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ORIGINAL RESEARCH

Evaluation of the changes of pulp response to the electric pulp test at different times in patients undergoing fixed orthodontic treatment

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Abstract

Background: Orthodontic treatment can be related to various pulp reactions such as hyperemia, pulp devitalization due to secondary dentin formation, internal root resorption, and pulp necrosis. The purpose of this study is to assess the changes in pulp response to an electric pulp test at two different time points in patients undergoing orthodontic treatment.

Materials and Methods: In this prospective descriptive analytical study, before bonding the brackets, the response to Electric Pulp Testing (EPT) was recorded in 22 patients who met the inclusion criteria. At intervals of 9 months following the initiation of treatment and 3 months after debonding the brackets (15 month after treatment began), the patients were called to repeat the EPT. Changes in the response to EPT were recorded at each time. The data were analyzed with Chi-square and Friedman statistical tests (α= 0.05).

Results: There was no significant difference in the response to EPT in incisor teeth 9 months after the start of treatment (P = 0.141) and 3 months after debonding (P = 0.585). Comparing the EPT test between the studied groups showed a significant difference. (P < 0.001).

Conclusion: Based on the results of this study most of the incisor teeth had an increased response to the electrical test in between intervals, although the difference in the recorded response was not significant. Also, the position of the teeth does not differ in the recorded response.

Key words: Orthodontic; Dental Pulp Test; incisor

Introduction

The health and integrity of the pulp are very important factors for the survival of teeth. A history of oral and dental pain in patients with fixed orthodontic treatment may be due to the physiological changes of the pulp as a result of orthodontic treatment. These changes can lead to a different response to pulp sensitivity tests (1). Orthodontic treatment is performed to restore the right occlusion, chew, and improve the beauty of the patient's face. However, like any other treatment, it has both benefits and risks. The force used to move the teeth during orthodontic treatment can cause an inflammatory process (2).

Tooth movement in orthodontic treatment is based on the force applied to the teeth in a certain period, which can range from months to years. These movements inevitably trigger biological reactions in the pulp and periodontal ligament. This becomes clinically significant when the pulp's reaction to orthodontic force can impact the long-term health of the tooth (1,3).

Excessive orthodontic force can destroy cementum hardness and tooth elastic modulus (4). It can also cause periodontal inflammation and metabolic changes, such as increased activity of Aspartate Aminotransferase and disruption in the odontoblastic layer. Additionally, it can cause damage to the pulp due to the lack of lateral blood circulation, which occurs due to orthodontic force and turns it into one of the most sensitive tissues in the body (3, 5, 6).

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After the application of orthodontic force, symptoms of pulp tissues damage can be detected early, including hemodynamic changes such as increased blood vessel volume and disruptions in blood circulation within the first few hours of force application.

Vitality tests are superior to pulp sensitivity tests for accurately assessing the health of damaged pulp (7, 8). Using devices on the teeth to increase or decrease the temperature and stimulate pulp sensory responses through thermal conductivity has been the most common method for pulp testing (9,10). The electric pulp test (EPT) is a pulp sensitivity test method based on stimulation of sensory nerves, which evaluates the vitality of the pulp by sending a gradual electric current that increases over time(11, 12). EPT registers a number from 0 to 80. Any reading below 80 indicates live pulp. If the reading is above 80, the pulp is considered dead, and the tooth may eventually become necrotic (13). Of course, the electric pulp test also depends on the mental reaction of the patient. Therefore, false positive and negative results should always be considered. When used correctly, electrical testing of the pulp is safe and can provide clinical information about the health status of the pulp (14-16). In the study conducted by Bhagat et al.'s (1), the electrical test threshold was higher for the orthodontic group compared to the group without orthodontic treatment. In the study performed by Cave et al. (14), shortly after applying orthodontic force, there was an increase in the stimulus-response threshold to the electric pulp tester, which remained at high levels until 9 months later. Then they observed negative responses to electric stimuli.

Utilizing a cold and electric test to assess pulp sensitivity during and after orthodontic treatment is a validated and reliable method. This study aimed to determine the response of pulp sensitivity in maxillary and mandibular incisors under orthodontic treatment.

Materials and Methods

This descriptive-analytical-prospective study (Ethic code: IR.IAU.KHUISF.REC.1402.064) analyzed the maxillary and mandibular incisor teeth of 22 female patients in the age range of 20 to 25 years. This age group was chosen for better cooperation and a reduced chance of caries and pulp calcification. Patients should be candidates for non-extraction fixed orthodontic treatment with minimum crowding so that only tipping movement would be necessary, with a duration treatment of one year, have maxillary and mandibular incisors with close apex at the time of treatment; maxillary and mandibular central and lateral teeth at the start of treatment should have a normal response to the cold test and be vital. All incisor teeth of the 22 patients (168 teeth) were included.

Patients were excluded from the study if they had any of the following conditions: previous orthodontic treatment or orthognathic surgery, use of medications affecting EPT response, systemic disease or pregnancy, periodontal disease (pocket depth greater than 3 mm), severe gingival recession, history of root canal treatment, deep caries restoration, coronal pulp calcification, root resorption, exposed dentin or dentin sensitivity, history of trauma or trauma from occlusion, history of bruxism, impacted canines, cleft lip and palate, immature incisors, mental health issues, or teeth requiring intrusion or extrusion forces during treatment.

After obtaining written consent from the patients, an orthodontic treatment plan was presented following a screening that included extra-oral and intra-oral examinations, as well as a review of panoramic and lateral cephalometric radiographs and dental casts.

Before starting the treatment and bonding the brackets, the teeth were isolated, and their surfaces were dried. The tooth surface was divided into 6 squares, and the middle third of the incisor surface, mesial of the bracket was chosen for the reproducibility of the measurement. Placing the probe tip on the incisal 2/3 of the crown gives more consistent results (15, 16). To perform and check the answer to the electrical test of the pulp probe tip, the electrical test was conducted with a toothpaste, and the corresponding measurement was made. (There should be no contact between the probe tip and the adjacent tissues and the device's wire). The machine wheel was set to number 3.

The patients were asked to give a manual or voice signal after understanding the stimulus and the response was recorded by recording the number of the EPT device. The response of the teeth was recorded in a checklist. At intervals of 9 months after the start of the treatment and 3 months after debonding of the bracket (15 months after the start), Pulpal electric test was performed again. Changes in the response to EPT were recorded at each time.

The data were analyzed using Chi-square and Wilcoxon statistical tests and SPSS version 27 software, and the error level set at 0.05.

Results

In comparing the changes in pulp sensitivity response between maxillary and mandibular incisors at two time

points—nine months after the start of treatment and three months after debonding—the Wilcoxon test results in Table 1 showed a significant difference in all the studied teeth between these two periods (P<0.05). The comparison of Figure 1 and Figure 2 confirms the result of Table 1, so that after nine months of treatment, the response to EPT test increased considerably compared to the beginning of treatment but three months after debonding it decrease compared to the nine months.

Table 1. Comparison of pulp sensitivity response in maxillary and mandibular incisors, between two times 9 months after the start of treatment and 3 months after debonding

Time	Response	Maxillary Central	Mandibular Central	Maxillary Lateral	Mandibular Lateral
		Percent	Percent	Percent	Percent
9 Months After the Start of Treatment	Increased response	90.5	95.2	85.7	97.6
	Decreased Response	-	4.8	9.5	-
	No Change in the Response	7.1	-	2.4	2.4
	Sensitive teeth	2.4	-	2.4	-
3 Months After debonding	Increased response	50.0	45.2	57.1	47.6
	Decreased Response	11.9	28.6	21.4	31.0
	No Change in the Response	33.3	23.8	19.0	19.0
	Sensitive teeth	4.8	2.4	2.4	2.4
Wilcoxon Test		-3.091	-3.318	-2.229	-3.987
P value		0.002	<0.001	0.026	<0.001

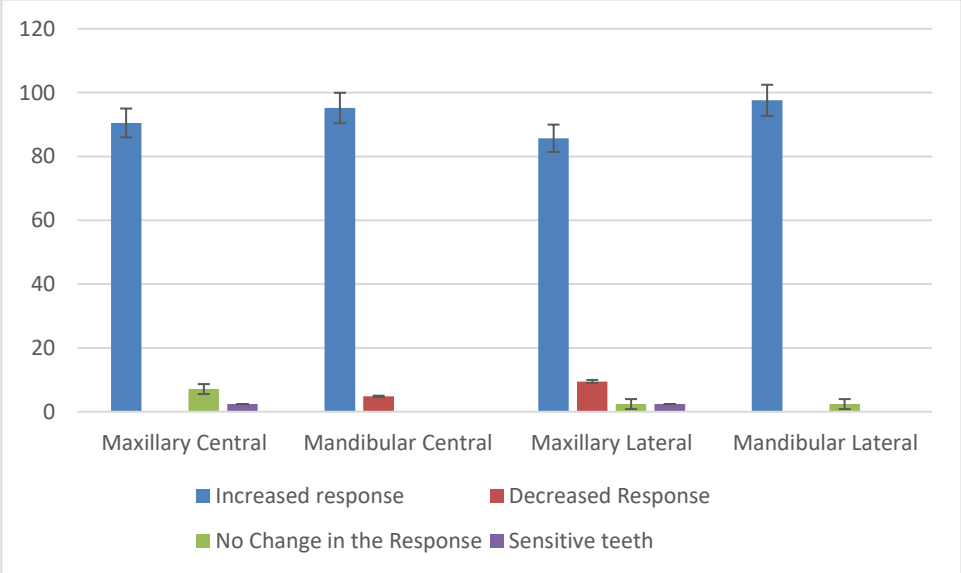

Figure 1. The percentage of test results according to the position of the teeth 9 months after the start of treatment

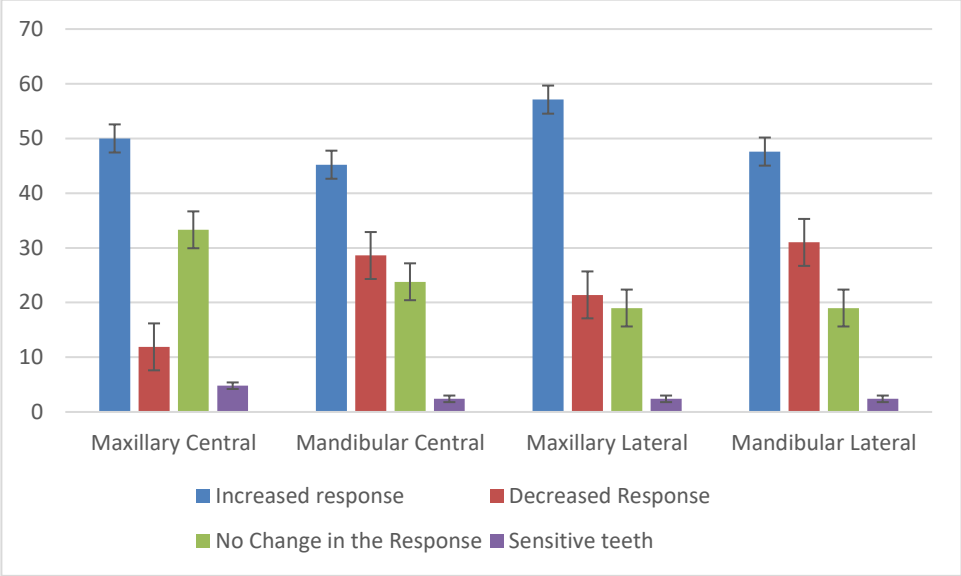

Figure 2. The percentage of test results according to the position of the teeth 3 months after fixed orthodontic debonding

Figure 2 shows the frequency of EPT test response results based on the time of the test that 9 months after the start of treatment, most people had an increased response to the EPT test, and the least number of people had sensitive teeth and three months after debonding the brackets, most people had an increased response to the EPT test, and the fewest people had sensitive teeth. The results of the Chi-square test in Table 2 showed that there was no significant difference in pulp sensitivity response in maxillary and mandibular incisors 9 months after the start of treatment (P = 0.141) and three months after bracket debonding (P = 0.571).

Table 2. pulp sensitivity response in maxillary and mandibular incisors, 9 months after the start of treatment and 3 months after fixed orthodontic debonding

Time	teeth	Increased response	Decreased Response	No Change in the Response	Sensitive teeth	P value
		No (%)	No (%)	No (%)	No (%)	
9 Months After the Start of Treatment	Maxillary Central	38 (90.5)	-	3 (7.1)	1 (2.4)	0.141
	Mandibular Central	40 (95.2)	2 (4.8)	-	-	
	Maxillary Lateral	36 (85.7)	4 (9.5)	1 (2.4)	1 (2.4)	
	Mandibular Lateral	41 (97.6)	-	1 (2.4)	-	
3 Months After debonding	Maxillary Central	21 (50.0)	5 (11.9)	14 (33.3)	2 (4.8)	0.571
	Mandibular Central	19 (45.2)	12 (28.6)	10 (23.8)	1 (2.4)	
	Maxillary Lateral	24 (57.1)	9 (21.4)	8 (19.0)	1 (2.4)	
	Mandibular Lateral	20 (47.6)	13 (31.0)	8 (19.0)	1 (2.4)	

Discussion

In the present study, all teeth showed an increased response to the test 9 months after the start of treatment and 3 months after the brackets were removed. However, the rate of increased response 9 months after starting the treatment was much higher than the three months after the brackets were removed. The number of sensitive teeth 9 months after treatment

was less than 3 months after the brackets were removed, which is consistent with the results of other studies (4, 5, 17).

Clinically, if the response to electrical stimulation is delayed or increased, it indicates that the pulp tissues are inflamed, as it takes more time to elicit a response to electrical stimulation. Conversely, if the pulp responds sooner to an electrical stimulus, it indicates the health of the pulp (18). There is also a possibility that the physiological changes in the pulp caused by orthodontic force led to this event (19).

A review study by Golež et al. (20) showed that dental movements in orthodontics can have a negative impact on pulp sensitivity. Orthodontic tooth movement increases the EPT threshold, and the risk of a negative pulp sensitivity test. Orthodontic tooth movements and patient age can be considered as risk factors that affect the result of pulp sensitivity. The risk of pulp insensitivity also increases to a lesser extent in the long term.

The results of the study by Khoshbin et al. (21) found that following the application of orthodontic force, the physiological changes of the pulp can affect the nerve response and increase the stimulation threshold. As result, EPT may not initiate a response, which is not a sign of pulpal necrosis. After a few weeks the response to orthodontic force will decrease. Modaresi et al. (22), studied the physiological changes of the pulp in the early stages of applying orthodontic force affecting the nerve fibers. As a result, the threshold of electrical stimulation increases, and EPT may not initiate a response contrary to the results of the present study, which could be due to the difference in the statistical population and the type of wires used.

The effect of orthodontic force on cement hardness and elastic modulus, as well as its effect on root resorption induction, and pulp tissue changes has been reported in several articles (18, 23, 24). Based on scientific evidence and clinical perspectives, it can be assumed that orthodontic treatment may endanger pulp vitality depending on the intensity and duration of the applied force. In the present study, the teeth showed an increased response to the EPT test for up to 3 months after debonding. In the study of Briseño-Marroquín et al. (25), increased sensitivity was observed one month after the start of treatment, and continued for up to 9 months after treatment.

According to the results of the current study, the mandible teeth had more increased response than the maxilla, although this difference was not significant. The reason for this increased response can be due to the application of different forces, the smaller surface of the crown and root, different types of jaw bone, which all lead to more pressure in the apical area (17). Additionally, the required amount of different orthodontic forces and morphological conditions are also effective (26). In the study performed by Modaresi et al (22), there was no significant difference according to the locations of the studied teeth.

In the study of Briseño-Marroquín et al. (25), all teeth responded to electrical stimulation at any time, but the threshold of this response was affected by the use of orthodontic force that the response sensitivity can be checked during orthodontics using an electric pulp test device. Also, consistent stimuli response threshold decreasing tendency was observed in all teeth groups. The maxillary first molar appeared to be the slowest, while the mandibular first incisor and canine showed the fastest recovery of electrical stimuli (27,28).

In the study of Allomari et al. (29), the response to the EPT tests in the experimental group increased during the treatment, reached the highest level after two months, and then returned to its initial value at the end. This was consistent with the findings of the current study, showing an increase in test response during the treatment period. However, in the present study, it did not reach its initial value after the treatment period, which could be due to the difference in the treatment duration of 12 months compared to 9 months in the present study.

The results of the present study showed that the anterior maxillary and mandibular teeth had a decreased reaction to the EPT test. In fact, the patient's response was recorded in higher numbers. In a study by Modaresi et al. (22), 16% of teeth showed higher EPT numbers of in the one-month examination, and in Briseño-Marroquín's study (25), the slowest response was observed in tooth 16 and the fastest in teeth 31 and 33.

It is a common belief that a reduced or unchanged response to an electrical stimulus indicates a non-vital pulp. However, results reported by various authors suggest a period after orthodontic movement or trauma in which the response threshold of electrical pulp stimulation may increase so that no response is possible. Orthodontic treatment reduces pulp blood flow, vacuolization, and disruption in the odontoblastic layer. In addition, increased expression of Calcitonin gene-rated peptide (CGRP) in the pulp due to excessive orthodontic force and increased angiogenic growth factors during orthodontic treatment has been observed (4, 5, 14, 30).

In Cave et al. study (14), after a short period of orthodontic force application, there was an increased response to the tests, and the increased response continued until 9 months after the start of treatment and before debonding, which is in line with the results of the present study. Such an increase in response to the test can be justified as a result of pressure or tension applied on the apical nerve fibers of the pulp (5, 30). Additionally, in Cave et al.'s study (14), the increased response to the test decreased after debonding, and the decreased response was much higher than when brackets were present. In Bhagat et al.'s study (1), the electrical test threshold for the orthodontic group was higher than the other group, which can be attributed to the physiological changes in the pulp caused by orthodontic force.

The electric pulp tester used in this study is clinically available, has an integrated and automated stimulus intensity unit scale, and is easy to operate. It has been reported that the threshold sensation it produces is not painful, making it an efficient and reliable method of pulp sensitivity testing (31).

Conclusion

The response to the electrical test in all the examined teeth during the treatment increased. However, after the treatment and removal of the brackets, the increased response and its amount decreased. However, the examined pulps continued to show an increased response until the end of the three months after the brackets were removed.

Conflict of Interests

The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or non-financial in this article.

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