

Effectiveness Of Transcutaneous Electrical Nerve Stimulation On Salivary Flow Rate In Patients With Xerostomia

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Abstract

Background: Xerostomia, or dry mouth, is a prevalent condition associated with systemic diseases, medications, and head and neck radiotherapy. It adversely affects oral health and quality of life. Transcutaneous electrical nerve stimulation (TENS) has emerged as a potential non-pharmacological approach for stimulating salivary secretion.

Objective: To evaluate the effectiveness of TENS in enhancing salivary flow among patients with xerostomia compared with age- and sex-matched healthy controls.

Methods: A quasi-experimental study was conducted among 50 participants (25 xerostomia patients and 25 healthy controls) at a tertiary dental care centre in South India. Xerostomia was confirmed by a mirror-stick test and unstimulated salivary flow ≤ 0.5 mL/5 min. Saliva was collected at baseline, immediately after TENS, and on the fifth day. TENS was applied bilaterally over the parotid region for 15 minutes at 20–50 Hz. Flow rates were compared using paired and independent t-tests, and repeated measures ANOVA.

Results: Baseline salivary flow was significantly lower in xerostomia patients (0.54 mL/min) than controls (1.21 mL/min). Post-TENS, flow increased to 0.78 mL/min and 1.43 mL/min, respectively ($p = 0.001$). On day 5, salivary flow remained above baseline in both groups. Relative improvement was greater in xerostomia patients.

Conclusion: TENS significantly improved salivary flow in both xerostomia patients and healthy controls, with proportionally greater benefits in xerostomia. It may serve as a safe, non-invasive adjunct for xerostomia management.

Keywords: Xerostomia; Transcutaneous electrical nerve stimulation; Salivary flow; Electrotherapy; Non-pharmacological therapy

INTRODUCTION:

Xerostomia, or the subjective sensation of oral dryness, is a prevalent condition often resulting from reduced salivary secretion. It can significantly impair oral health and quality of life, leading to difficulties in speaking, swallowing, and taste perception, as well as dental caries, periodontal disease, and oral candidiasis^[1–3]. The condition may arise due to systemic diseases such as diabetes mellitus, autoimmune disorders like Sjögren's syndrome, head and neck radiotherapy, and the use of multiple medications, including antihypertensives, antidepressants, and anticholinergics^[2–5].

Conventional pharmacological management relies on systemic sialogogues such as pilocarpine and cevimeline. While effective stimulation of salivary secretion in clinical application is limited by systemic side effects, contraindications in patients with comorbidities, and poor accessibility in many settings^[2,5]. Saliva substitutes, gels, and mouth rinses may provide temporary symptomatic relief but do not restore glandular function or improve long-term outcomes^[2].

Non-pharmacological approaches are increasingly being investigated as safer and more sustainable alternatives. Among these, transcutaneous electrical nerve stimulation (TENS) has emerged as a promising method. TENS delivers pulsed electrical currents through surface electrodes placed over the parotid region, stimulating the auriculotemporal nerve and subsequently activating parasympathetic pathways to enhance salivary secretion^[6–8]. Clinical studies have demonstrated a significant increase in salivary flow rates in both xerostomia patients and

healthy adults following TENS therapy ^[1,9-11]. Furthermore, studies on patients with Sjögren's syndrome and radiation-induced xerostomia support the potential of neuro-electrostimulation in restoring salivary gland function ^[9,12,13].

Despite reassuring results, existing studies vary in design, sample size, and methodology, making it difficult to establish standardized protocols. Therefore, the present study was designed to evaluate the effectiveness of TENS in stimulating salivary flow in patients with xerostomia and to compare the outcomes with those in age- and sex-matched healthy controls.

MATERIALS AND METHODS

Study Design and Setting

This was a quasi-experimental study conducted in the Department of Oral Medicine and Radiology, Mahatma Gandhi Post Graduate Institute of Dental Sciences, between April 2024 to December 2024. The objective was to evaluate the effectiveness of transcutaneous electrical nerve stimulation (TENS) in stimulating salivary flow among patients with xerostomia, using age- and sex-matched healthy volunteers as a comparison group.

Participants

A total of 50 individuals were enrolled, comprising 25 patients with xerostomia (Group I) and 25 healthy volunteers (Group II). Patients with xerostomia were recruited consecutively from the outpatient department, while healthy volunteers were selected from among attendants and staff members. Matching for age and sex was carried out to minimize confounding.

The inclusion criteria for Group I were adults aged 18–70 years with xerostomia confirmed by a positive mirror-stick test and an unstimulated salivary flow rate ≤ 0.5 mL over five minutes. Xerostomia attributable to autoimmune salivary gland disorders, medication-induced causes, diabetes mellitus, psychogenic conditions, or prior head and neck radiotherapy was considered eligible. Group II comprised age- and sex-matched healthy individuals without complaints of oral dryness and with unstimulated salivary flow >0.5 mL over five minutes.

Exclusion criteria for both groups included the presence of cardiac pacemakers, current use of sialogogues, pregnancy, a history of salivary gland aplasia or parotidectomy, and obstructive salivary gland disorders such as strictures or stenosis.

Armamentarium

The materials used in this study included a portable transcutaneous electrical nerve stimulation (TENS) unit (Figure 1), sterile surgical gloves, and a graduated measuring flask for saliva collection (Figure 2).

Saliva Collection

All participants were instructed to refrain from eating, drinking, chewing gum, smoking, or performing oral hygiene procedures for at least one hour prior to sample collection. To minimize circadian variability, all procedures were carried out during morning hours.

For baseline collection, participants were seated in an upright position with the head slightly inclined forward. They were asked to swallow once, allow saliva to accumulate passively in the floor of the mouth, and expectorate into a sterile graduated test tube using the “low forced spitting” method for a duration of five minutes.

Following this, surface electrode pads of the TENS unit were placed bilaterally over the parotid gland region (anteroposteriorly between the tragus and mid-masseter, and superoinferiorly between the condylar head and mandibular border). The device was activated at a frequency of 20–50 Hz with a fixed pulse duration of 250 μ s. The intensity was gradually increased to the maximum tolerable level for each participant and maintained for 15 minutes. Stimulated saliva was then collected for five minutes in a separate sterile graduated test tube using the same technique.

To evaluate the sustained effect of therapy, unstimulated saliva was collected once again on the fifth day after TENS application using the same protocol as baseline collection.

Outcome Measures

The primary outcome was the salivary flow rate, expressed in milliliters per minute (mL/min). Comparisons were made within each group (pre- vs post-TENS; baseline vs five-day follow-up) and between groups (xerostomia patients vs healthy controls).

Ethical Considerations

The study protocol was reviewed and approved by the Institutional Ethics Committee (No.417/MGPGIDS/IEC/2024/MDS/No.24/2024). Written informed consent was obtained from all participants before enrolment.

Statistical Analysis

Data were entered in Microsoft Excel (Microsoft Corp., Redmond, WA, USA) and analyzed using IBM SPSS Statistics version [XX] (IBM Corp., Armonk, NY, USA). The Shapiro–Wilk test was used to assess the normality of distribution. Within-group comparisons of salivary flow before and after TENS, as well as between baseline and five-day follow-up, were analyzed using the paired t-test. Between-group comparisons were performed using the independent t-test. Repeated measures across baseline, post-TENS, and day 5 follow-up were evaluated using repeated measures analysis of variance (ANOVA) with Bonferroni post-hoc correction. A p-value <0.05 was considered statistically significant.

RESULTS

A total of 50 participants were enrolled, including 25 patients with xerostomia and 25 age- and sex-matched healthy controls. The mean (standard deviation) age was 48.2 (11.6) years in the xerostomia group and 47.8 (12.1) years in the control group. Overall, 24 (48.0%) participants were male and 26 (52.0%) were female. The age and sex distribution is shown in **Table 1**.

Among the 25 patients with xerostomia, drug-induced causes accounted for 7 (28.0%), autoimmune disorders for 6 (24.0%), diabetes mellitus for 5 (20.0%), radiation therapy for 4 (16.0%), and psychogenic causes for 3 (12.0%). The etiological profile of xerostomia patients is shown in **Table 2**.

Table 3 presents the baseline and post-stimulation salivary flow rates at the first appointment. The mean unstimulated flow rate was 1.2080 mL/min in the healthy group and 0.5368 mL/min in the xerostomia group. Following TENS stimulation, both groups demonstrated statistically significant increases in salivary flow, reaching 1.4328 mL/min in healthy individuals and 0.7808 mL/min in xerostomia patients ($p = 0.001$ for both comparisons).

On the fifth day, mean salivary flow remained higher than baseline in both groups (**Table 4**). In healthy individuals, salivary flow increased from 1.2080 mL/min to 1.3760 mL/min, while in xerostomia patients it rose from 0.5368 mL/min to 0.9232 mL/min ($p = 0.001$ for both). Although absolute salivary flow was greater in healthy participants, the relative improvement was more pronounced in the xerostomia group, despite their lower baseline values.

Table 1. Sociodemographic characteristics of study participants (N = 50).

Characteristics	Xerostomia group (n = 25)	Healthy group (n = 25)	Total (N = 50)
Age groups (years)			
<30	4 (16.0)	4 (16.0)	8 (16.0)
30–39	6 (24.0)	7 (28.0)	13 (26.0)
40–49	9 (36.0)	9 (36.0)	18 (36.0)
≥50	6 (24.0)	5 (20.0)	11 (22.0)
Sex			
Male, n (%)	12 (48.0)	12 (48.0)	24 (48.0)
Female, n (%)	13 (52.0)	13 (52.0)	26 (52.0)

Table 2: Etiological distribution of xerostomia among patients (n = 25)

Etiology of xerostomia	n (%)
Autoimmune disorders	6 (24.0)
Drug-induced	7 (28.0)
Diabetes mellitus	5 (20.0)
Radiation therapy	4 (16.0)
Psychogenic	3 (12.0)

Table 3. Mean unstimulated (pre-TENS) and stimulated (post-TENS) salivary flow rates at first appointment in healthy and xerostomia patients (N = 50).

Group	Pre-TENS (mL/min)	Post-TENS (mL/min)	p-value
Healthy (n = 25)	1.2080	1.4328	0.001
Xerostomia (n = 25)	0.5368	0.7808	0.001

Table 4. Mean salivary flow rate at baseline and after five days of TENS stimulation in healthy and xerostomia patients (N = 50).

Group	Baseline (mL/min)	After 5 days (mL/min)	p-value
Healthy (n = 25)	1.2080	1.3760	0.001
Xerostomia (n = 25)	0.5368	0.9232	0.001

DISCUSSION:

Salivary flow increased significantly after TENS therapy in both xerostomia and healthy participants. The relative improvement was greater among xerostomia patients despite their lower baseline values. Similar findings were reported by Chandra et al., who showed significant increases in salivary flow with TENS among xerostomia patients ^[1]. Dyasnoor et al. also observed enhanced salivary flow in individuals with diabetes mellitus, supporting its wider applicability ^[14].

The improvement in salivary flow is likely mediated by stimulation of parasympathetic fibers of the auriculotemporal nerve, enhancing residual acinar cell activity. Lakshman et al. demonstrated that patients with radiation-induced xerostomia also responded favorably to TENS, emphasizing the role of preserved gland function in determining treatment outcomes ^[9]. Ramadoss et al. more recently demonstrated that a novel low-level TENS device significantly improved salivary flow in older adults with oral dryness and also enhanced certain biochemical properties of saliva, such as antioxidant activity ^[15].

Although healthy individuals had higher absolute flow rates, xerostomia patients showed proportionally greater gains. This observation is consistent with Bhasin et al., who found that repeated TENS therapy sustained salivary output over time ^[10]. A recent systematic review highlighted that non-pharmacological interventions, including electrostimulation, remain feasible and safe options for managing post-radiotherapy xerostomia, with several studies reporting significant improvements ^[16].

Other non-pharmacological approaches such as photobiomodulation, salivary gland massage, and acupuncture have shown variable results. Sharifnia et al. conducted a network meta-analysis in hemodialysis patients and reported that TENS was among the most effective non-pharmacological interventions for improving unstimulated salivary flow ^[17]. Recent reviews have emphasized that cancer treatment-related xerostomia requires multimodal management, with TENS highlighted as one of several promising non-pharmacological approaches ^[18].

The strengths of this study include the use of matched controls, objective measurement of salivary flow, and evaluation of both immediate and short-term effects. However, its quasi-experimental design without randomization, modest sample size, and lack of symptom-based outcomes limit generalizability. These findings echo the concerns raised by Villa et al., who emphasized the importance of combining patient-reported measures with objective salivary data in xerostomia research ^[2].

Despite these limitations, our findings contribute to existing evidence on the potential of TENS for stimulating salivary flow in xerostomia. By demonstrating both immediate and short-term improvements, the study highlights the relevance of electrostimulation in clinical practice and provides a basis for further hypothesis-driven trials.

CONCLUSION:

TENS therapy significantly improved salivary flow in both healthy individuals and patients with xerostomia, with proportionally greater benefits in the latter. These results suggest that TENS can serve as a practical and non-invasive adjunct in the management of xerostomia.

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