applications have often been directed at the C2 dermatome or areas of the vagus nerve close to the ear. (6,16) In our study, we applied TENS treatment to the C2 dermatome over 9 sessions.

Various parameters and questionnaires have been adapted for evaluating tinnitus. One of the most widely used is the Tinnitus Handicap Inventory (THI), a reliable tool to assess tinnitus severity and quality of life. (11) THI provides specific results based on gender, age, and hearing loss, making it easy to apply and providing more specific psychometric measurements. Additionally, it is beneficial for tracking symptom changes before and after treatment. The Visual Analog Scale (VAS) evaluates tinnitus based on four parameters: duration, pitch, discomfort, and interference with daily activities. Aydoğan et al., in their study on the effectiveness of TENS therapy for tinnitus, reported improvements in both THI and VAS scores. (17) Similarly, Rattan et al. reported significant improvement in Tinnitus THI and VAS subscales in their study involving 60 patients with chronic subjective tinnitus. (18) Another study on 60 patients also reported a significant decrease in THI scores after treatment. (11) In our study, significant improvements were observed in THI scores after TENS therapy. THI and VAS have been identified as reliable methods for evaluating the effectiveness of TENS treatment. In our study, both THI and VAS scores showed significant improvements post-treatment ($p=0.045$, $p < 0.001$).

There is no single cause for depression or anxiety, and it is generally accepted that multiple factors, including biological, psychosocial, and environmental factors, contribute to these disorders. Tinnitus can significantly trigger and maintain these conditions. (19) Emotional abnormalities such as hearing loss, anxiety, social withdrawal, sleep disturbances, and depression often accompany tinnitus, leading to a significant impact on quality of life. Literature reports that between 24–28% of tinnitus patients experience anxiety disorders, and 17-39.5% experience moderate-to-severe depressive symptoms. (20–24) Various treatments, including antidepressants, auditory training, sound enrichment therapy, transcranial magnetic stimulation, and acupuncture, have been investigated for tinnitus. Beck's Anxiety and Depression Scales are important methods for measuring anxiety and depression in tinnitus patients. Kehrle et al. observed high values in Beck Anxiety and Depression Scale scores in their study. (25) Their research emphasized the role of cognitive dysfunction in the perception and interpretation of tinnitus. It has been suggested that hyperactivity of the dorsal cochlear nucleus secondary to cochlear damage may activate the locus coeruleus, leading to anxiety. (26) Kreuzer et al. reported no significant improvement in their study on tinnitus patients after TENS therapy in the multiple test evaluation, but they observed a significant improvement in the Beck Depression Scale. (15) In our study, we found improvement in Beck Anxiety Scale scores after TENS therapy, though it was not statistically significant. No improvement was found in the Beck Depression Scale scores.

Several limitations exist in our study. If a placebo TENS had been applied to the control group, we could have more clearly interpreted the reliability of the results and whether TENS has a true physiological effect. Additionally, the small sample size may have affected the results of our study. Furthermore, the treatment duration of three weeks may be considered short for evaluating the effectiveness of TENS. More sessions and an extended treatment duration could yield more meaningful results for chronic tinnitus.

Conclusion

Tinnitus significantly reduces the quality of life of patients. In our study, TENS therapy has been found to be an effective and safe new treatment approach for reducing the discomfort and negative impact on daily activities caused by tinnitus.

Declarations

Statement of Ethics

Study approval statement: Ethical approval was obtained from XXXUniversity before the study.(date 22/02/2023 number 3-03)Informed consent forms were obtained from all patients before the study.

Consent to participate statement: This study applied the principles of the Declaration of Helsinki and local laws. Written informed consent forms were obtained from the participants included in the study.

Conflict of Interest Statement:There is no conflict of interest in this study.

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Data availability:

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

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