

1                    **EFFICACY OF TRANSCUTANEOUS ELECTRICAL NERVE STIMULATION ON WHOLE**  
2                    **SALIVARY FLOW RATE- A CLINICAL STUDY**

3                    **ABSTRACT**

4                    **Aim:** To evaluate the efficacy of transcutaneous electrical nerve stimulation (TENS) over the whole salivary  
5                    flow rate in normal healthy adults. **Materials and methods:** 20 healthy adults were included in this study with  
6                    no salivary gland pathology. Saliva before tens therapy was collected for each patient in a plastic container on  
7                    each minute one split basis for about 5 minutes. The tens electrode pads were placed on the skin over the  
8                    parotid gland on both sides. Post therapy salivary collection done by the above same basis. **Statistics used:**  
9                    Paired 't' test used to compare unstimulated and stimulated whole salivary flow rate. P value is 0.03 and hence  
10                    results are statistically significant. **Results:** Out of 20 patients, 19 patients have been observed with increased  
11                    salivary flow post tens therapy. **Conclusion:** TENS acts as a valuable device in increasing salivary flow rate  
12                    and can be used in all cases of xerostomia and hyposalivation to increase the salivary flow.

13                    **Key words:** TENS, saliva, salivary flow

14                    **INTRODUCTION**

15                    **Saliva** is an important fluid required to maintain normal oral health. There are three major salivary glands  
16                    (parotid, sub-mandibular and sub-lingual gland) and many minor salivary glands that produces 1.2 to 1.5 litre of  
17                    saliva into the oral cavity.<sup>1</sup> The functions of saliva in oral cavity are digestion, speech, mastication, caries  
18                    prevention, immune function, defensive function and nutrition. Xerostomia is a clinical condition characterized  
19                    by decrease in the amount of saliva in oral cavity. Some doctors restrict the use of the term xerostomia to refer  
20                    to a subjective complaint or oral dryness, and use the term hyposalivation to describe an objective decrease in  
21                    volume. There are various causes of salivary hypofunction, some are systemic diseases, prescription/non-  
22                    prescription medications, chemotherapy, and head-neck radiotherapy. The methods of treating patients with  
23                    xerostomia is aimed as a palliative treatment for the relief of symptoms as well as prevention of oral  
24                    complications. It includes topical agents such as saliva substitutes, increased water intake, application of lip

25 balm, chewing sugar-free gums, sucking sour lemon drops, paraffin containing lozenges and rinses.<sup>2</sup> Patients  
26 need to be advised to avoid mouth breathing, smoking, carbonated beverages, alcohol-based drinks and  
27 mouthwashes, and to change or discontinue drugs causing dry mouth.

28  
29 **Transcutaneous electrical nerve stimulation (TENS)** is a well-known physiotherapy unit, which is useful in  
30 various orofacial pain relief. Electro-stimulation to produce saliva has been studied in the past and the results  
31 were encouraging.<sup>3</sup> Transcutaneous electrical nerve stimulation (TENS) consists of application of low  
32 frequency, pulsed electrical currents. These electrical currents are transmitted via surface electrode pads placed  
33 on the skin surface. They potentially initiate the peripheral nerves to produce various physiological effects. The  
34 first TENS units were developed in the year 1965 by Melzack and Wall.<sup>4</sup> Since 1965, TENS is considered to be  
35 one of the most common therapeutic resources used in clinical practice for the relief of chronic and acute pain.  
36 In recent times, many researchers have observed that in addition to the analgesic effects of TENS, it may also  
37 be used to increase salivary flow by stimulating the peripheral nerves that reaches the salivary glands. By  
38 having this idea, the present study was undertaken to evaluate the efficacy of TENS on whole salivary flow rate  
39 in healthy adult subjects and to compare the whole salivary flow rate between unstimulated saliva before TENS  
40 and stimulated saliva after TENS.<sup>5</sup>

#### 41 **MATERIALS AND METHODS**

42 Twenty healthy adults who visited the Department of Oral Medicine and Radiology in the period  
43 of July 2019-September 2019 with no history of salivary gland pathology were included in this clinical study.  
44 Written informed consent was obtained before the start of study from all the participants. Ethical clearance  
45 approval for the study is obtained from the institutional review board members. Inclusion criteria were normal  
46 patients without any underlying systemic diseases and local diseases of salivary gland that may affect the normal  
47 salivary outflow. Age group will be within 20-40 irrespective of sex. Informed consent was obtained from the  
48 patient prior to the study.

49 Exclusion criteria were patients with history of salivary gland pathology, patients wearing active  
50 pacemakers, hearing aids, cochlear implants, patients suffering from systemic diseases or conditions, patients  
51 currently taking medications for any conditions, those with a history of radiation to the head and neck region,  
52 patients with a history of psychiatric disorders and pregnant women, patients having tobacco and pan chewing  
53 habits. All the patients were explained the details of the procedure and were informed to refrain from eating,  
54 drinking alcohol, chewing gum, smoking, and oral hygiene procedures for at least 1 hour prior to the  
55 appointment.

56 The subjects were made to sit in an upright position, with the head inclined slightly forward.  
57 They were asked to swallow saliva first and then instructed to stay motionless, so that the saliva would collect  
58 passively in the anterior region of the floor of the mouth. Patient were asked to split the whole saliva into the  
59 ependorff vial for each minute for about five minutes (5 splits). After 5 minutes the whole unstimulated saliva  
60 level in the vial is noted. Then, the surface electrode pads were placed externally on the skin, overlying the  
61 parotid glands, with the TENS unit in the 'off' position. The unit was preset at a frequency of 100 Hz and a  
62 pulse width of 100-150 $\mu$ s. After a gap of about two minutes the TENS unit was activated and the amplitude was  
63 gradually increased to a maximum tolerable level of patient. Once the maximum tolerable amplitude is achieved  
64 the flow of current is maintained for about 30 minutes. After 30 minutes, the device is switched off and the pads  
65 were removed. Patient was instructed to sit in the same upright position with head slightly inclined forward. The  
66 stimulated saliva gets pooled in anterior part of floor of the mouth. Patient was again asked to split the saliva  
67 into the vial for each minute for about five minutes (5 splits).

## 68 **RESULTS**

69 Among 20 patients, 7 were male and 13 were female. Among 7 male cases, 6 patients had increased  
70 salivary flow after TENS therapy, and 1 patient had decreased salivary flow. Among 13 female cases, all  
71 patients had increased salivary flow after TENS therapy. Student's t-test (paired) was used for comparisons.

Correlation Analysis was performed to assess the relationship between measurements. For all the tests, P value of 0.05 or less was considered statistically significant.

Statistical analysis of flow rates for inter-group analysis demonstrated that the difference between unstimulated and stimulated salivary flow was given in [Table 1 and Graph 1]. The mean difference in salivary flow rate between males and females was given in [Table 3]. The difference in salivary flow rate between different age groups was given in [Table 3].

Type of saliva	N	Mean	Std. Deviation	Std. error of mean
Unstimulated saliva	20	1.28	0.469	0.105
Stimulated saliva	20	1.63	0.621	0.139

Table 1: Comparison between stimulated and unstimulated salivary flow rate (ml/min)

	Age	N	Mean	Std. Deviation	Std. Error Mean
Post-value(ml)	20-29	16	1.5875	.69174	.17293
	30-39	4	1.6750	.22174	.11087

Table 2: Statistics between two age groups in post TENS values

	Gender	N	Mean	Std. Deviation	Std. Error Mean
Post-value(ml)	male	7	1.8429	.70441	.26624
	female	13	1.4769	.55999	.15531

Table 3: Statistics between two gender group in post TENS values

Age	Post value (ml)	P value
20-29 years	1.58 ± 0.69	0.89
30-39 years	1.67 ± 0.22	

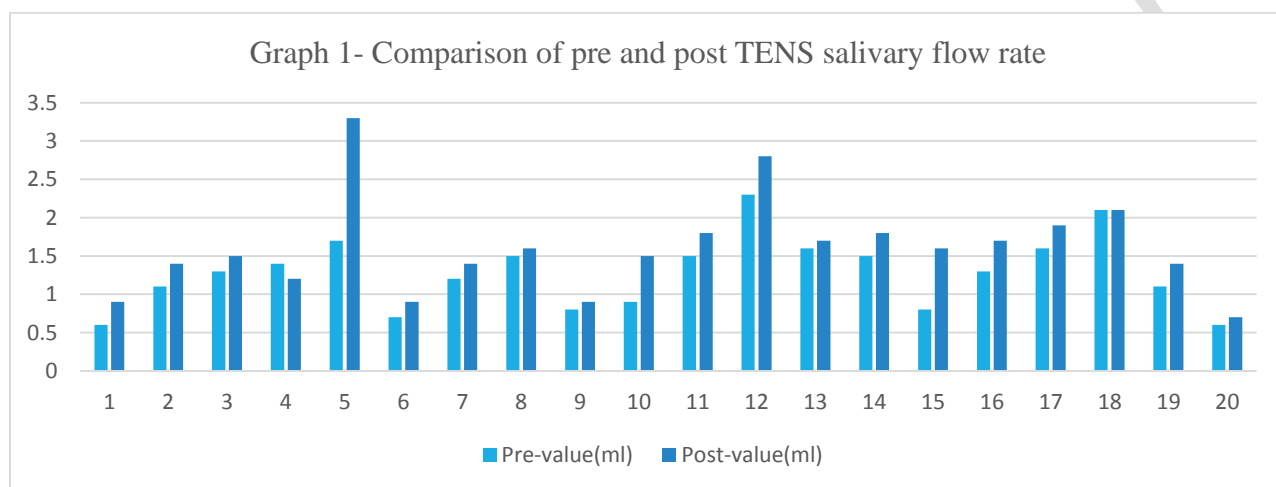
Table 4: P value for different age groups

Gender	Post value (ml)	P value
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Male	1.84 ± 0.70	0.218
Female	1.47 ± 0.55	

Table 5: P value for both gender groups

Both the parameters are not statistically significant.



## DISCUSSION

The application of electric current through the oral mucosa to the afferent neuronal pathway causes electrical stimulation of the salivary glands and this has been reported to increase the production of saliva and to reduce the symptoms of xerostomia.<sup>6</sup> The effect of transcutaneous electrical nerve stimulation (TENS) has been observed in stimulating salivary flow and it was found to be more effective even in patients with xerostomia secondary to radiation therapy for head and neck cancer.

Salivary flow is classified as unstimulated, resting, and stimulated. Both the parasympathetic and sympathetic nerve supply innervate the salivary glands. Parasympathetic stimulation induces more watery secretions, whereas the sympathetic system produces more viscous salivary flow.<sup>7</sup> Therefore, sensation of dryness may occur, during episodes of acute anxiety or stress, which produce alteration in salivary composition owing to predominant sympathetic stimulation during such periods.

The mechanism by which the TENS unit worked on the parotid gland may be that it directly stimulates the salivary secretion arc. Salivary secretion is performed by a neuronal mechanism composed of a

99 reflex arch. This neuronal mechanism has three basic components; (1) afferent receptors and nerves which carry  
100 impulses generated by both masticatory and gustatory actions; (2) a central connecting and processing center  
101 which is the salivatory nucleus; and (3) an efferent neuronal pathway consisting of both parasympathetic and  
102 sympathetic nerve bundles that separately but in a coordinated manner innervate the blood vessels and acini of  
103 their target glands leading to regulation of salivary secretion. It is believed that afferent nerves carry impulses  
104 from the periphery to the salivary nuclei which is the salivation center in the medulla oblongata, which in turn  
105 directs the signals to the efferent part of the reflex arch leading to initiation of salivation.

106 Manu dhilon *et al* stated that TENS unit was effective in increasing parotid gland salivary flow in  
107 healthy subjects. There was no gender-related variability of salivary flow rate of parotid gland. In another study  
108 conducted by Pattipati *et al* in 2013, showed an increase in salivary flow rate on application of TENS, and more  
109 so, this increase in salivary flow was pertinent even one hour after the application of TENS in a select group of  
110 individuals.

111 In one patient, the salivary flow was decreased with the application of TENS. The reason for the  
112 effects depends upon the frequency and intensity settings.<sup>8</sup> The stimulus perceived by the brain may be painful  
113 and the salivary reflex is enhanced when nociceptive input reaches the brain via trigeminal sensory nuclei. Not  
114 all preganglionic parasympathetic fibers are necessarily facilitated; some may be inhibited thus leading to the  
115 decrease in salivary flow rate.

116 Dipti singh *et al* conducted a similar study in which forty-three out of 50 subjects showed increase  
117 in salivary flow when stimulated via TENS. The mean of unstimulated salivary flow rate found out was 0.354  
118 ml/min (range 0.1-0.6 ml/min). There was 37% significant increase in the salivary flow, i.e. 0.494 ml/min  
119 (range 0.1-1.3 ml/min), during TENS application and the difference was highly significant.

120 The main advantages offered by TENS over other non-pharmacologic measures are as follows.  
121 TENS unit is an extraoral device. Thus, the potential for salivary production while eating would be beneficial.  
122 TENS is a non-pharmacologic measure. One of the side effect of noted in TENS therapy is the twitching of the  
123 facial musculature. This effect was minimal and transient. These effects could be minimized by adjusting the

124 electrode placement and ceased once the TENS unit was turned off. Perhaps modifications can be made in  
125 future in TENS units, such as smaller electrodes, to minimize the side effects and make electro-stimulation  
126 more effective.<sup>9</sup>

## 127 **CONCLUSION**

128 TENS therapy was highly productive in significantly increasing the whole salivary flow in healthy  
129 adult subjects with minimal side effects. Tens is an effective adjunct to sialologues and also cost effective with  
130 user friendly feature. However it provides only momentary relief. Further modifications can be made on TENS  
131 in the future to reduce side effects and to improve more electrostimulation.

## 132 **CONSENT**

133 Informed consent obtained from the patient prior to the study.

## 134 **ETHICAL APPROVAL**

135 Ethical approval obtained from the institutional review board members prior to the study.

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