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Original Article

Evaluation of Pain Perception During Orthodontic Debonding of Metallic Brackets with Simultaneous Application of TENS Therapy

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Main Points

- The application of transcutaneous electrical nerve stimulation (TENS) therapy results in pain reduction during the debonding procedure.
- Female subjects experienced more pain than the male subjects during debonding.
- Higher pain scores were recorded for the mandibular anterior teeth than for the maxillary teeth.
- Patients displayed good acceptance and satisfaction with TENS therapy for pain control during the debonding of fixed appliances.

ABSTRACT

Objective: The objective of the present study was to evaluate the effectiveness of transcutaneous electrical nerve stimulation (TENS) therapy on pain during the debonding procedure.

Methods: A placebo-controlled, randomized split - mouth study was conducted on 30 orthodontic patients. The right and left anterior teeth in the maxilla and mandible were randomly allocated to the control and experimental groups (EG) and were stimulated. TENS application was made through a modified electrode probe that was used from an ammeter. The control group (CG) received the mechanical application of the device with no current, whereas the EG received progressively increasing current from 0.1 mA to the point where the patient experienced a mild tingling sensation for 60 s for each tooth. This was followed by a debonding procedure using an orthodontic debonding plier. Pain perception was recorded on a numerical rating scale after debonding each tooth.

Results: The mean pain score was higher in the CG than in the EG, and the difference between the two groups was significant (p=0.001). The pain score was higher in the mandibular teeth than in the maxillary teeth, and the difference between the two groups was also significant (p=0.021). Pain score was higher in female subjects than in male subjects, and the difference between the two groups was significant (p=0.015).

Conclusion: The application of TENS therapy results in pain reduction during the debonding procedure. The female subjects experienced more pain. Higher pain scores were recorded for the mandibular anterior teeth than for the maxillary teeth.

Keywords: Debonding, randomized controlled clinical trials, transcutaneous electrical nerve stimulation

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INTRODUCTION

A frequent adverse effect of many orthodontic procedures is pain. Pain is subjective and is expressed both verbally and non-verbally.[1] It has been noticed that pain is typically felt during or immediately after the adjustment of an orthodontic appliance and may even last for 2 to 4 days, despite there being no quantitative documentation. From a slight soreness when clenching to a constant, throbbing pain, the level of pain varies.[2] Orthodontic pain is a result of pressure, ischemia, inflammation, and edema at the periodontium level. 95% of orthodontic patients feel some level of pain or discomfort during or after various orthodontic operations. The insertion of separators, activation or placement of archwires, use of miniscrews, and debonding of fixed appliances are among the orthodontic operations that are most likely to cause pain or discomfort.[1]

Techniques used to control pain are broadly classified into pharmacological and non-pharmacological methods. Pharmacological methods include local anesthesia, general anesthesia, pharmacologic sedation, nitrous oxide relative analgesia, and hypnosis. Bite wafers, chewing gum, low-level laser therapy (LLLT), vibratory stimulation, transcutaneous electrical nerve stimulation (TENS), application of ice/cryotherapy, acupuncture/acupressure, and psychological interventions such as a structured phone call to patients during treatment are examples of non-pharmacological methods for pain control. TENS has found its greatest use with physical therapists in rehabilitation and chronic pain control.[2-4]

Greeks were the first to document the use of electricity to ease pain in writing. Walsh and Cavendish provided the first written account of the numbing effects of electrical generators in the 1770s. The first person to mention the use of electricity to treat tooth discomfort was Francis in the 19th century.[3,4] TENS is used to treat the symptoms of mild to moderate pain from any source, including neuropathic, musculoskeletal, and nociceptive pain.[5] TENS has been used previously for the treatment of myofascial pain dysfunction, trigeminal neuralgias, and temporomandibular joint pain.

Bond strength is crucial for maintaining the effectiveness of orthodontic treatment, but quick debonding of the brackets is preferable at the end of the procedure.[6,7]

A thorough review of the literature found no studies evaluating the effect of TENS during the debonding procedure. Therefore, the objective of this study was to evaluate the analgesic effect of a single application of TENS on pain during the debonding procedure. Therefore, the aim of the present study was to evaluate and compare the effectiveness of TENS therapy on pain during the debonding procedure.

METHODS

This study was approved by the I.T.S. Institutional Ethics Committee with protocol number: ITSCDSR/IIEC/RP/2019/014 and date: 22.11.2019. Sample size was estimated using the data obtained from a previous study conducted by Roth and Thrash[2] where the mean and standard deviation of visual analog scale scores were 4.77±6.96 for the treatment group and 15.22±15.86 for the control group (CG). This data revealed that, for an effect size of 0.85, a total sample size of 60 sites would provide an adequate statistical power of 95% to detect a significant difference.

This placebo-controlled, randomized split - mouth study was conducted on 30 orthodontic patients aged between 12 and 27 years in whom fixed orthodontic treatment had been performed using conventional metallic MBT brackets and in whom debonding was scheduled. Patients who had no missing teeth except the first premolar and who had not undergone any tooth transplantation were selected. Patients using antibiotics or analgesics, pregnant or breastfeeding, and those with a history of systemic diseases such as seizures, cardiac arrhythmia, or pacemakers were excluded. Patients with treated or untreated apical bone lesions, parafunctional habits, temporomandibular dysfunction, or smokers and alcoholics were also not included in study.

All patients meeting the inclusion criteria were given oral and written information by the operator and consented to participate in the study. Before starting the procedure, 30 opaque envelopes were made, out of which 15 envelopes were from the experimental group (EG) and 15 were from the CG. Allocation concealment was performed via unmarked envelopes. When the operator was about to start the procedure, patients were instructed to choose one envelope, and subsequently, the right maxillary and left mandibular teeth were given the same intervention as mentioned in the envelope. The left maxillary and right mandibular teeth were subjected to the opposite intervention. Both groups were informed that they would be evaluating a pain reduction device that would administer a mild electric current and that the strength of the stimulation could range from sub-sensory to negligible tingling.

The brackets on the anterior teeth in the maxilla and mandible were deboned in the study for pain evaluation. Immediately before the debonding procedure, a conductive gel was applied to the labial surface of the anterior teeth. The teeth allocated to the EG received stimulation from the TENS device on the incisal edges of the anterior teeth (Figure 1a). The device used was a modified electrode probe that was derived from an ammeter. It was selected because it had a detachable metallic head that could be autoclaved (Figure 1b). It generated a biphasic, symmetrical pulse with a net neutral charge and a maximum current of 10 mA. The current was progressively increased from 0.1 mA to the point where the patient experienced a mild tingling sensation (Figure 2). From this stage, the current was delivered for 60 s to each tooth. The teeth in the CG group received the same mechanical application of the device with no current. After delivery of the current for 60 s, the dental operator started the debonding

procedure. The elastomeric modules, ligature ties, e-chains, and any other accessories were removed to separately record the pain score of each tooth. Debonding was performed with debonding pliers by placing the blades of the plier at the bracket-adhesive interface, and gentle squeezing action was applied until bond failure occurred.

Pain intensity was scored on a numerical rating scale after debonding in both the EG and CG groups immediately after the debonding procedure. A score of 0 indicated no pain, whereas a score of 10 indicated maximum pain. The patients were asked to rate the pain levels separately for each tooth. Acceptance of TENS therapy was assessed after the debonding procedure using a questionnaire provided to the patients.

Statistical Analysis

Data were analyzed using SPSS v20.0 software (SPSS Inc, Chicago, Il, USA). The level of significance was maintained at 5%. The data were subjected to normality testing using the Shapiro-Wilk test, which showed that the data deviated from the normal distribution. The demographic details of the study participants were presented using descriptive statistics. Pain scores between the control and EG groups were compared using the Mann-Whitney U test. Pain scores were also compared between gender and arch using the Mann-Whitney U test.

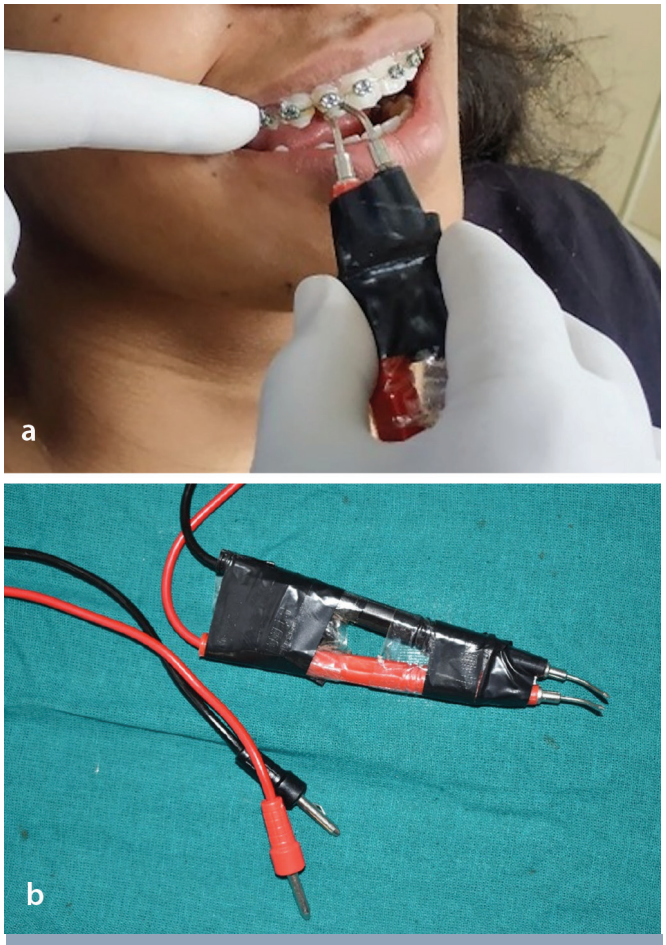

Figure 1. a) Patient receiving tens application. b) Modified electrodes for intraoral application

RESULTS

The mean age of the sample was 19.63±3.11 years. The sample size was 30 out of which 13 participants were male and 17 participants were female (Table 1). The Mann-Whitney U test revealed that the mean pain score was higher in the CG than in the EG, and the difference between the two groups was significant (p=0.001). A significant difference was also observed when comparing pain score in individual arches in the CG as compared to EG (p=0.001) (Table 2). Also, the pain score was higher in mandibular teeth as compared to maxillary teeth in control (p=0.021) and EG, and the difference between the two groups was significant (p=0.012).

Female subjects had a higher score than male subjects in both groups, and the difference between the two groups was significant (Table 3).

The pain score was higher in the CG than in the EG in female and male subjects, and the difference between the two groups was significant (p=0.001) for females and non-significant for males (p=0.064) (Table 4).

For individual teeth pain scores, the maximum mean pain score was recorded for the lower right central and lateral incisors and the minimum for the upper right central incisor in the CG. For the EG, the maximum mean pain score was recorded for the lower right central incisors and the minimum mean pain was recorded for the upper left central incisors (Table 5).

The questionnaire regarding their experience with TENS therapy revealed that 50% of patients expected the debonding procedure was painful, whereas 76.7% reported mild pain. Thirty percent of patients had excellent responses, and 60%

Figure 2. TENS machine
TENS, transcutaneous electrical nerve stimulation.

reported excellent responses with TENS therapy. 93.3% patients agreed to use the same therapy as needed. Almost all the patients 100% agreed to recommend this therapy to friends and family, and only 13% of patients were aware of the TENS machine/therapy (Table 6).

DISCUSSION

Modern dentistry has increasingly prioritized minimizing patient pain and discomfort during dental procedures. However, in orthodontics, research in this area is relatively limited compared to other fields within orthodontics.[8] Pain remains a significant concern as it can impact patient decisions and treatment acceptability.[9] Management of orthodontic pain includes both pharmacological and non-pharmacological interventions. Pharmacological therapeutic therapies, however, may have some side effects and limitations. For these reasons, non-pharmacological treatments for orthodontic discomfort have also been explored, including chewing gum, bite-sized wafers, LLLT, vibratory stimulation, and TENS.[10]

TENS, approved by FDA in 1972, delivers a pulsed electrical current via electrodes on the skin to stimulate superficial nerves for pain relief.[4] It offers advantages such as non-invasiveness and safety, but its use in dentistry, particularly in orthodontics, has received only limited attention.

The analgesic action of TENS is mediated by two mechanisms: it stimulates the A-delta and A-beta fibers, which blocks the transmission of painful stimuli by the small unmyelinated C-fibers in the spinal cord; this is in accordance with Melzack and Wall's "gate control" theory. The endogenous opioid theory is an alternative explanation for this and was given by Reynolds. According to this theory, TENS stimulates the activation of local circuits within the spinal cord or from the activation of descending pain-inhibitory pathways, which results in the release of endogenous opioids in the spinal cord.[4] The present study evaluated the efficacy of TENS application to control pain during the debonding procedure in fixed orthodontic patients. The results showed that the pain score was higher in the CG than in the EG, and the difference between the two groups

Table 1. Demographic details of study participants

Variable	Category	Mean±SD/n (%)
Age	--	19.63±3.11 years
Gender	Male	13 (43.3%)
	Female	17 (56.7%)

SD, standard deviation

Table 2. Comparison of pain score between control and experimental groups of maxilla and mandible

Groups (n=30 each)	Mean±SD	Difference (95% CI of difference)	Maxilla	Mandible	P value Maxilla vs mandible	p value
Control	3.11±2.08	2.01 (1.16-2.85)	2.35±1.88	3.60±1.97	0.021	0.001*
Experimental	1.10±0.96		0.76±0.96	1.49±1.38	0.012*	

*p<0.05 indicating a statistically significant difference. SD, standard deviation; CI, confidence interval

Table 3. Comparison of pain score between maxillary teeth and mandibular teeth in the two study groups

Groups	Gender	n	Mean	SD	Difference (95% CI of difference)	p value
Control	Female	17	3.91	2.00	1.84 (0.40-3.27)	0.015*
	Male	13	2.07	1.76		
Experimental	Female	17	1.38	1.07	0.63 (-0.02-1.28)	0.094 (NS)
	Male	13	0.75	0.66		

*p<0.05 indicating a statistically significant difference. SD, standard deviation; CI, confidence interval

Table 4. Comparison of pain score between males and females

Groups	Gender	n	Mean	SD	Difference (95% CI of difference)	p value
Female	Control	17	3.91	2.00	2.53 (1.41-3.65)	0.001*
	Experimental	17	1.38	1.07		
Male	Control	13	2.07	1.76	0.63 (0.25-2.40)	0.064 (NS)
	Experimental	13	0.75	0.66		

*p<0.05 indicating a statistically significant difference. SD, standard deviation; CI, confidence interval

Table 5. Descriptive statistics of pain scores in different teeth in the control and experimental group

		Control group			Experimental group		
Tooth no	N	Minimum	Maximum	Mean±SD	Minimum	Maximum	Mean±SD
11	15	0	4	1.13±1.45	0	6	0.93±1.62
12	15	0	7	2.53±2.56	0	4	0.93±1.28
13	15	0	7	2.07±2.55	0	2	0.73±0.88
21	15	0	7	2.87±2.53	0	2	0.2±0.56
22	15	0	9	3.13±2.61	0	3	0.87±1.18
23	15	0	5	2.4±1.88	0	4	0.93±1.48
31	15	0	8	2.93±2.76	0	5	1.8±1.56
32	15	0	6	2.47±2.35	0	9	1.87±2.41
33	15	0	8	2.07±2.25	0	3	0.8±0.94
41	15	1	9	5.2±2.1	0	6	2.07±2.08
42	15	3	9	5.47±1.60	0	5	1.6±1.45
43	15	1	6	3.47±1.50	0	4	0.8±1.26

SD, standard deviation

Table 6. Descriptive table of responses of questionnaire to assess acceptance of TENS therapy by patients

	No pain	Mild	Moderate	Severe
1. What type of pain did you expect in the postoperative period?	1 (3.3%)	5 (16.7%)	15 (50%)	9 (30%)
2. What type of pain did you experience in postoperative period?	7 (23.3%)	23 (76.7%)	0	0
	Excellent	**Very good**	**Fair**	**Poor**
3. What was the quality of pain relief after TENS therapy?	9 (30%)	18 (60%)	3 (10%)	0
4. How was your overall experience with pain management/TENS therapy?	13 (48.3%)	14 (46.7%)	3 (10%)	0
	Yes		No	
5. Would you use the same analgesia modality again if required?	28 (93.3%)		2 (6.7%)	
6. Would you recommend the same modality to your family/friends?	30 (100%)		0	
7. Were you aware of this treatment modality prior to its application?	4 (13.3%)		26 (86.7%)	

TENS, transcutaneous electrical nerve stimulation

was significant (p=0.001) which indicated that the patients experienced less pain when subjected to TENS therapy.

This result is in accordance with two studies that have previously reported the use of TENS therapy for pain control in orthodontic patients. Roth and Thrash[2] demonstrated reduced pain in orthodontic patients receiving TENS therapy, while Haralambidis[7] found pain relief for up to 48 hours post-TENS application. Additionally, TENS therapy has also been reported to be effective for pain control in different dental procedures. Suzuki suppressed pain during cavity preparation using 4 to 10 AA through the bur.

Christensen and Radue[11] provided updates on TENS use for dental anesthesia, reporting a 50% success rate in 1987. Clark et al.[12] treated fifty patients, with an 80% effectiveness rate in the active group. Six hundred patients were examined by Hochman[13], with 76% experiencing pain relief. Jensen examined 35 people using three different waveforms and three different frequencies. Patients' expectations of pain were positively correlated with success. Malamed et al.[14] achieved an 86% success rate in 109 patients treated with H-Wave equipment.

Electrodes are crucial for TENS equipment. Intraoral electrodes come in sponges, conductive fabrics, and adhesive materials.[14] Different types of electrodes have been used in previous studies, such as through burs, and on the lip and mucosa, and extraoral pads. In this study, a modified electrode probe was used directly on the tooth's incisal edge. Roth and Thrash[2] noted rapid onset of analgesia with TENS, lasting for several hours. Therefore, in the present study, the current intensity was gradually increased until a mild tingling sensation was felt, then delivered for 60 seconds per tooth.

Debonding process should be swift, painless, and safe. Previous research analyzed the pain and discomfort during appliance implantation, but debonding pain remains process poorly understood.[6] According to Williams and Bishara[15] the mobility of the tooth and the direction of force application have a considerable impact on the threshold of patient discomfort at debonding. Patients have been found to be far more able to endure intrusive forces than mesial, distal, facial, lingual, or extrusive forces at the moment of debonding.[15] Applying a biting force stabilizes teeth and balances debonding pressures applied to the periodontal ligament. In addition,

increased pressure on the periodontal ligament can induce proprioceptive stimulation that lessens discomfort.[1] Therefore, in this study, debonding was performed mesio-distally with a plier, while applying intrusive force on the incisal edge of the tooth. The study found significant differences in pain scores between mandibular and maxillary teeth, with mandibular teeth exhibiting higher pain scores in both study groups. Additionally, females experienced higher pain levels compared to males, consistent with previous findings.

Study Limitations

The present study had some limitations, such as a small sample size and unequal number of males and females. It is recommended that more procedures should be evaluated at different time periods to evaluate the duration of pain control and follow-up. To test various electrodes, electrode placements, wave patterns, frequencies, and combinations with other pain control methods, a pain model that mimics the discomfort of surgical operations is required.

CONCLUSION

Within the limitations of this study, the following conclusions may be drawn:

• The application of TENS therapy results in pain reduction during the debonding procedure.

• The female subjects experienced more pain than the male subjects during debonding.

• Higher pain scores were recorded for the mandibular anterior teeth than for the maxillary teeth.

Patients displayed good acceptance and satisfaction with TENS therapy for pain control during the debonding of fixed appliances.

Ethics

Ethics Committee Approval: This study was approved by the I.T.S. Institutional Ethics Committee with protocol number: ITSCDSR/IIEC/RP/2019/014 and date: 22.11.2019.

Informed Consent: All patients meeting the inclusion criteria were given oral and written information by the operator and consented to participate in the study.

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