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Research Article

Efficacy of ULF-TENS on Muscle Relaxation at 15, 30 and 45 Minutes Time Intervals in TMD Individuals with Myofascial Pain - A Prospective Randomized Clinical Study

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Abstract

Introduction: Temporomandibular joint disorder pain conditions are consequences of a few factors associated with impaired co-ordination and incorrect relation with structures involved in temporomandibular joint function and uncontrolled contractions in masticatory muscles. Occlusion plays a vital role in the maintenance of temporomandibular joint health and a developing malocclusion may lead to bite displacement and loss of teeth which significantly affects the functioning of muscle in association with the temporomandibular joint.

It is worth clarifying the efficacy of ULF TENS treatment at the duration of 15, 30, and 45 min at Vth and VIIth cranial nerves and "Prabu's Point" XIth cranial nerve for treating myofascial pain associated temporomandibular joint disorder.

Method: A total of 30 individuals participated in the study with the age group 18 - 55 years. Subjects were recruited in each group and assessed for their TMJD status:

- Group 1: (n = 24) individuals with chronic TMJD conditions and systemic disease.
- Group 2: (n = 06) healthy individuals with no TMJD association and systemic disease.

Results: Results obtained in the study suggested the efficacy of ULF-TENS treatment at the duration of 15, 30, and 45 minutes at the coronoid notch and "Prabu's Point" for treating myofascial pain associated temporomandibular joint disorder have shown to significantly improve the head and neck muscles activity with decreased pain levels.

Conclusion: Considering the result, it might be concluded that the efficacy of ULF-TENS treatment at 15, 30, and 45 minutes stimulating Vth, VIIth and XIth cranial nerves for treating myofascial pain associated with the temporomandibular joint disorder is significant.

Keywords: *ULF-TENS - Ultra-Low Frequency Transcutaneous Electrical Nerve Stimulation; TMJD - Temporomandibular Joint Disorder; Myofascial Pain; Masticatory Muscles; Neuromuscular Dentistry*

Abbreviations

ULF-TENS: Ultra-Low Frequency Transcutaneous Electric Nerve Stimulation; TMJ: Temporomandibular Joint; TMJD: Temporomandibular Joint Disorder; OPD: Outpatient Department; EMG: Electromyography; Sec: Second; mA: Milliampere; µs: Micro-Seconds; Hz: Hertz; 3D:

Three-Dimensional; CBCT: Cone-Beam Computed Tomography; CT: Computerized Tomographic; T0: Time Interval 0 Minutes; T1: Time Interval 15 Minutes; T2: Time Interval 30 Minutes; T3: Time Interval 45 Minutes; CDC: Centers for Disease Control and Prevention; S.D.: Standard Deviations; CD: Critical Difference; VAS: Visual Analogue Score; VRS: Verbal Rating Score; NS - Statistically Not Significant; S - Statistically Significant; TAC: Total Antioxidant Capacity; TPA: Total Pro-Oxidant Activity; HRV: Heart Rate Variability; DET: Percent of Determinism of Heart Rate Variability; RR: Respiratory Rate; ANS: Autonomic Nervous System; SST: Sensory Stimulation Threshold; MST: Motor Stimulation Threshold

Introduction

Temporomandibular joint dysfunction, also known as craniomandibular disorders, has garnered significant attention in the field of dentistry. This disorder is characterized by muscle disorders that affect the structure and function of the jaw joint. The most prevalent symptom is pain, which affects a large population worldwide [1]. The pain associated with the temporomandibular joint disorder is caused by impaired coordination and incorrect relations with the structures involved in jaw joint function, as well as uncontrolled contractions in masticatory muscles [3].

Clinical studies state evidently that proper diagnostic and treatment approaches play a vital role in the management of temporomandibular joint disorder. Various instrumentation developments have enabled the measurement of muscular activity, such as surface electromyography, jaw movement sounds, and tracking of mandibular movements during various motions [2]. The muscle relaxation treatment approaches for temporomandibular joint disorder achieved by reducing muscle hyperactivity re-establishes temporomandibular joint movement [4,5].

Muscle tension and hyperactivity can be recorded by electromyographic methodology, which is commonly used in the assessment of myofascial disorders during normal resting positions and postural states [6]. The ultra-low frequency transcutaneous electric nerve stimulation ULF-TENS approach, which applies electrical stimulus to motor fibres at a rate of once per second, is commonly used in the treatment of temporomandibular joint disorder [7].

Jankelson in 1969 proposed the neuromuscular TENS approach, involving the application of three electrodes: two active electrodes at the sigmoid notch of the jaw before the tragus point and a third electrode (cathode) at the midline neck below the hairline. The current frequency of 0.66 Hz and each pulse duration - is 500 microseconds with an amplitude - of 8 - 12 mA. Clinical studies have shown that the application of ULF-TENS for 30- 40 minutes in TMD individuals with and without hyperactive muscles at rest results in the reduction of EMG activity of stomatognathic muscles [3,9,14,17,19,20].

Objective of the Study

The primary objective of this study is to assess the duration of ULF- TENS application to promote a masticatory muscle relaxation state and to evaluate the efficacy of ULF-TENS application in pathological and normal individuals at the V^{th}, VII^{th} and XI^{th} cranial nerves. By examining the effects of ULF-TENS on muscle relaxation, this study aims to improve the treatment of temporomandibular joint disorder, thereby enhancing the quality of life for individuals affected by this condition.

Materials and Methods

This study was conducted at the Department of temporomandibular joint disorder, dental world super-speciality clinic, Kolkata. A total of 30 individuals participated in the study with the age group 18 - 55 years (mean average age - 36 ± 14.14). The individuals were recruited into two groups based on their TM joint status and systemic health group 1: (n = 24) myofascial pain with TM joint disorder and group 2: (n = 06) healthy individuals without TM joint disorder.

The exclusion criteria of individuals in the study are as follows:

- Radiation or immunosuppressive therapy.
- Allergic or sensitive to any drug or history of steroid therapy for the past 6 months.

- TMJD with subluxation.
- Any critical systemic conditions - Acute/chronic kidney disease, Liver cirrhosis, Organ
- failure, Cardiac disease and supportive treatments and Autoimmune diseases.
- Pacemaker or any other electrical devices.
- History of local or general trauma, neurological or psychiatric disorders.
- Muscular diseases.
- Consumption of anti-inflammatory.
- Analgesic, antidepressant or muscle relaxant drugs.
- Orthognathic surgery.
- Excessive facial hair.

Inclusion criteria

Group I:

- TMJD with myofascial pain with or without reduction.
- TMJD with disc displacement.
- Partially edentulous/complete dentition.
- Complete edentulous.
- Sleep apnea.
- Orthodontic previous history.
- Bruxism.
- Fixed prosthesis.
- Systemic disease.

Group II:

- No temporomandibular joint disorder diagnosed.
- No systemic conditions associated.
- No referral pain associated.
- No arthritis or fibromyalgia condition associated.
- Partially edentulous or complete dentition.

Case selection protocol

Individuals were screened from OPD of Dental World Super Speciality clinic, Kolkata in which Twenty individuals were screened:

- Twenty-four Individuals suffered from Myofascial pain condition and were selected for group I and Six individuals were screened and selected for a healthy, control group i.e. group II.
- Each individual was evaluated with a myofascial pain questionnaire followed by clinical assessment within a time period of pre-treatment assessment and post-treatment assessment.
- Muscle palpation assessment was done including myofascial masticatory muscle - head and neck were palpated and pain assessment.

- Pain intensity was assessed with visual analogue pain intensity scale evaluation and auscultation of the temporomandibular joint with crackling and clicking sounds.
- Mouth opening was individuals with a limited evaluation with a range of motion scale.
- The control group illustrated no signs and symptoms associated with temporomandibular joint disorder or facial pain.

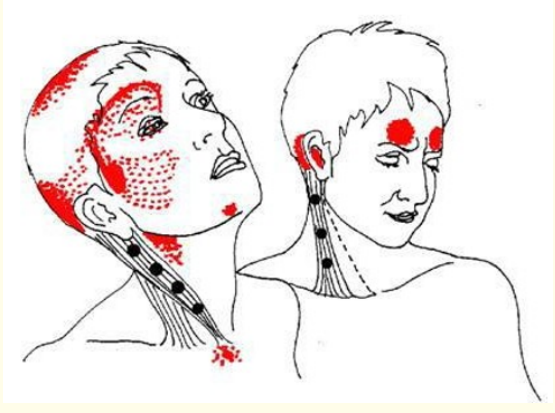

Figure 1: *Trigger points on SCM and associated referred pain areas associated with it.*

Evaluation and recordings:

- The muscle activity was measured using K7 EMG and muscle relaxation was carried out using J5 Myo-monitor with disposable duotrode and electrodes respectively.
- The J5 Myo - monitor is battery-operated with dual TENS unit of ultra-low frequency inducing bilateral parallel stimulus of facial and masticatory as well as cervical muscles.
- The electrodes generate a reproducible synchronous bilateral stimulus which is delivered in 1.5-sec intervals with an amplitude of approximately 0 - 24 Ma at the duration of 500 µs and frequency of 0.66 Hz.

Figure 2: *K7 equipment setup.*

Figure 3: *J5 myo-monitor.*

Steps involved in recording muscle activity:

- Step 1: Clean the muscle sites with skin disinfectant to remove cosmetics and skin oil.
- Step 2: Place electrodes (coronoid notches and Prabhu point and two ground at the neck) and duotrode (Anterior temporalis, masseter, digastric and sternocleidomastoids) on the patient.
- Step 3: Placing Preamp on the patient and connect wires.
- Step 4: Recording of Scan 9 - Resting EMG before TENS application.

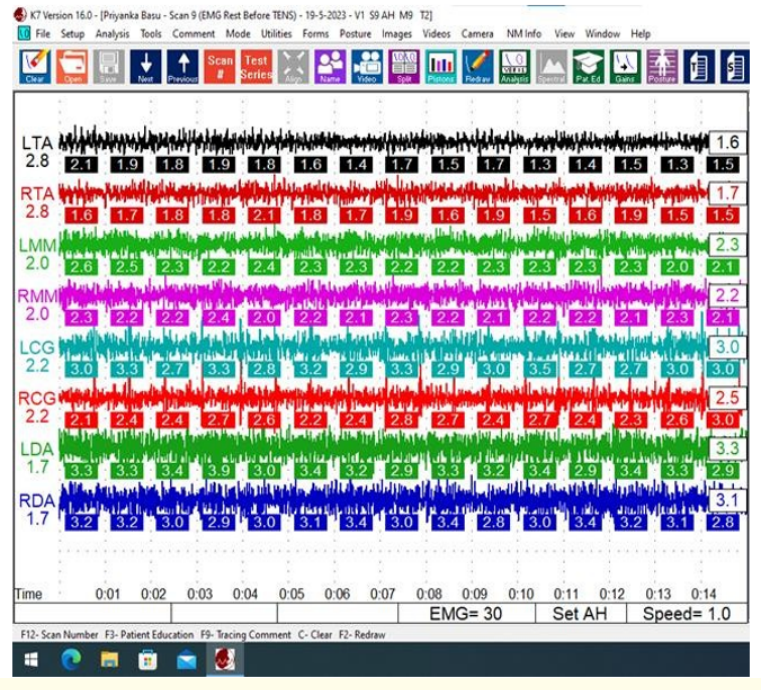

Figure 4: *Scan 9 showing resting EMG data.*

Scan 9 is used for the analysis of accommodated resting EMG raw data before pulsing. It shows the relative resting activity of the masticatory and or cervical muscles and muscle tension in each muscle group relative to one another.

- Step 5: Switch on the J5 Myo-monitor device and connect the wires.
- Step 6: Recording scan 10 - Resting EMG after TENS application at 15, 30 and 45 minutes application.

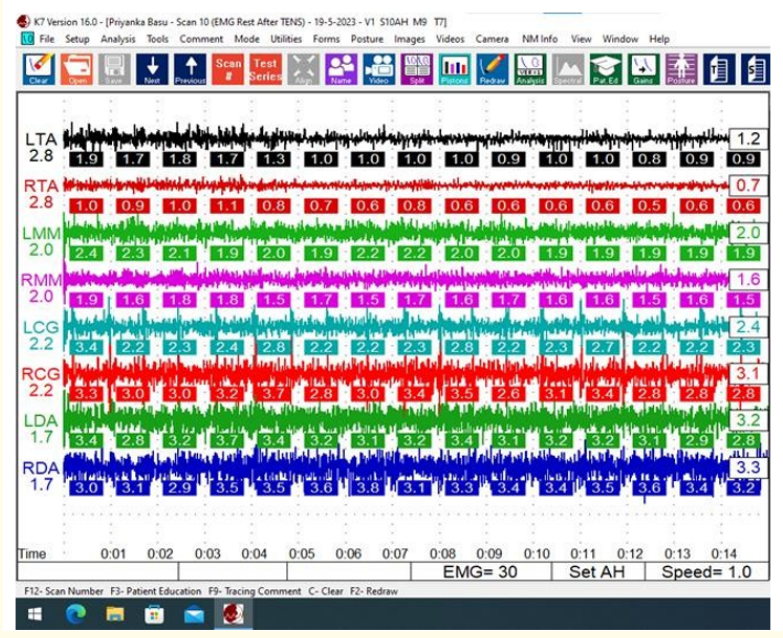

Figure 5: *Scan 10 showing resting EMG data after TENS application.*

Scan 10 is used for the analysis of EMG raw data after pulsing. It shows the degree of muscle relaxation at the physiologic rest position.

TENS applied to the sigmoid notch allows the excitation of motor nerve fibers of the V^{th}, VII^{th} and when applied to Prabu's point allows the excitation of XI^{th} pair of cranial nerves.

The application of ULF-TENS for a single 45-minute session would reduce the electromyographic activity of masticatory muscles at rest, and would increase the interocclusal distance.

Figure 6: *Duotrode placement on the various muscle groups for checking the EMG activity.*

Prabu's point [16]:

Anatomical locations:

- Assessment of accessory nerve XIth cranial nerve in which posterior cervical triangle is evaluated which is anteriorly by sternocleidomastoid and posteriorly by the trapezius and inferiorly by the middle of the clavicle.
- Inferior to mastoid process.

Figure 7: *Anatomical location of Prabu's point.*

There is a functional relationship involving mandibular posture with cervical postures in which the temporomandibular joints, Atlanto - occipital and cervical spine joints. The muscles of the head, neck and upper trunk act as contributors to stabilize mandibular positions and movements.

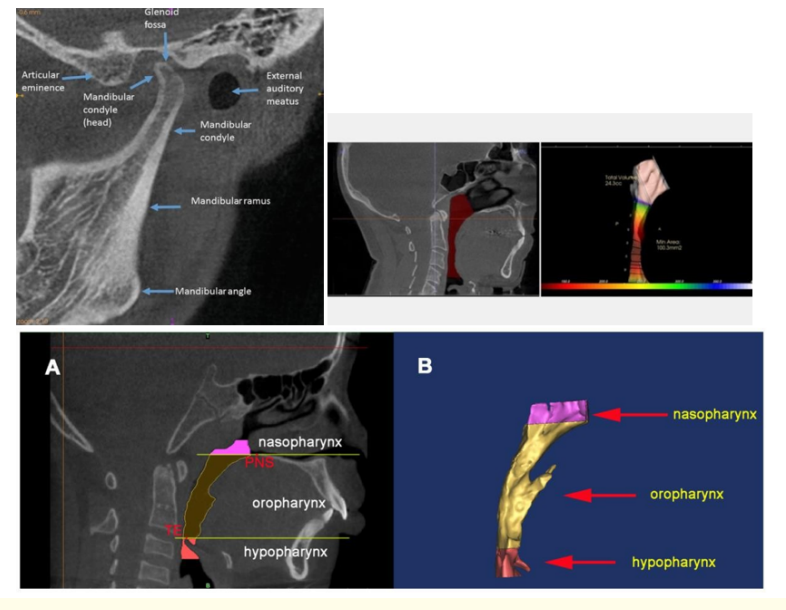

Figure 8: *Radiological investigation: CBCT scan - TMJ and airway evaluation.*

Figure 9: *Orthopantomograph.*

Figure 10: *TMJ - 2D mouth view-open and closed-normal individual.*

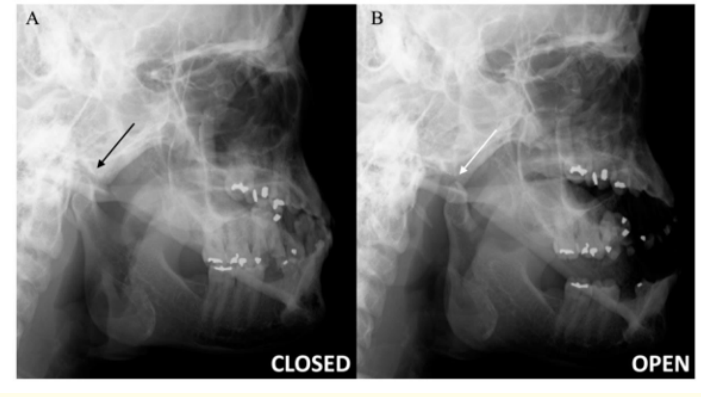

Figure 11: *TMJD - 2D x-ray mouth view- open and closed.*

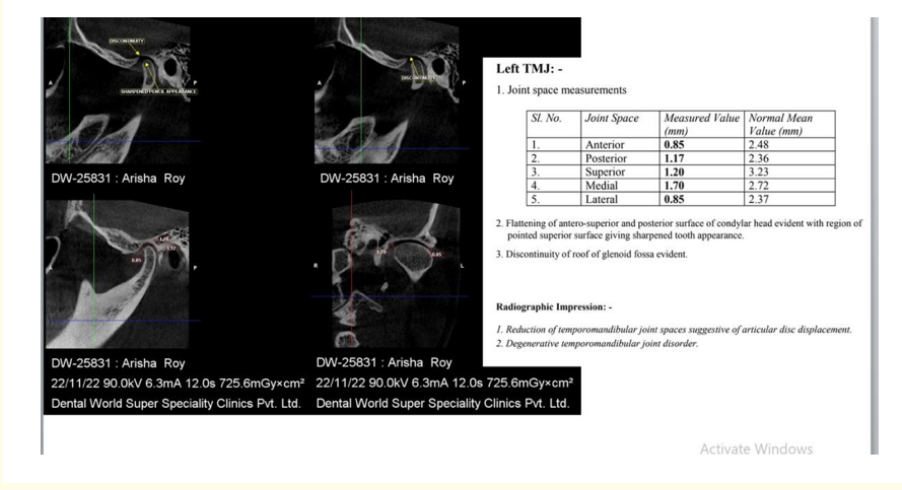

Figure 12: *CBCT scan - temporomandibular joint with measurements.*

Result

The present study was conducted in Dental World Super- Speciality Clinics PVT Limited, Kolkata with the aim of assessing of efficacy of ULF-TENS application at optimal time intervals on masticatory muscles innervated by V^{th}, VII^{th} and XI^{th} cranial nerves in myofascial pain associated TMD individuals. The study is conducted with 30 individuals within the age group 18 - 55 years (mean average age - 36.14). 6 individuals in the control group and 24 individuals in the study group. The selection of individuals was based on a randomized controlled trial method to eliminate bias sampling. Data analysis and collection were computerized and subjected to statistical analysis followed by which the results were obtained.

Statistical analysis

Statistical analysis was performed with help of Epi Info (TM) 7.2.2.2 EPI INFO is a trademark of the Centers for Disease Control and Prevention (CDC). Descriptive statistical analysis was performed to calculate the means with corresponding standard deviations (s.d.). A test of proportion was used to find the Standard Normal Deviate (Z) to compare the different proportions. t-test was used to compare means. One Way Analysis of variance (ANOVA) followed by post hoc Tukey's Test was performed with the help of Critical Difference (CD) at 5% and 1% level of significance to compare the mean values of more than two groups. $P < 0.05$ was taken to be statistically significant.

This table illustrates a statistical analysis of the myofascial pain associated TMD individual's pain score which were assessed based on the visual analogue score scale (VAS) and verbal response scale (VRS) parameters during pre-evaluation of ULF-TENS application.

The table demonstrates a clinically significant difference in analysis in pre and post ULF-TENS application at baseline and 45 min time intervals and on clinical evaluation, individuals were relieved from pain and tenderness of muscles. All the pain scores decreased after treatment and most of the decreases were significant ($p < 0.05$).

This table demonstrates the ANOVA analysis of variance of EMG evaluation when compared from baseline T0 to T45 min showed clinically significant ($p < 0.05$) in myofascial pain associated with TMD individuals which illustrated that muscle relaxation was induced significantly as per time frame interval increased for ULF-TENS application. Tukey's post hoc test showed that the mean muscle relaxations of the patients were significantly lower as compared to prior to treatment ($p < 0.05$).

Site	Study Group	Mean	s.d.	t-value	p-value
Pain Visual Analogue Score (VAS Score)	Pre-treatment	6.50	1.75	6.81	<0.001S
	Post-treatment	3.42	1.50		
Pain Verbal Rating Score (VRS score)					
Rt. Temporalis	Pre-treatment	4.35	1.02	5.62	<0.001S
	Post-treatment	2.92	0.80		
Lt. Temporalis	Pre-treatment	4.50	1.42	5.87	<0.001S
	Post-treatment	2.65	0.75		
Rt. Masseter	Pre-treatment	3.96	1.31	1.54	0.13 NS
	Post-treatment	3.38	1.39		
Lt. Masseter	Pre-treatment	4.15	0.83	4.21	<0.001S
	Post-treatment	3.15	0.88		
Rt. Medial pterygoids	Pre-treatment	4.04	0.96	3.84	<0.001S
	Post-treatment	3.12	0.77		
Rt. Medial pterygoid	Pre-treatment	2.85	1.05	0.28	0.78 NS
	Post-treatment	2.82	0.94		
Lt. Lateral pterygoid	Pre-treatment	6.58	1.27	7.72	<0.001S
	Post-treatment	4.08	1.06		
Rt. Lateralpterygoid	Pre-treatment	6.92	0.89	12.49	<0.001S
	Post-treatment	3.88	0.86		
Lt. SCM	Pre-treatment	2.35	1.38	0.75	0.46 NS
	Post-treatment	2.32	1.20		
Rt. SCM	Pre-treatment	2.73	1.59	1.21	0.23 NS
	Post-treatment	2.27	1.12		
Scalene	Pre-treatment	1.08	0.74	0.88	0.38 NS
	Post-treatment	1.03	0.83		
Trapezius	Pre-treatment	1.38	1.30	0.11	0.91 NS
	Post-treatment	1.31	1.14		

Table 1: *Comparison of pain score of pre-treatment and post-treatment of ULF-TENS [Visual analogue score (VAS) and verbal rating score (VRS score)].*

NS - Statistically not significant; S - Statistically significant.

Site	Time interval (minute)	Mean	s.d.	F-value	p-value
Right masseter	T0	2.72	1.65	4.756	0.004 S
	T15	2.45	1.55		
	T30	1.71	1.15		
	T45	1.42	1.05		
Left masseter	T0	2.76	1.79	3.017	0.034 S
	T15	2.50	1.77		
	T30	1.77	1.08		
	T45	1.70	1.18		
Right Temporalis	T0	2.80	1.57	6.308	<0.001 S
	T15	2.20	1.27		
	T30	1.55	0.78		
	T45	1.55	0.87		
Left Temporalis	T0	2.40	0.89	10.668	<0.001 S
	T15	2.08	0.74		
	T30	1.46	0.63		
	T45	1.43	0.57		
Right SCM	T0	4.17	2.76	4.548	0.005 S
	T15	2.98	1.69		
	T30	2.80	1.37		
	T45	2.32	0.85		
Left SCM	T0	4.73	3.44	6.207	<0.001 S
	T15	2.95	1.46		
	T30	2.78	1.78		
	T45	2.23	1.05		
Right Digastric	T0	7.70	8.65	5.916	<0.001S
	T15	3.59	2.35		
	T30	3.26	1.24		
	T45	2.84	0.81		
Left Digastric	T0	4.40	3.80	4.606	0.003 S
	T15	3.41	2.40		
	T30	3.46	1.60		
	T45	2.85	1.38		

Table 2: *Comparison of muscle relaxation (muscle stimulation) of the treated patients at different time intervals of treatment with ULF-TENS (at T0 - T45).*

NS - Statistically Not Significant; S - Statistically Significant.

Discussion

The objective of this study was to evaluate the effects of ULF-TENS on the relaxation of masticatory muscles innervated by the V^{th}, VII^{th}, and XI^{th} cranial nerves at specific time intervals (T0, T1, T2, T3). The study assessed the baseline and subsequent muscle relaxation at 15, 30, and 45 minutes after ULF-TENS application. The results showed significant muscle relaxation in the masseter, temporalis, sternocleidomastoid, and digastric muscles. Interestingly, even the control group exhibited significant muscle relaxation compared to the study group of individuals with temporomandibular joint disorders (TMJD) from baseline to the T3 time interval. A similar study by Susumu Abe., *et al*. [9,11,13] also demonstrated significant relaxation of masticatory muscles in TMJD individuals with myofascial pain [34].

Myofascial trigger points are hypersensitive points located in taut muscle bands that cause specific local or referred pain upon stimulation. They can be classified as active or latent based on whether they cause spontaneous pain or only provoke pain when stimulated. In this study, the application of ULF-TENS resulted in a significant reduction in the Visual Analog Scale (VAS) [10,13,14,17] scores of individuals with TMJD-associated myofascial pain from baseline to the post-T3 interval evaluation. This reduction in VAS scores was also observed in a study by Susumu Abe., *et al*. in 2020 [9,16,17].

The study focused on comparing the electromyographic activity of masticatory muscles, as well as those in the head, neck, and cervical regions, at specific time intervals of ULF-TENS application. The study found reduced muscle activity from baseline to the T3 interval in individuals with TMJD-associated myofascial pain, compared to the control group. TMJD individuals exhibited higher electromyographic activity at baseline compared to healthy individuals. A similar study by Delain Rodrigues., *et al*. in 2004 [11,18,21] indicated that the increase in electromyographic amplitude of jaw elevator muscles at rest may be due to sensorimotor interactions, with pain being a modifying factor. The present study also demonstrated non-homogeneous patterns of electromyographic activity at the T1 and T2 time intervals. However, a significant reduction in muscle activity was observed from baseline to the T3 interval of ULF-TENS application. In contrast, a study by Cooper., *et al*. in 1991 [12,23] reported a uniform decrease in electromyographic activity at rest and an increase during isometric contraction of jaw elevator muscles following a 60- to 90-minute low-frequency TENS application [26,28].

The study demonstrated significant muscle relaxation in the masseter, temporalis, and lateral and medial pterygoid muscles from baseline to the T3 interval with ULF-TENS application in individuals with TMJD-associated myofascial pain. There was a negative correlation between increased time frame and reduced electromyographic activity. Similar studies by Remi Esclassan., *et al*. in 2016 [13,27] and Ester Moneira de Castro Carletti., *et al*. in 2023 [14,29,31,33] also demonstrated significant muscle relaxation in TMJD individuals with myofascial pain following ULF-TENS application at specific time intervals.

Furthermore, the study showed a significant reduction in electromyographic activity of the sternocleidomastoid muscles at the T3 interval of ULF-TENS application compared to baseline. Similar findings were reported by Lili Xu., *et al*. in 2021 [15,29] who also correlated electromyographic values with neutral head position and tooth contact.

The study by Raman P in 2009 [16,26,31,34] introduced the "Prabu point" methodology to improve cervical posture and mandibular position through ULF-TENS-induced relaxation. Considering the result, it might be concluded that the efficacy of ULF-TENS treatment at 15, 30, and 45 minutes stimulating V^{th}, VII^{th} and XI^{th} cranial nerves for treating myofascial pain associated with the temporomandibular joint disorder is significant.

Conclusion

1. Significant changes were observed in electromyographic activity of masticatory muscles in the head, neck and cervical region at baseline and T45 min interval of ULF-TENS application. The time interval of 45 min of ULF-TENS application resulted in reduced muscle activity and significant pain relief.
2. The ULF-TENS application has a significant impact on the muscles of the head and neck and improvement in cervical posture [25,32,36].

Summary

A clinical prospective study of 30 individuals in the age group of 18 - 55 years was conducted at Dental World Super speciality Clinics Pvt Limited, Kolkata, India. In the study, the effectiveness of ULF-TENS application at optimal time intervals was assessed for masticatory muscles associated with V^{th}, VII^{th} and XI^{th} cranial nerves. The VAS and VRS score demonstrated a reduction in pain scores and muscle tenderness post-ULF-TENS application. On increasing the time frame for ULF-TENS application significant reduction in muscle activity was observed along with noticeable muscle relaxation.

Conflict of Interest

The author declares no financial interest and no conflict of interest exists.

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