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CONTENT

The Appendix

The Faculty of Electrical Engineering at Goce Delcev University (UGD), has organized the Second International Conference Electrical Engineering, Informatics, Machinery and Automation - Technical Sciences Applied in Economy, Education and Industry-ETIMA on September, 27th-29th 2023.

ETIMA has a goal to gather scientists, professors, experts, and professionals from the field of technical sciences in one place as a forum for exchanging ideas, strengthening multidisciplinary research and cooperation, and promoting the achievements of technology and its impact on every aspect of living. Conference ETIMA was held as an online conference. More than sixty colleagues contributed to this event, from five different countries with more than thirty papers.

The Organizing Committee selected five papers that will be published in this number of the BJAMI.

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TRANSCUTANEOUS ELECTRICAL NERVE STIMULATION METHOD IN PATIENTS WITH XEROSTOMIA

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Abstract. Patients with salivary gland hypofunction typically complain of dry mouth, difficulty chewing, swallowing and/or speaking; they hardly tolerate spicy, acidic, and crunchy food and often report taste changes or difficulty wearing dentures. It can also increase the chance of developing dental decay, demineralization of teeth, tooth sensitivity, and oral infections. The goals of treating xerostomia include identifying possible causes, relieving discomfort, and preventing complications. In this study, we investigate the most effective frequency to increase salivary secretion, without side effects on the skin and orofacial structures. Transcutaneous electric nerve stimulation (TENS) is a simple, inexpensive, and non-invasive modality that uses electric current to activate nerves for therapeutic reasons. It is a non-pharmacological method of pain management for which it is widely used. The application of electric impulses to one or more of the three components of the salivary reflex arch should theoretically improve salivary secretion and lessen the various long-term effects of hyposalivation. For this study a total of 23 published studies in the last 10 years were analyzed. The study is made on narrative review of the published articles that go into the related subject, evaluation of the impact of a transcutaneous electrical nerve stimulation (TENS) system on patients' dry mouth and salivary flow rates. The TENS unit was effective in increasing the quantity of stimulated saliva and was also found to be more effective in increasing saliva in diabetic individuals. From the results of the study, it can be concluded that TENS was effective in increasing the salivary flow rate in hyposalivatory patients with residual saliva.

1. Introduction

Xerostomia is the result of a decrease in the volume of saliva secreted because of the salivary gland hypofunction. If this is present all or most of the time, then it can be uncomfortable and also indicate health problems and, as a result, it should be brought to the attention of a health care professional [1]. Saliva is secreted by salivary glands and has multiple proteins and enzymes. The saliva flow rate and pH are very important for the maintenance of oral tissues and overall health. Causes of dry mouth can include toxicity from chemotherapy, adverse effects of medications, autoimmune disease, or other conditions (e.g., uncontrolled diabetes, infections, hormonal changes). Xerostomia occurs commonly in those with Sjögren disease or those receiving radiation therapy for head and neck cancer [2]. The flow of nonstimulated saliva in humans varies between 0.25 and 0.90 ml/min with a mean of approximately 0.4 ml/min. It is the result of the secretion of different glands in different proportions: 20% from parotid glands, 65% from submandibular glands, 7% to 8% from sublingual glands, and less than 10% from

Keywords. Salivary glands, xerostomia, saliva flow rate, dry mouth therapy, TENS, hyposalivation treatment.

numerous minor glands. However, given different stimuli (visual, olfactory, or gustatory) or parasympathetic activity, saliva flow increases, and in this case, more than 50% of the total secretion is due to parotid glands. The clinical features are very variable and reflect the differing functions of the saliva. Patients with a salivary gland hypofunction typically complain of dry mouth, difficulty chewing, swallowing and/or speaking; they hardly tolerate spicy, acidic, and crunchy food and often report taste changes or difficulty wearing dentures [3], [4]. It can also increase the chance of developing dental decay, demineralization of teeth, tooth sensitivity, and oral infections. Salivary gland dysfunction is associated with a number of oral problems but also with more generalized problems. Indeed, SGD is associated with a significant negative impact on the quality of life. The goals of treating xerostomia include identifying possible causes, relieving discomfort, and preventing complications Xerostomia may be alleviated by the use of saliva substitutes and other palliative measures; lifestyle tips (chewing sugar-free gum) and other dental and oral health specific recommendations (brushing teeth gently at least twice a day with fluoridated toothpaste) may help provide relief from or prevent adverse sequelae of dry mouth. The treatment for hyposalivation consists of a combination of general measures for good oral hygiene with salivary substitutes. It is recommended to increase the intake of water, lubrication of the mucosa and lips, and avoid toxic habits, tobacco, alcohol, and the intake of irritating foods. Among general measures that must be considered is the control of systemic diseases, among the most important of which are Sjogren's syndrome, and the side effects produced by radiotherapy and drugs used in the treatment of head and neck cancer. It is important to consider the psychological factors that are increasingly common in the onset of xerostomia, especially chronic anxiety and excessive stress. Transcutaneous electric nerve stimulation (TENS) is a simple, inexpensive, and non-invasive modality that uses electric current to activate nerves for therapeutic reasons. It is a non-pharmacological method of pain management for which it is widely used [4], [5]. TENS is a method of electrical stimulation which primarily aims to provide a degree of symptomatic pain relief by exciting sensory nerves. TENS was majorly concentrated on pain, but few clinical trials have been conducted to identify the effect of electrical nerve stimulation on salivary flow. As the controversy between the articles existed, this study was done to determine the efficacy of TENS on the salivary flow rate in relation to both gender and age including healthy adult, non-diabetic, as well as diabetic individuals since diabetes is one of the diseases that affect salivary secretions leading to hyposalivation. The application of electric impulses to one or more of the three components of the salivary reflex arch should theoretically improve salivary secretion and lessen the various long-term effects of hyposalivation [6], [7].

Aim: To evaluate the impact of a transcutaneous electrical nerve stimulation (TENS) system on patients' dry mouth and salivary flow rates.

2. Material and method

For this study a total of 23 published studies in the last 10 years were analyzed. The study is made on narrative review of published articles that go into the related subject, evaluation of the impact of a transcutaneous electrical nerve stimulation (TENS) system on patients' dry mouth and salivary flow rates, written in English. Research was done by using the most common databases: NCBI (US National Library of Medicine), PubMEd, Webmd and Google scholar. The key words that were used for this research were the following: salivary glands, xerostomia, saliva flow rate, dry mouth therapy, TENS, hyposalivation treatment. The search included: systematic reviews, qualitative studies, and clinical studies. This study was made online by selecting the articles that contained the research key words, and then the articles that met the needed criteria were selected and analyzed in detail. So, from the total number of 35 studies that were initially found, 23 were selected for detailed analysis about the researched topic. The inclusion criteria for the articles analyzed for this study were: studies made in vivo; articles published in the last 10 years; articles that are written in English; studies on patients with hyposalivation; studies evaluating the TENS method. The exclusion criteria were studies done in vitro; articles older than 15 years; case report articles; articles about patients with salivary gland surgery. The collected data was gathered in a database in the order of these parameters: first the author's name; the year when the article was published; the number of analyzed cases; the treatment technique; and the clinical outcome after the TENS.

This paper represents a literature review survey regarding the main research topics where the authors compare and contrast different studies or ongoing research in the field of electrostimulation.

3. Evaluation and results

Other alternative options for xerostomia treatment were tried on some patients, such as the appliances for intraoral electrostimulation, that have shown good results and satisfaction in the treated patients, with increasing the volume of the secreted saliva [8]. Of intraoral appliances, the most often used were the saliva stimulation device Saliwell Crown and the electrostimulating device GenNarino, that has given very satisfying results for the xerostomia treatment. This study presents the development of a new tool to be validated in patients with salivary hypofunction. In this study, we investigate the most effective frequency to increase salivary secretion, without side effects on the skin and orofacial structures [9]. Physiological conditions such as circadian rhythms, heat, or stress affect salivary flow, which can also be reduced pathologically in various circumstances such as after the use of drugs, head and neck radiotherapy, neurological damage, and metabolic or immunological diseases as the Sjögren's syndrome [10]. The use of neuro-electro-stimulation as a tool is aimed at stimulating the residual functional parenchyma of the glands and is a new effective proposal for non-nonpharmacological treatment of oral

dryness. They base their operation on electrical stimulation [11], [12]. Novel approaches for treating xerostomia are being investigated, including acupuncture and transcutaneous electric nerve stimulation (TENS), (Figure 1).

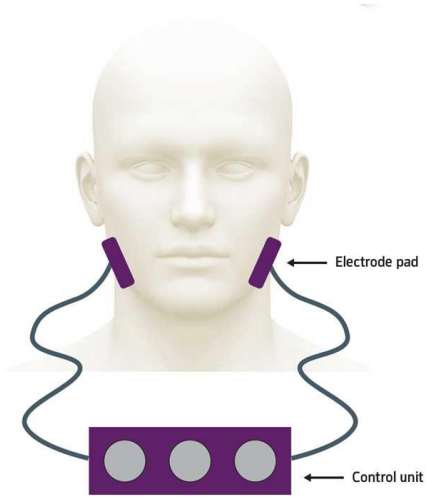

Figure.1 *Illustrative presentation of the use of a TENS, to stimulate parotid glands by placing a pair of pads containing electrodes*
Source: https://www.dentaltown.com/magazine/article/7456/electrostimulation-and-xerostomia

The use of neuro-electrostimulation as a tool is aimed at stimulating the residual functional parenchyma of the glands and is a new effective proposal for nonpharmacological treatment of oral dryness The first attempt to exploit neurostimulation to increase salivary secretion was made in the USA, through the design and commercialization of the Salitron device (Biosonics, Fort Washington, PA, USA) [13]. The device gave promising results without local or systemic adverse effects The TENS unit was effective in increasing the quantity of the stimulated saliva and TENS was also found to be more effective in increasing saliva in diabetic individuals [14]. The mean unstimulated salivary rate was 1.64ml/5min and the mean stimulated salivary rate was 1.914ml/5min.

The TENS is a battery-operated device that delivers an electric current administered across the surface of the skin through electrodes (Bertolucci and Didario, 1995), (Figure 2). A standard TENS device generates a pulse current in a repetitive manner with a pulse duration between 50 microseconds and 1000 microseconds, and pulse frequencies between 1 and 250 pulses per second (pps) (Johnson, 2001).

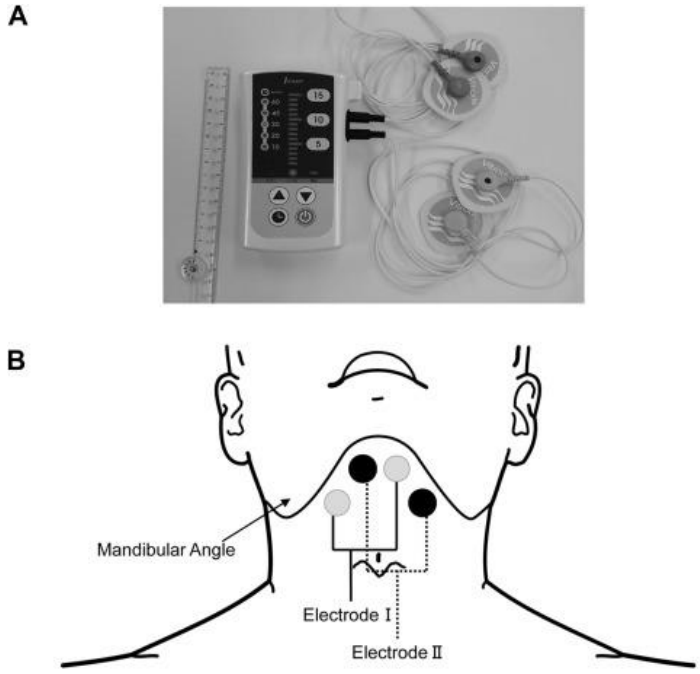

Figure. 2 *A) Device for TENS B) Possible positions of placing electrodes*
Source: https: //pubmed.ncbi.nlm.nih.gov/27017403/

The treatment dosage is determined by the frequency, intensity, mode, duration (minutes), and length of treatments (days/weeks) [15]. Some of the side effects of the TENS therapy included twitching of the musculature and anesthesia of the skin; however, these effects ceased once the TENS unit was turned off (Hargitai *et al*., 2005). TENS has been used for managing symptoms such as pain, postoperative pulmonary function, and physical performance outcomes (Cheing and Hui -Chan, 2004; Jahangirifard *et al*., 2018; Johnson, 2017; Li and Song, 2017). These studies provide a variety of application protocols for TENS in the management of different symptoms [16]. Unfortunately, no study has examined if TENS could produce better outcomes on the salivary flow rate for hemodialysis patients. Hargitai *et al*. (2005), and Wong *et al*. (2003) studied the effects of TENS respectively on healthy adults and on patients with symptomatic xerostomia after radical radiotherapy but with evidence of residual salivary function [17]. The results showed that the participants demonstrated significantly increased salivary flow rates. It is possible that TENS stimulated the auriculotemporal nerve that supplies secretomotor drive to the parotid gland (Hargitai *et al*., 2005). Therefore, the purpose of this study was to apply TENS to stimulate acupoints, thereby increasing salivary flow rates and reducing dry mouth intensity [18].

Transcutaneous electric nerve stimulation (TENS) is a simple, inexpensive, and non-invasive modality that uses electric current to activate nerves for therapeutic reasons. Earlier, TENS was majorly concentrated on pain, but few clinical trials have been

conducted to identify the effect of electrical nerve stimulation on salivary flow [19]. As the controversy between the articles existed, this study was done to determine the efficacy of TENS on salivary flow rate in relation to both gender and age including healthy adult, non-diabetic, as well as diabetic individuals since diabetes is one of the diseases that affect salivary secretions leading to hyposalivation. Studies carried out by Bhasin *et al.* reported that 96 out of 100 individuals responded positively to TENS therapy [20]. Moreover, in the study conducted by Hargitai et al, it was stated that 15 out of 22 healthy adult individuals also showed a significant increase in the stimulated salivary flow [21]. In the study by Manoj Kumar *et al.*, 62 out of 80 individuals showed an increase in saliva and in the study conducted by Aggarwal *et al.*, 65 out of 80 individuals showed an increase in the salivary flow rate after stimulation by TENS. Bhasin *et al.* conducted a study on 100 individuals of the age range of 20-69 years and they excluded individuals with systemic diseases and salivary gland disorders. They divided the participants into 5 groups of 20 each. TENS was activated for 5 minutes, then after 30 minutes and after 24 hours. An increase in saliva was seen by 38.46% post-stimulation. Hargitai *et al.* conducted the study on 22 healthy adult individuals with no salivary gland disorders. TENS was used for salivary stimulation and collected after 5minutes; two-thirds of individuals showed an increase post application of TENS. Aggarwal *et al.* conducted the study on 80 healthy individuals, out of which 40 were male and 40 female [22]. They were in the age range of 20-50 years. Individuals having salivary gland pathologies, systemic diseases, and radiation therapy in the head and neck regions were excluded from their study. Saliva was collected by low forced spitting for 5 minutes with and without TENS application and 65 individuals showed an increase in salivary stimulation. In another study, in the age group 20-40 years, the mean unstimulated saliva was 1.64 ml/5min, which increased to 1.91ml/5min post-stimulation [23]. This data was consistent with the study conducted by Bhasin *et al.* and Singla *et al.* where they also noticed an increase in the saliva after stimulation by TENS.

4. Conclusion

It seems that TENS has shown positive results in increasing salivary secretions and salivary values may diminish with age; therefore, TENS might be used in aged individuals as well as in diabetic patients to increase the quantity of saliva. From the results of the study, it can be concluded that TENS was effective in increasing the salivary flow rate in hyposalivatory patients with residual saliva. TENS was less effective in patients who are under xerogenic drugs. Thus, TENS may be an ever-growing armamentarium in the management of the salivary gland hypofunction when other therapies have failed or are contraindicated.

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