RESEARCH ARTICLE

Effects of vibrations induced by electric tooth brush on amount of canine retraction: A cross sectional study done at University of Lahore

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Abstract

Objective: To evaluate the effect of localized vibration on amount of canine retraction after 1st premolar extractions and to assess the anchorage loss.

Methods: This quasi-experimental clinical study was conducted at University College of dentistry, Department of Orthodontics, University of Lahore. Data was collected from 30 patients who were already undergoing orthodontic treatment after taking their consent. The study was completed in one year, from Jan 2019 to Feb 2020. Results were compared with independent samples t-test using IBM-SPSS version 23.0.

Results: There was no statistically significant difference in the amount of tooth movement between the experimental and control side ($p= 0.22$). There was also no significant difference in the loss of anchorage (in terms of mesial movement of molar and rotation of canine) between both the groups ($p > 0.05$). Patients reported the use of electric tooth brush very practical and comfortable. No harm was observed.

Conclusion: Supplemental vibrations induced by electric tooth brush did not increase the amount of tooth movement in terms of canine retraction nor did it decrease the loss of anchorage.

Keywords: Accelerated tooth movement, light force, tooth vibration. (JPMA 72: 1740; 2022)

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Introduction

Orthodontic treatment is a complex treatment which on average takes up to about 24-36 months to complete. This long duration poses risks of dental caries, periodontal disease, root resorption and a drop of patient compliance.[1] So, Orthodontists worldwide are continuously working on developing new techniques to achieve a reduction in the time taken to complete the orthodontic treatment. In some patients the treatment is longer than usual owing to the complexity of treatment and patient related factors.[2] Any technique that would be able to accelerate the stage of canine retraction (enhancing space closure) may result in an overall decreased treatment time which is beneficial to both the patient and doctor.

A number of invasive and non-invasive procedures have been introduced to accelerate orthodontic tooth movement. The invasive procedures include corticotomy, periodontally accelerated orthodontics, piezocision, micro-osteoperforation and piezopunture.[2] While non-invasive techniques include pharmacological approaches such as the injection of prostaglandin, relaxins, cytokines and platelet rich plasma and physiological approaches such as photobiomodulation, pulsed electromagnetic fields, piezoelectricity, low dose laser therapy and vibration.[1,3]

Lately a method that has gained much popularity in attempt to accelerate orthodontic tooth movement is low frequency high magnitude vibration. The process of mechanotransduction takes place in the bone tissue at the level of osteocytes in response to various forms of mechanical loading via biological signals, resulting in an enhancement of turnover of alveolar bone.[4] Many studies were initially conducted on animals which revealed an increase in tooth movement after the application of vibration in association with light orthodontic forces.[3] Pavlin et al conducted a randomized clinical trial in humans with first maxillary premolar extraction to assess the effect of cyclic loading with an AccleDent (frequency of 30 Hz). The adjunct use of the cyclic loading with fixed orthodontic treatment led to an increase in tooth movement.[5] Similarly Bowman was able to demonstrate a 30 % decrease in orthodontic treatment time in Class II non extraction patients for leveling and alignment.[5] Whereas Miles et al conducted a randomized control trial in which he concluded that tooth movement did not accelerate after the application of vibration (frequency 11 Hz for 20 minutes) when compared with the control group.[4] Many studies have been done with the aim of accelerating orthodontic treatment using different devices and frequencies with which vibration was delivered. However none of them accounted for the loss of anchorage which could occur at both the maxillary canine and maxillary first molar during the retraction phase after maxillary first

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premolar extractions. This could have misled into assuming speedy space closure. So the aim of this study was to assess the effect of vibratory stimuli accompanying light orthodontic forces on canine retraction and to assess whether anchorage loss had occurred at the maxillary canine or maxillary first molar.

Patients and Methods

This quasi experimental clinical study was conducted at University College of dentistry, Department of Orthodontics University of Lahore; from January 2019 to February 2020 after obtaining Ethical approval. A sample size of 12 for each group (2 groups: 12 in control side and 12 in experimental side) was calculated using online sample size calculator (https://clincalc.com/stats/samplesize.aspx)[5] with 90% confidence level, test power of 80%, absolute effect of 0.92 and margin of error 5%.[6] To compensate for possible future dropouts, thirty patients (20 females and 10 males) aged 15-29 years were randomly selected after obtaining informed consent. All included patients were to undergo maxillary first premolar extraction with bilateral distalization of maxillary canines as a part of their orthodontic treatment plan for bimaxillary dental protrusion with maximum anchorage and presented with a periodontal status that was fairly good. Patients presenting with mutilated teeth (with hereditary abnormalities of dental hard tissue), class III malocclusion, facial asymmetry or medically compromised patients were excluded. Split mouth design was used in this study with the right side being the control and the left being experimental in all patients.

Roth prescription (Discovery brackets; Dentauram GmbH & Co.KG, Germany) slot size 0.22 using straight wire orthodontic appliance was placed on the maxillary arch of all the patients. Maximum anchorage preparation was done by installing a transpalatal arch with a nance button. The anchorage was further reinforced by ligating both banded maxillary second and first molar together with a 0.001"stainless steel ligature. Leveling and alignment was initiated with 0.014-in, 0.016-in and 0.016 x 0.022-in nickel titanium wires after which remaining leveling was carried out on 0.020 and 0.019 x 0.025-in stainless steel wires. The patients then got their maxillary first premolars extracted. The process of maxillary canine retraction proceeded using a 9 mm nickel titanium coil spring followed by 6 mm coil spring, which was stretched across the mesial hook from each maxillary canine to the hook on ispilateral maxillary first molar band, delivering a continuous light force of approximately 150 gm on both the control and experimental sides. The same force level was re-applied at the start of second and third month of maxillary canine retraction.

Standardized oral hygiene instructions were given to all participants as a routine protocol for orthodontic treatment. Each participant received a battery powered Oral B® deep cleaning action electric tooth brush (14,400 oscillations per minute). They were instructed to use the electric toothbrush three times a day after meals for 5 minutes i.e. total 15 minutes per day. The electric tooth brush was to be placed on the mesio-labial aspect (fig.1) of the right maxillary canine (experimental side) and not to be used to clean the teeth. A daily reminder in the form of text message was also sent as a reminder to each patient. The patients were asked to time the duration of electric toothbrush induced vibration application using a stop watch and to record it in a chart that was provided to them. The chart was returned to the orthodontist at each appointment.

A fresh alginate impression of the maxillary dentition was taken to obtain study models at each appointment. A number of landmarks were identified on each study cast. The mid sagittal plane was constructed by joining the most anterior point on the mid palatal raphe (anterior raphe point) with the most posterior point on the mid palatal raphe (posterior raphe point). This vertical plane was used

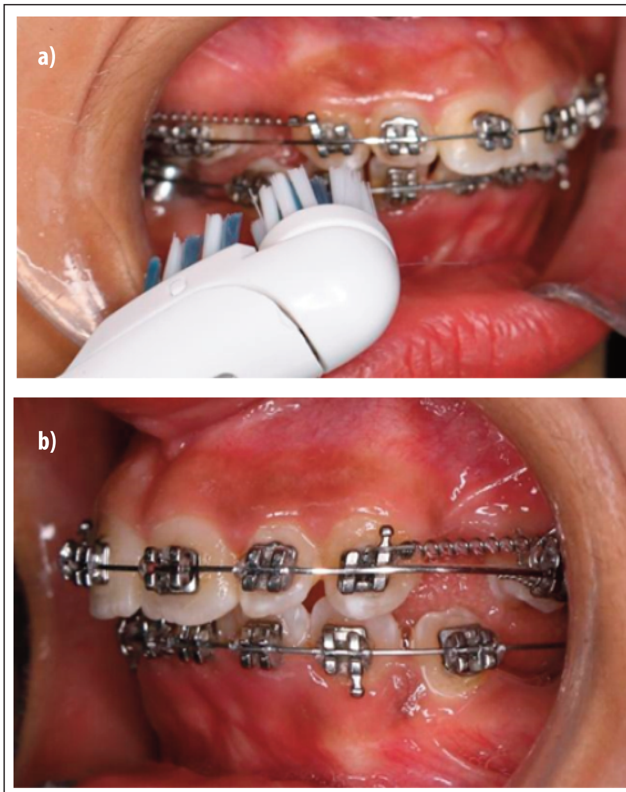

Figure-1: (a) Application of low magnitude high frequency vibration delivered by Oral B electric tooth brush on the mesiolabial surface of maxillary canine on the experimental side and (b) Control side at T0 where the vibration protocol was not applied.

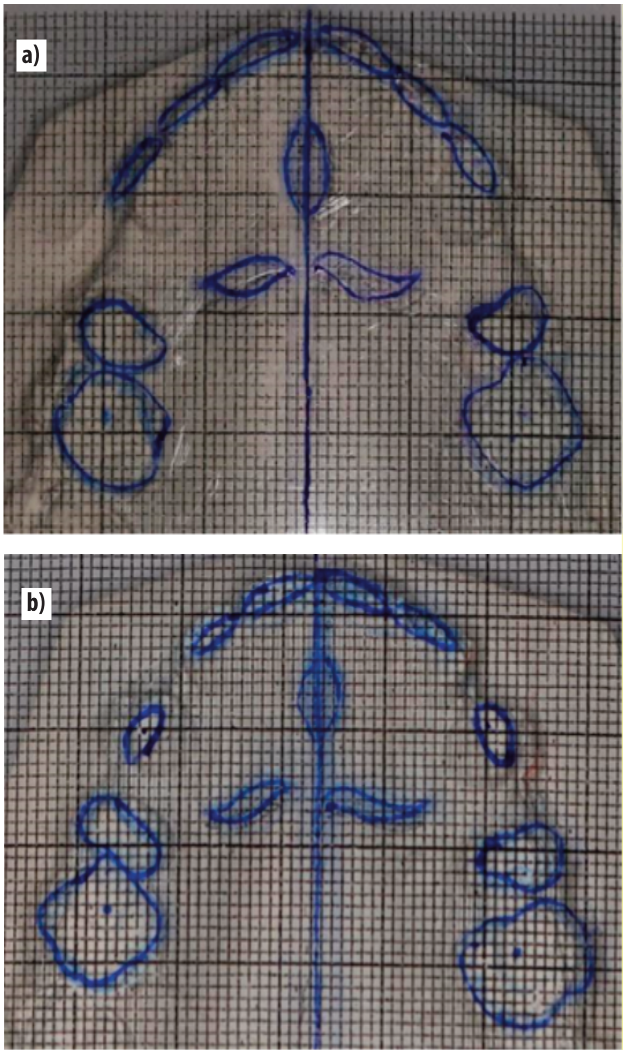

Figure-2: Mid palatal raphe line constructed by joining poinst a and b and transferred to an occlusogram of a dental cast before (a) and (b) after canine retraction.

as a reference plane for the various measurements. A second horizontal reference plane was constructed by joining the most mesial point of the third palatal rugae on both right and left sides of the mid palatal raphe. A number of points were also marked on the cast including the cusp tip, mesial and distal contact points of both right and left maxillary canines and the central fossa and buccal cusp tips of both right and left maxillary first molars. These landmarks were first superimposed on to occlusogram (Figure-1) after which they were transferred on to an acetate tracing paper (Figure-2).

Perpendiculars were dropped from both maxillary canine cusp tip points on to the horizontal reference line and the distance between these two points were measured with a

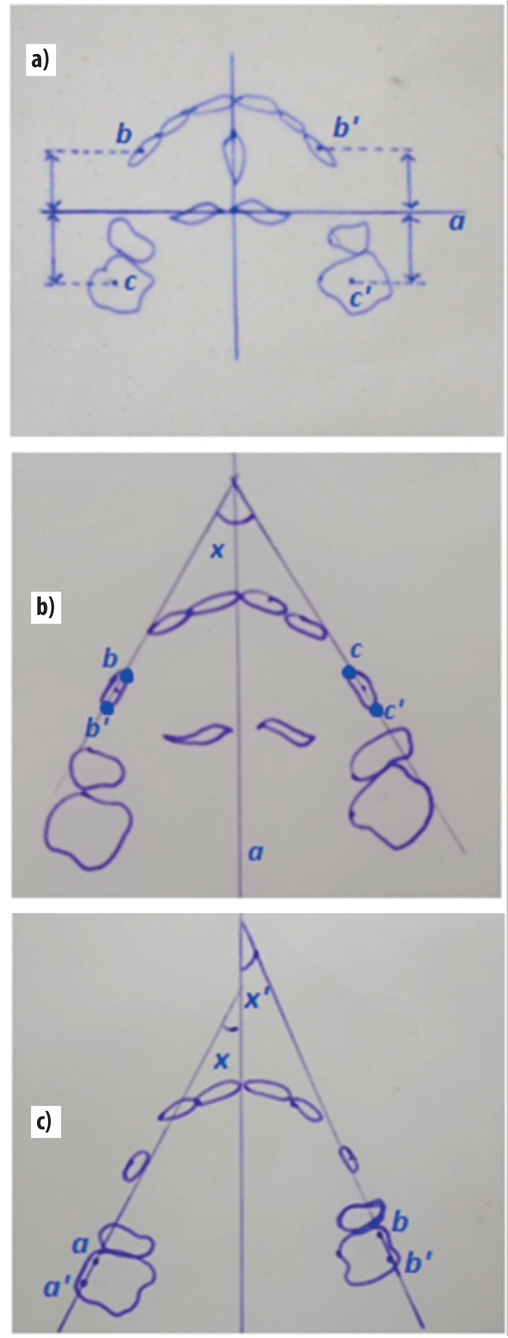

Figure-3: (a) Perpendiculars are dropped from point b and b' (the cusp tip points on maxillary right/left canine) and from point c and c'(the central fossa points on the maxillary right/left first molar) on the horizontal reference plane (a). Distance measured between b-a and b'-a marks the amount of canine retraction on the right and left side respectively. Similarly distance measured between c-a and c'-a marks the amount of mesial movement of maxillary first molar on the right and left side respectively. (b) Determination of canine rotation by measurement of angle x which is formed by a line passing through mesial and distal contact points (b-b') and (c-c') of the right and left maxillary canine respectively. (c) Determination of molar rotation is done by measuring the angle x and x' formed by joining the points on mesiobuccal and distobuccal cusp tip (a-a' and b-b') of the right and left maxillary first permanent molar respectively.

ruler at T_0 (before retraction began), at T_1 (4 weeks after retraction had started), T_2 (8 weeks after retraction) and T_3 (12 weeks after retraction). Similarly the amount of mesial movement of maxillary first molars was measured by drawing perpendiculars from the central fossa point on to the horizontal reference plane and measuring the distance with the help of a ruler at initial (T_0) and after 12 weeks (T_3)(Figure-3a).

Canine rotation was measured as the angle between a line joining the mesial and distal contact points of maxillary canine and the mid palatal reference plane. Similarly Molar rotation was measured as the angle between a line joining the cusp tip points of the maxillary first molar and the mid palatal reference plane. All of the measurements were repeated three times by the principal investigator and the average of three were taken. These measurements were taken for both sides at T_0 (before canine retraction) and T_3 (after 12 weeks of canine retraction). (Fig.3 b and c).

Data was entered and analyzed using SPSS version 23.0. Mean and standard deviation (SD) was calculated for canine retraction, molar retraction, canine rotation and molar rotation of control and experimental side. The Amount of Canine Retraction in 12 weeks was calculated by the difference between initial (T_0) and final position (T_3) for each case. Mean and standard deviation (SD) of the Amount of Canine Retraction for both groups was calculated and compared using independent sample t-test. Similarly, the Amount of Canine Rotation, Molar Retraction and Molar Rotation in 12 weeks were calculated and their means compared. P-value of 0.05 was considered statistically significant.

Results

There were no dropouts, so all of the thirty patients were included. Hence, there were 30 sides in the experimental group and 30 sides in the control group because of the split mouth design. In this study the average time of tooth brush use was 11.49 ±2.11 minutes. No discomfort was reported with the use of the electric tooth brush.

Results show that after 12 weeks of canine retraction, there was no difference in the Amount of Canine Retraction between the control and experimental side.

Table-2 show that anchorage loss in the form of molar mesialization was present in both groups to some extent but the difference between the control and experimental group was insignificant.

The difference between the anchorage loss in the form of maxillary canine and first molar rotation was also found to be statistically insignificant [Table-1, 2].

Table-1: Mean Comparison of the change in the position and rotation of Canine between Control and Experimental Group.

	Control (n=30) Mean±S.D	Experimental (n=30) Mean±S.D	*p*-value
Canine Position at T_0	9.82±1.66	9.52±1.55	
Canine Position at T_1	8.65±1.71	8.35±1.57	
Canine Position at T_2	7.48±1.39	7.07±1.38	
Canine Position at T_3	6.52±1.45	6.12±1.34	
Amount of Canine Retraction in 12 weeks in mm	3.3±0.62	3.4±0.52	0.22
Canine Rotational Position at T_0	26.9±3.8	27.0±5.0	
Canine Rotational Position at T_3	26.1±3.9	26.3±4.7	
Amount of Canine Rotation in 12 weeks in degrees	0.82±0.77	0.68±0.81	0.47

Table-2: Mean Comparison of the change in the position and rotation of First Molar between Control and Experimental Group.

	Control (n=30) Mean±S.D	Experimental (n=30) Mean±S.D	*p*-value
Molar Position at T_0	12.12±1.96	12.47±1.79	
Molar Position at T_1	11.37±1.79	11.33±1.70	
Amount of Molar Retraction in 12 weeks in mm	0.75±0.86	1.13±0.96	0.34
Molar Rotational Position at T_0	39.4±3.6	38.5±3.2	
Molar Rotational Position at T_1	39.4±3.6	38.5±3.2	
Amount of Molar Rotation in 12 weeks in degrees	0.00±0.26	-0.07±0.25	0.35

Discussion

Despite many recent advances in orthodontic devices and techniques, the average orthodontic treatment still takes up to 2 and 3 years to complete.[1] The goal of accelerating tooth movement is not only to reduce the treatment duration but also to decrease the side effects associated with prolonged orthodontic treatment. Among the different methods to accelerate tooth movement, patients prefer non-invasive procedures over invasive techniques.[7] Interestingly, they are even ready to pay up to 20% extra to try new methods to accelerate orthodontic treatment and reduce the overall treatment duration.[8]

Application of vibrational force using portable devices is a non-invasive technique to speed up orthodontic tooth movement. Since it has the convenience of being used at home, it may have better compliance. In our study patients were given ORAL B electric tooth brushes for applying vibrational forces. In our study, the frequency of vibrations was 14,400 compared to 125 Hz in a previous study.[9] For easy comparison we used the same duration of application of vibration.[9] A split mouth technique was employed to avoid any variability in terms of treatment effects that may have been present inter-individually.

A randomized trial conducted by Katoochi et al[10] using AccelDent as the vibrational force device in the treatment with invasalign had no effect on the final alignment within one week. Similarly another clinical trial conducted by Miles et al assessed the effect of vibrations induced by AccelDent on the rate of premolar extraction space closure in maxillary arch in forty one patients.[1] They concluded that there was no difference between the rates of space closure between both groups. The results of our study were similar to the above studies, as we found no difference in the amount of canine retraction between the control side and the experimental side.

On the other hand, a study conducted by Pavlin et al suggested that the orthodontic tooth movement was enhanced when supplemented by vibrational stimuli for 20 min/day at a frequency of 30 Hz. The amount of tooth movement for the AccelDent group was 1.16 mm/month where as it was 0.79 mm/month for the other group.[11] Bowman et al carried out a similar study using AcceleDent device. They noted a 30% increase of tooth movement during the leveling and alignment in non-extraction Class II treatment.[12] Leethanakul et al also did a study to assess the rate of space closure after maxillary premolar extraction and aided tooth movement with electric tooth brush induced vibrations. He found greater tooth movement on the experimental side compared to the control side (mean, 2.85±0.17 mm vs 1.77±0.11 mm, respectively).[4]

Our study used electric tooth brush as the device to apply vibrations to augment orthodontic tooth movement similar to Leethanakal et al. The major difference however, was the module used for the retraction of maxillary canine.[4] Leethanakul et al used elastic power chain stretched between the maxillary canine and maxillary first molar. This may result in a decay of the force applied by the elastic power chain due to the change in oral environment[13] and hence the retraction force applied may not be constant. On the other hand, we used Niti coil spring which exerts reproducible and constant forces of about 150g. This could explain why translatory movement was achieved without any tipping.

Anchorage loss is seen in all three planes of space when retraction of the canine is carried out. It can be controlled both intra orally and extra orally by different methods. In the present study, we made a single anchorage unit by banding the second maxillary molars and steel ligating them with the first molar and second premolar. A transplatal arch was also used to further increase the anchorage value. Retraction was carried out with the help of Niti coil spring which exerts a relatively constant force. In the presence of this assembly, there was almost no rotation and minimal forward movement of the first permanent maxillary molar while the maxillary canine was being actively retracted on both sides. Another possible explanation for minimal anchorage loss could be that the maxillary retraction was carried out just after the maxillary 1st premolar was extracted. At that time the extraction socket is refilled with regenerative bone tissue while the molars are still in the lag phase or are just beginning mesial movement.[14]

In a study on anchorage loss by Geron et al, the total loss of anchorage noted by them was 3.9-2.3 mm in patients who underwent maxillary 1st premolar extraction. They suggested that anchorage loss observed took place when the nance button was removed from the nance appliance for retraction of incisors (67%) rather than when the canine was actively being retracted (33%).[15] According to another study on the comparison of anchorage control using a conventional method and skeletal anchorage, they concluded that anchorage achieved was comparable using both methods and was stable enough to reach the desired treatment goals with no difference in the forward movement of molars.[16] Based on our results we can assume that we were able to control the anchorage loss with our protocol.

In order to control anchorage loss in the form of canine rotation, the force should pass through the center of resistance of canine. In our study we were able to reduce the rotational movement of canine by stretching the Niti coil spring between the hook of canine and molar resulting in a force that extended close to the center of resistance.

The main limitation observed in our study were: (1) we did not evaluate the inflammatory markers associated with the type of intervention; (2) the study was done on a small period of time i.e. 3 months follow up period; (3) compliance with the use of electric tooth brush was obtained by the log book provided to the patient and hence was not very accurate; (4) there could be errors in measurements as the dental casts were manually poured.

Patients reported that electric tooth brush was easy, practical and comfortable to use. However, compliance data is necessary irrespective of the gain of positive or negative results.

Current evidence regarding the effectiveness of vibration on accelerating canine distalization is of very low quality, mainly due to the lack of high-quality primary studies.

Conclusion

There was no added benefit of supplemental vibrations using house hold electric tooth brush on amount of space closure in maxillary 1st premolar extraction cases.

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Conflict of Interest: None.

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