Original Article

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Dentistry Section

Evaluation of Sensibility Threshold of Dental Pulp to Electric Pulp Test (EPT) in the Teeth under Fixed Orthodontic Treatment with 0.014 and 0.012 Initial NiTi Archwire

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ABSTRACT

Introduction: The health and integrity of the dental pulp following orthodontic therapy is of major importance for tooth survival. EPT is a conventional method for evaluation of pulp vitality.

Aim: The aim of the study was to evaluate sensibility of the dental pulp to EPT in the teeth under fixed orthodontic treatment with 0.014 and 0.012 initial NiTi archwire.

Materials and Methods: In this study, 516 teeth (maxillary central and lateral incisors) were studied prospectively in 129 patients assigned to three groups: the 0.012 NiTi archwire, the 0.014 NiTi archwire and the control group. The aligning forces were administered using initial NiTi archwires of 0.012 and 0.014 ligated on fixed appliances by using the MBT straight wire technique. Stimulation of electrical sensibility threshold was done by EPT and was measured pre-bonding (EPT0), immediately upon initiation (EPT1) and one month post orthodontic therapy (EPT2). The data were analysed by paired sample t-test and one-way ANOVA test ($p<0.05$).

Results: The mean values of sensibility threshold for all the experimental and control maxillary incisors at EPT0, EPT1, and EPT2 times were 28.5, 40.8, and 38.0, and 23.2, 23.5, and 22.7 units respectively. The mean values of sensibility threshold for all experimental teeth at EPT0, EPT1 and EPT2 times were statistically different by using Paired sample t-test ($p<0.05$). Statistical analysis using one-way ANOVA shows that there is a statistically significant difference between sensibility threshold when groups were compared with the control group ($p<0.05$).

Conclusion: Following application of orthodontic forces, physiological changes of the dental pulp could affect the neural response. Response thresholds to electrical stimulation are also increased and consequently the EPT may not initiate a response. This finding is not an indication of loss of pulp vitality because after a few weeks the response threshold decreases. Therefore, the results of electrical pulp testing need to be carefully interpreted and closely scrutinised in orthodontics.

Keywords: Maxillary incisors, Orthodontic forces, Pulp tissue

INTRODUCTION

The health and integrity of the dental pulp during orthodontic treatment is of major importance for tooth survival [1]. Therefore, the effect of orthodontic treatment on the dental pulp vitality is of specific concern to the orthodontist. Orthodontic forces are known to produce cell damage, inflammatory changes, and circulatory disturbances in dental pulp as well as inflammatory reactions, cell and mechanical damage in the periodontium [2,3].

Different pulp dental tests have been planned and tested in order to assist the clinicians in diagnosis and treatment planning [4]. The current gold standard for detecting the actual state of pulpal health is histological examination of the dental pulp; but this method is neither practical nor feasible in clinical situation. Therefore, application of other methods is suggested to provide additional diagnostic information [5].

Dental Pulp vitality Tests (DPT) including Lesser Doppler flowmetry (LDF) and Pulse Oximetry (PO) are employed to assess the pulpal status of the teeth and measure the blood flow within the dental pulp directly [1,6]. These methods provide the clinician with valuable diagnostic and treatment planning information. However, the need for costly equipment, high technique sensitivity, long duration of the experiment, and possibility of false readings as a result of periodontium are among the limitations of such methods [5,7].

Pulp sensibility tests including thermal stimulation (cold and heat) and electrical stimulation have been widely used to indirectly determine the state of pulpal health by assessing the condition of the dental pulp [8].

EPT is a simple and non-invasive method which provides the clinician with qualitative sensory manifestations regarding the health status of the pulp tissue, as morphological changes of cells and dental nerve fibres are accompanied by abnormal responses to sensitivity tests [9]. EPT mechanism works on the principle that electrical stimuli instigate an ionic change across the neural membrane. As a result, it influences action potential with a fast jumping action at the nodes of ranvier in myelinated nerves [7]. Nevertheless, like thermal pulp sensibility tests (thermal and electric), it does not provide any direct information about the vitality (blood supply) of the pulp or if pulpitis or necrosis are suspected.

There are conflicting reports regarding the effect of orthodontic forces on pulp responses to EPT. Some studies have reported an increased level of sensitivity to EPT in teeth undergoing orthodontic forces [10,11]. Conversely, some of them reported decreased level of sensitivity [12,13].

The aim of the study was to determine the response of dental pulps to EPT before (EPT0), immediately after (EPT1), and one month subsequent to the initiation of orthodontic treatment (EPT2) in the patients under fixed orthodontic treatment with 0.014 and 0.012 initial NiTi archwire in comparison with the control group.

MATERIALS AND METHODS

This in-vivo study was performed on patients referred to department of orthodontics ward of dental faculty of Hamadan University of Medical Sciences, Iran from November 2015 to May 2018.

In this study, 516 teeth (maxillary central and lateral incisors) were studied prospectively in 129 patients assigned to three groups: the 0.012 NiTi archwire, the 0.014 NiTi archwire and the control group(each group consisting of 43 patients) at three stages during active orthodontic treatment. The Sample size was obtained from previous study [11,14]. Orthodontic patients were divided into two groups based on their types of NiTi archwires (0.012 and 0.014). The mean age of orthodontic patients using 0.012 and 0.014 NiTi archwires, and non-orthodontic group were 21.2±6.7 years (with a range of 12 to 33 years), 23.6±9.5 (with the range of 13 to 44 years), and 23.8±9.1 (with the range of 14 to 39 years), respectively. A total of 516 maxillary central and lateral incisors were tested.

All research participants provided written informed consent after full understanding of the study procedure. For participants under 18 years of age, consent forms were signed by their legal guardians. The study protocol was approved by the Ethics Committee of Hamadan Medical University.

Inclusion criteria: All cases in the study group had class I malocclusion (with health skeletal and dental deformities), healthy periodontium and positive initial EPT responses before orthodontic treatment.

Exclusion criteria: Consumption of any medications, systemic diseases, previous removable orthodontic appliances, history of orthodontic treatment and caries or restoration on the subjected teeth.

The 0.022- inch slot MBT prescription brackets were used and round NiTi 0.012 and 0.014 wires were applied in all cases. The aligning forces were achieved using NiTi archwires that were ligated on the maxillary teeth and fixed appliances on the erupted permanent teeth based on the MBT Straight Wire technique. NiTi archwires could apply continuous physiological force for tooth movement irrelevant to the amount of their deflection.

The selected teeth were dried and isolated by using cotton rolls and cotton gauze. Electrical stimulation was supplied by the EPT device (Parkell, Farmingdale, NY, USA). Examination procedures were performed by same operator and same EPT unit in accordance with manufactures' instructions. The electrical stimulator was applied to the test teeth (maxillary central and lateral incisors). The measured scale was a number between 0 and 64. The electrode tip was coated by toothpaste (Crest ® toothpaste, UK) as the conducting medium and was put at the midpoint of the incisal edge of each tooth. The probe did not contact the orthodontic brackets. Testing of each tooth started after contact of the electrode tip on the tooth surface and terminated when the beneficiaries raised their hands to show sensing the first sensation (heat or tingling). The numerical values on the digital display on the machine were recorded after each test. Teeth that failed to respond to electric testing were recorded as a reading of 64 EPT units.

During testing, current flow was raised gradually from the initial zero current state by adjusting the variable voltage control. Two consecutive measurements were done for each teeth at one minute intervals and the mean value of the consecutive measurements was calculated. The numerical values on the EPT display were recorded at three treatment points: prior to bonding of orthodontic brackets (EPT0); immediately (5 min) after bonding and ligation of initial archwires (EPT1) and one month subsequent to initiation of orthodontic treatment (EPT2). In the control group, the EPT values were recorded as EPT0 (baseline), 5 minutes after EPT0 (EPT1) and one month afterwards (EPT2).

The data collected from the orthodontic and non-orthodontic groups were categorised by subject, tooth type and time and also EPT responses. Statistical Package for Social Sciences, version 20 (SPSS-V20, Chicago, IL, USA) software, was used for the analyses. The paired sample t-test was used to assess the significance of the differences in EPT response between the test groups. One-way analysis of variance (ANOVA) was used to compare the differences in values of sensibility threshold between test teeth and control teeth. All of the analyses were performed with a confidence level of 95%. A p-values <0.05 were considered statistically significant.

RESULTS

The electric sensibility thresholds of each of 516 teeth (maxillary central and lateral incisors) were determined. All of the control group teeth responded to electric test stimuli. All teeth tested (516) gave positive responses to EPT within the first two time points (EPT0 and EPT1) and 12% failed to respond to EPT after one month. The mean thresholds of response to electrical stimuli for 516 teeth for double measurements are presented in [Table/Fig-1]. The mean values of sensibility threshold for 43 subjects (172 teeth) with NiTi archwires 0.012 for all maxillary incisors at EPT0, EPT1, and EPT2 were 31.21, 44.93, and 43.08 units, respectively. The mean values of sensibility threshold for 43 subjects (172 teeth) with NiTi archwires 0.014 for all maxillary incisors at EPT0, EPT1, and EPT2 were 25.75, 36.73, and 33.08 units, respectively. The mean values of sensibility threshold for 43 subjects (172 teeth) in the non-orthodontic groups for all maxillary incisors at EPT0, EPT1, and EPT2 were 23.25, 23.49, and 22.72 units, respectively. The experimental teeth showed higher threshold values than did the control group. The mean values of sensibility threshold for all experimental teeth at EPT0, EPT1 and EPT2 times were statistically different by using Paired sample t-test (p<0.05) [Table/Fig-1]. Statistical analysis using one-way ANOVA shows that there is a statistically significant difference between all teeth using orthodontic treatment with NiTi archwires 0.014 and 0.012 when compared with the control group (p<0.001).

Archwires	Teeth	Mean EPT0	Mean EPT1	Paired Sample t-test	Mean EPT1	Mean EPT2	Paired sample t-test	Mean EPT0	Mean EPT2	Paired sample t-test
NiTi 0.012	Right central	27.9±1.2	38.2±3.3	0.03	38.2±3.3	31.9±2.8	0.000	27.9±1.2	31.9±2.8	0.017
	Left central	24.9±2.3	46.7±3.7	0.000	46.7±3.7	43.0±2.5	0.000	24.9±2.3	43.0±2.5	0.000
	Right lateral	37.5±3.1	51.1±4.1	0.000	51.1±4.1	47.3±3.1	0.000	37.5±3.1	47.3±3.1	0.000
	Left lateral	34.3±1.8	53.6±4.3	0.000	53.6±4.3	50.1±2.9	0.000	34.3±1.8	50.1±2.9	0.000
NiTi 0.014	Right central	28.5±2.3	36.6±3.3	0.011	36.6±3.3	32.1±2.2	0.000	28.5±2.3	32.1±2.2	0.022
	Left central	24.4±1.1	36.4±1.1	0.000	36.4±1.1	31.9±1.0	0.000	24.4±1.1	31.9±1.0	0.000
	Right lateral	25.3±1.5	40.8±2.2	0.000	40.8±2.2	37.3±2.7	0.000	25.3±1.5	37.3±2.7	0.000
	Left lateral	24.7±1.4	32.9±3.2	0.000	32.9±3.2	31.0±2.3	0.000	24.7±1.4	31.0±2.3	0.01
Control group	Right central	19.7±1.8	20.2±2.2	0.126	20.2±2.2	19.7±1.8	0.32	19.7±1.8	19.7±1.8	0.764
	Left central	18.8±2.9	18.5±1.1	0.546	18.5±1.1	18.2±1.9	0.473	18.8±2.9	18.2±1.9	0.509
	Right lateral	26.7±3.1	27.4±2.2	0.183	27.4±2.2	26.2±1.9	0.206	26.7±3.1	26.2±1.9	0.244
	Left lateral	27.6±2.2	27.7±1.7	0.878	27.7±1.7	26.8±3.1	0.210	27.6±2.2	26.8±3.1	0.2

[Table/Fig-1]: Comparison of mean threshold responses between experimental teeth with control group.

DISCUSSION

After tooth movement, some physiological changes ranging from mild hyperemia to complete necrosis in dental pulp are believed to be caused by orthodontic forces. Among the contributing factors are the type of the applied force, the patients' age, the apical foramen size, duration, and the force dimension [15,16]. As a result, it is necessary to assess and monitor the dental pulp vitality during orthodontic treatment. Pulp vitality should be assessed by an ideal method which is standardised, accurate, reproducible, inexpensive, non-invasive, easily completed, non-painful, and objective [17]. In the present study, digital electric pulp tester was utilised due to its simple non-invasive test, clinical popularity and ease of use, and because its numerical display made it possible to quantify and standardise the test. Moreover, testing without touching the brackets is possible because of its small probe tip, and it causes no painful sensations [1,17]. As in other pulp sensibility tests, the main limitation of electric pulp test is that pulpal vitality assessment happens through stimulation of the sensory neural fibers which are unreliable as in dental traumas [18]. Therefore, the present study was aimed at investigating the sensibility thresholds in the maxillary lateral and central incisors in the patients who were under fixed orthodontic treatment with 0.014 and 0.012 initial NiTi archwires.

Factors such as the pressure applied to the electrode, lack of a dry working field, and the position of the electrode on the tooth can influence EPT measurements [17]. In this regard, in order to apply approximately the same pressure to the electrode in all measurements, a dry working field was applied, and the electric pulp testing was carried out by the same operator. The tip of the EPT probe was utilised on sound enamel on the midpoint of incisal edge of each tooth, which is the most suitable place for EPT because it is close enough to the highly innervated pulp horns, which helps avoid contact with orthodontic bands and brackets and provides a readily reproducible position for subsequent visits [11,19].

Almost immediately following the bonding of orthodontic appliances and ligation of the initial archwires (NiTi 0.014 and NiTi 0.012), the results of the present study showed, there was a significant increase in response threshold in the bonded teeth, while the threshold decreased after one month, but it still remained higher than the EPT value before initiation of orthodontic treatment. These findings are in agreement with the studies conducted by Modaresi J et al., and Burnside RR et al., who reported that an increase in response threshold could remain for up to nine months after treatment [11,20]. Also, Veberiene R et al., observed that there was an increase in the response threshold to EPT (by 3.5 times) in the dental pulps of orthodontically treated teeth compared with the control group seven days after orthodontic intrusive load initiation [21]. In the study of Vlad R et al., used electrical pulp testing for teeth subjected to orthodontic treatment with fixed appliances and the results showed that short after the forces were applied, there was an increase in threshold for electric stimulation [9]. This increase can be attributed to pressure or tension on apical nerve fibers [12,21].

In their studies, Alomari F et al., and Šimovic M et al., reported relatively constant response thresholds for the non-orthodontic group over a one month period after the experiments [1,17]. This finding proves EPT as a repeatable method.

Conversely, results by Barwick PJ et al., and Brodin P et al., showed no significant effect of a orthodontic force (intrusive and/or extrusive) on dental pulp vitality [22,23]. Studies have also demonstrated that application of orthodontic forces on teeth for certain periods of time increase the expression of various Growth Factors (GFs), such as Fibroblast Growth Factor-2 (FGF-2), Epidermal Growth Factor (EGF), Transforming Growth Factor beta (TGF-b), Vascular Endothelial Growth Factor (VEGF), and Platelet Derived Growth Factor (PDGF) in pulpal tissues, which in turn contribute to angiogenesis [24,25].

As indicated by previous studies, using orthodontic force is the main factor in determining EPT response threshold, and orthodontic force immediately affects pulp vascularity leading to hypoxia and inflammatory processes of the pulpal tissues [26,27]. Such changes in the blood flow are considered to be temporary which will return to normal status within a few days. It could be assumed that orthodontic forces could induce circulatory disturbances in altered tissue, which consequently reduces oxygen levels in the pulp. It is stated that such changes may influence pulp tissue, and can alter the integrity of the $A\delta$ and $A\beta$ fibers, resulting in an increased pulpal neural response. This issue is recommended to be taken into further account in future studies.

LIMITATION

False-positive and false-negative responses are commonly encountered with EPT test, especially when the examined teeth are immature or have undergone injuries that temporarily disable the sensory nerves [28]. Since the results of this test might be accompanied with errors, a correlation with other symptoms and clinical findings is necessary in order to have a correct diagnosis [29]. Further studies can be undertaken considering the above mentioned points.

CONCLUSION

After orthodontic forces are applied, neural response can be affected by physiological changes in dental pulp. Moreover, there will be an increase in response thresholds to electrical stimulation, which consequently causes the EPT not to initiate a response. This finding does not show loss of pulp vitality, because the response threshold decreases after a few weeks. Therefore, it is necessary to carefully interpret and closely study the results of electrical pulp testing in orthodontic patients.

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