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Original Research Article

Cyclic loading; its impact on the orthodontic tooth movement in growing patients: in vivo study

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ABSTRACT

Background: The objective of the study was to evaluate the impact of vibratory stimulation on the orthodontic tooth movement rate in growing patients and to compare the orthodontic tooth movement rate in experimental and control sides.
Methods: Split-mouth design study was done on 30 growing fixed appliance therapy orthodontic cases with bilateral first premolar extractions in maxillary arch. Individual canine retractions were performed in all the subjects with type-1 active tiebacks. Oral-B powered toothbrushes (125 Hz) were used to provide vibratory stimulation for 15 minutes per day (splits into 5 minutes thrice a day). The tooth movement was measured with calibrated digital vernier caliper clinically at various time intervals (T0, T1 and T2). OPG were taken at regular mentioned time intervals and grid method was used to calculate the tooth movement on OPGs.
Results: Results were evaluated statistically and the p-value revealed significantly increased rate of tooth movement on experimental side as compared to control side.
Conclusions: The high-frequency vibratory stimulation along with fixed orthodontic appliance can reduce treatment time expeditiously in growing patients. Powered toothbrushes can use successfully for providing vibrations to enhance the rate of tooth movement.

Keywords: Accelerated orthodontics, Vibrations, Vibratory stimulation, Grid method, Orthodontic tooth movement

INTRODUCTION

Orthodontics underwent many evolutions from old phase of metal banding to bonding braces, lingual orthodontics, aligners, self-ligating brackets and is still progressing. These appurtenances invigorate us to deliver better and faster results to the patients. With technology advancement, the aesthetics and fast results are becoming the key concepts of treatment objective.[1,2]

The most mystifying challenge in the orthodontic treatment is the long duration of the treatment. It takes couple of years for the completion of treatment which is troublesome for the patient as these long spans results in, caries, poor oral hygiene and the increased possibility of root resorption which leads to decrease in patient's cooperation and satisfaction. The pace of orthodontic tooth movement is an important aspect that determines the treatment duration. Thus, efforts to shorten the time of treatment would be beneficial to the patient and to the clinician both.[3-5] Innumerable methods have been developed and are still developing with the objective of accelerated orthodontic tooth movement and which can possibly reduce the overall treatment time.[2] One non-surgical approach that has acclaimed as potent method and has the possibility to fasten the tooth movement in orthodontics is Vibration. Vibration has proved its osteogenic response on bones.[5] Various studies on animals and humans were conducted and authors have different school of thoughts on the use of mechanical vibration in accelerated orthodontics. Studies by Liu and Kau et al demonstrated positive impact of vibration on rate of orthodontic tooth movement whereas studies by Woodhouse et al and Miles et al elucidated no such effects.[6-9] The projected study was conducted with the aim to evaluate the effectiveness of vibratory stimulation on the rate of orthodontic tooth movement in growing patients and to compare the rate of orthodontic tooth movement in both experimental and control groups.

METHODS

This study involves a parallel-arm and a split-mouth Clinical trial. The projected study was approved by the Institutional Human Ethical Committee and Institutional Research Development Committee. Projected study was conducted in the Department of Orthodontics and Dentofacial Orthopedics, Saraswati Dental College, Lucknow from January 2017 to December 2018. Convenience sampling method was used to collect the data.

The subjects who participated in this study were recruited from the pool of patients seeking fixed orthodontic treatment in the Department of Orthodontics and Dentofacial Orthopedics, Saraswati Dental College, Lucknow. Total 30 fixed orthodontic treatment cases of age 13 to 15 years undergoing bilateral maxillary first premolar extractions were selected based on certain inclusion and exclusion criteria. Written consent was taken from patient's guardians prior to the study. Each subject met the following inclusion and exclusion norms.

Inclusion criteria

Patients undergoing fixed orthodontic treatment with bilateral maxillary first premolar extractions. Patients having good periodontal condition and oral hygiene. Patients having complete permanent dentition

Exclusion criteria

Patients with impacted canines. Patients having poor oral hygiene. Patients with any systemic disease. Patient receiving analgesic prior to the treatment.

To avoid confusion, the right side of maxillary arch in all the patients was assigned as the experimental side and left side as the control side. The fixed orthodontic treatment was initiated with 0.022" slot preadjusted edgewise prescription bracket kit followed by bilateral maxillary first premolar extraction. Maximum anchorage was prepared and individual canine retraction was done with 0.019"×0.025" SS archwires ligated in maxillary arches. Type-1 active tiebacks given on to the experimental as well as the controlled side with 150 gm force, which was standardized with Dontrix gauge on both the sides (Figure 1).[10]

The patients were provided with powered electric toothbrushes having 125 Hz vibration and were instructed to place and hold the toothbrush on to the lingual surface of the right canine (Figure 2) for 15 minutes/day (which is splitted in 5 min each with the gap of 6 hrs) for 3 months. Standardized OPGs were obtained at 3 intervals: T0 (prior to the canine retraction), T1 (after one month of initiation of canine retraction) and T2 (three months after the initiation of canine retraction). Standardized OPGs were obtained using same exposure parameters (73 kVp, 08 mA, exposure time 13.9 sec) with 100% magnification and the same machine (Kodak 8000C Digital Panoramic and Cephalometric machine operating with Kodak Dental imaging Software and Cephalometric Acquisition Interface Module) at a constant distance.

The x-rays were printed using Fujifilm Medical Dry Imaging film (10×8 inches in size) and the Fujifilm Dry pix plus printer. Tracing of all the relevant structures were done manually by the same operator twice to avoid inter operator error and average values were taken. Landmarks traced were maxillary canines, maxillary second premolars and maxillary first molars. Measurements were obtained using grid method and with the help of digital vernier caliper, from long axis of maxillary canine to long axis of second premolars and long axis of maxillary canine to long axis of buccal cusps of first molars at crown tip and root apex on both experimental and control sides at T0, T1 and T2 on OPG (Figure 3).[11]

Statistical analysis

The collected data were thoroughly screened and entered into MS-Excel spread sheets and analysis was carried out using Statistical package for social sciences (SPSS) version 20. Descriptive statistics and Paired t-test was used to assess statistical significance of differences observed. $P \leq 0.05$ was considered statistically significant.

RESULTS

Result was obtained at various time intervals from the mentioned landmarks and was presented in frequencies, percentages and mean±SD. Comparison of the monthly rate of canine retraction measured from canine to second premolar between experimental and control side (T0-T1) was significantly higher ($p=0.001$) on to the experimental side (2.41±1.04 mm) as compare to control side (2.27±1.02 mm) (Table 1, Figure 4).

Table 1: Comparison of tooth movement between experimental and control side from T0-T1 (13-15 and 23-25).

Side	Movement (in mm) (Mean±SD)
Experimental side (13-15)	2.41±1.04
Control side (23-25)	2.27±1.02
P value[1]	0.001*

[1]Paired t-test, *Significant

Table 2: Comparison of tooth movement between experimental and control side from T0-T2 (13-15 and 23-25).

Side	Movement (in mm) (Mean±SD)
Experimental side (13-15)	3.73±0.98
Control side (23-25)	3.46±0.91
P value[1]	0.001*

[1]Paired t-test, *Significant

Table 3: Comparison of tooth movement between experimental and control side from T0-T1 (13-16 and 23-26).

Side	Movement (in mm) (Mean±SD)
Experimental side (13-16)	2.73±1.10
Control side (23-26)	2.56±1.04
P value[1]	0.001*

[1]Paired t-test, *Significant

Table 4: Comparison of tooth movement between experimental and control side from T0-T2 (13-16 and 23-26).

Side	Movement (in mm) (Mean±SD)
Experimental side (13-16)	4.15±1.04
Control side (23-26)	3.83±0.99
P value[1]	0.001*

[1]Paired t-test, *Significant

The comparison of tooth movement between experimental and control side from T0-T2 (13-15 and 23-25) was significantly (p=0.001) higher in experimental side (3.73±0.98 mm) compared to control side (3.46±0.91 mm) (Table 2, Figure 5).

Values for the comparison of tooth movement between experimental and control side from T0-T1 (13-16 and 23-26) was found to be significantly (p=0.001) higher in experimental side (2.73±1.10 mm) compared to control side (2.56±1.04 mm) (Table 3, Figure 6).

Figure 1: Force measured with Dontrix gauge

Figure 2: Vibratory stimulation introduced with toothbrush

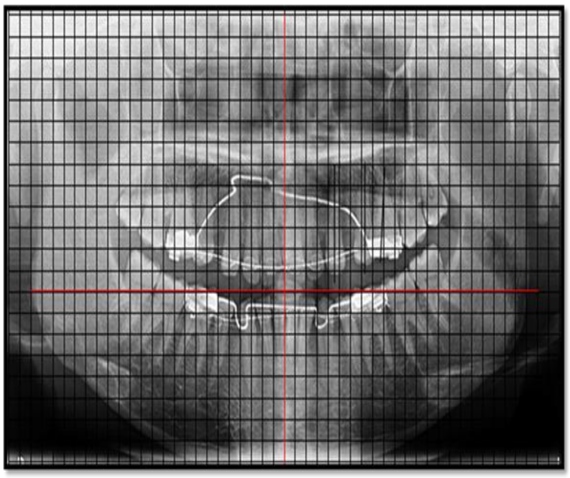

Figure 3: Orthopantomogram used for measurements of tooth movement.

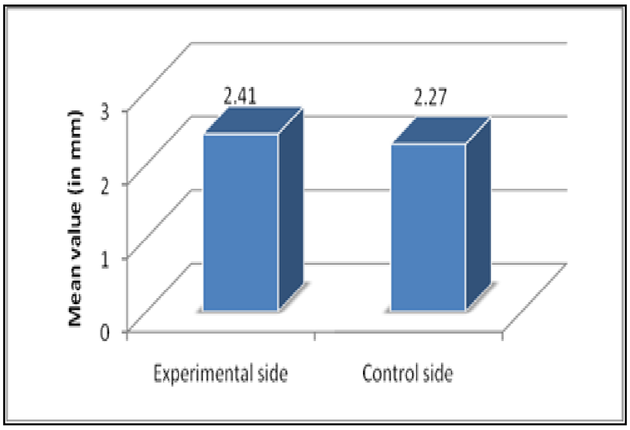

Figure 4: Comparison of tooth movement between experimental and control side from T0-T1 (13-15 and 23-25).

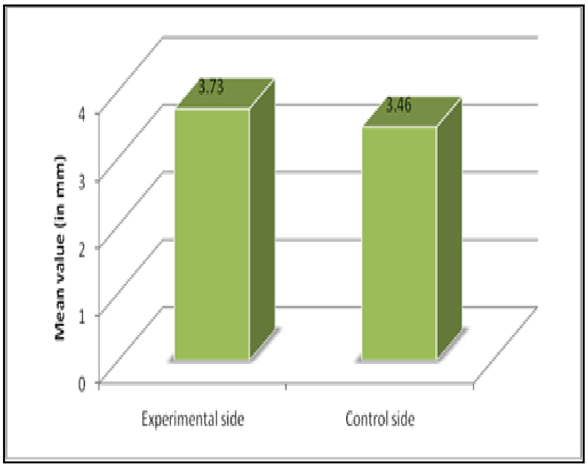

Figure 5: Comparison of tooth movement between experimental and control side from T0- T2 (13-15 and 23-25).

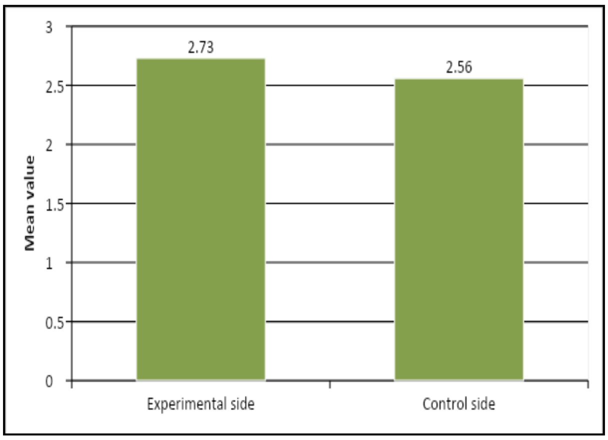

Figure 6: Comparison Of tooth movement between experimental and control side from T0-T1 (13-16 and 23-26).

Final comparison of tooth movement between experimental and control side from T0-T2 (13-16 and 23-26) was also found to be significantly ($p=0.001$) higher in experimental side (4.15±1.04 mm) compared to control side (3.83±0.99 mm) (Table 4, Figure 7). The results disclosed that the rate of orthodontic tooth movement was significantly higher on the experimental side as compared to control side from the time period T0-T1 and T0-T2 when measured from 13-15, 23-25, 13-16 and 23-26 in growing patients.

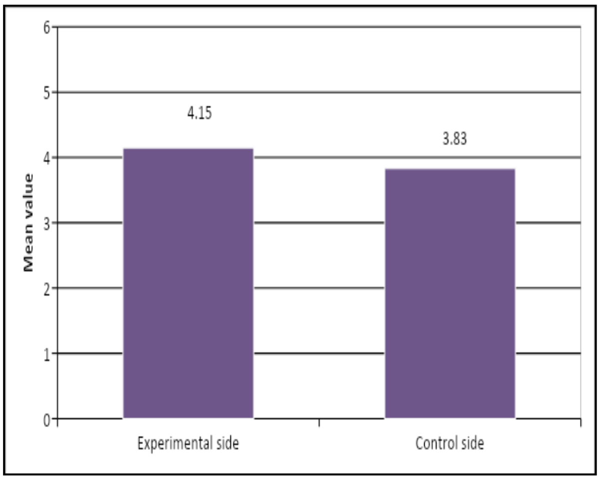

Figure 7: Comparison of tooth movement between experimental and control side from T0-T2 (13-16 and 23-26).

DISCUSSION

Vibration therapy recently gained the attention as the potential approach in the field of accelerated orthodontic tooth movement. There are growing evidences that prove its efficacy. Certain studies done by Showkatbakhsh et al and Bowman demonstrated the positive effect of vibrational therapy.[12,13] In contrast to this, studies done by Woodhouse et al and Pavlin et al showed no influence of vibration on to the rate of tooth movement.[4,8] Oral–B battery powered toothbrushes (125Hz) were used in this study for providing vibratory stimulation. A correlative study conducted by Leethanakul et al also used battery powered toothbrushes (Colgate Motion multi-action, 125 Hz) along with canine retraction to predict the rate of orthodontic tooth movement and reported positive results without any pathological effects after application of vibrations with battery powered toothbrushes.[14] Acceledent™ and OrthoAccel are commercial devices available for vibration therapy and studies done by Kau et al, Pavlin et a showed their positive role in reduction of orthodontic treatment duration.[7,14] On the contrary, studies done by Cobourne et al, Katchooi et al demonstrated no such effect of these vibration devices which made their use questionable.[15,16] Also, these devices are expensive and majority of patients cannot afford these, thus we preferred toothbrushes as these are practical and cost effective to use for stimulation purpose. Liao et al in their study mentioned that all-teeth vibration with such devices (Acceledent™, OrthoAccel) had less control and also, target tooth receives vibration of lower frequency as compared to electronic toothbrushes that targets single tooth, which favors the choice made in this study.[17]

Vibrational frequency is another topic of discussion and is an important consideration for the efficient use of devices. Different studies used different frequencies for vibratory stimulation. Yadav et al, Liao et al and Bozkurt in their studies supported low-frequency (30-60 Hz) as virtual method for speedy tooth movement whereas, Woodhouse et al, Bowman, Katchooi et al showed dissimilar results with same frequency level.[8,13,16] Kalajzic et al in their study used 30 Hz vibrational frequency and observed that low-frequency vibrations significantly decreased the rate of tooth movement by inhibiting osteoclastic activity.[19] They suggested that low-frequency vibrations are responsible for reducing number of osteoclasts, thus causing contrary effects. Rubin et al in their study analyzed that bone formation increased with high-frequency vibrations as compared to low-frequency.[20] Other studies by Leethanakul et al and Alikhani et al demonstrated that high-frequency produced strong impact over the acceleration of tooth movement as compared to low-frequency.[14,21] Lala in his review article quoted various studies and concluded that high-frequency vibrational forces have more osteogenic effects thus have positive impact on rate of tooth movement.[22] Majority of the studies described positive results with high-frequency vibration, thus we used high-frequency vibration stimulation as it is convinced to be more potent. Instead of segmental approach for canine retraction, we tend to used sliding mechanics with tight bracket wire interface to reduce the risk of second order tipping, rotational and vertical displacements. This is in accordance with the study by Pavlin et al according to whom side effects of segmented arch mechanics is troublesome to regulate.[4] In distinction, Leethanakul et al used segmental canine retraction approach, however, unexpected distal tipping of both experimental and control teeth was observed in their study Standardized OPGs were taken at mentioned time intervals i.e, T0, T1 and T2 for the measurement of space closure with certain degree of accuracy.[14]

Measurements were done from cusp tips as well as root apex in case any crown tipping if present, with the help of grid method. This is in accordance with Khan et al study, in which they used OPG for the measurements of space closure.[11] Despite the efficiency and versatility of CBCT, OPG was chosen because of its cost-effectiveness and low radiation dose. The comparison of the monthly rate of canine retraction measured from canine to second premolar between experimental and control side (T0-T1) was measured. The mean value at experimental side was found to be 2.41±1.04 mm and at control side was 2.27±1.02 mm. The p-value was calculated which revealed that the tooth movement was significantly (p=0.001) higher on to the experimental side (2.41±1.04 mm) compared to control side (2.27±1.02 mm) with the mean difference of 1.4 mm.

Similar results have been shown by Showkatbakhsh et al and Pavlin et al with increased movement at vibrational side as compared to non-vibrational side.[12,4] The comparison of the monthly rate of canine retraction measured in both experimental and control side (T0-T2) from canine to second premolar indicated significant results (p=0.001). The tooth movement reported was higher on to the experimental side with the mean value (3.73±0.98) mm as compared to control side with the mean value of (3.46±0.91) mm. It indicated that the vibrational forces speed up the orthodontic tooth movement. Monthly rate of canine retraction measured from canine to first molar for experimental and control side (T0-T1) was compared. Values suggested that the rate of tooth movement was found to be significantly (p=0.001) higher in experimental side (2.73±1.10) mm as compared to control side (2.56±1.04) mm. This significant result concluded that the use of cyclic loading accelerates the rate of tooth movement which is in agreement with the study done by Liao et al who examined the clinical efficacy of vibration and observed that space closure and canine distalization of vibration group was significantly higher (p<0.05) than those of control groups.[17] The comparison of the monthly rate of canine retraction measured from canine to first molar between experimental and control side (T0-T2) was calculated. The p-value revealed that the tooth movement was significantly (p=0.001) higher in the experimental side (4.15±1.04 mm) as compared to the control side (3.83±0.99 mm) with the mean difference of 0.32 mm. This result was similar to the results by Showkatbakhsh et al that illustrated increased movement at vibrational side as compared to non-vibrational side.[12] The results disclosed significant difference between experimental and control side at various time intervals and concluded that high-frequency vibratory stimulation along with fixed orthodontic appliance can reduce treatment time expeditiously. The rate of orthodontic tooth movement was significantly higher on the experimental side as compared to control side from T0-T1 and T0-T2 when measured from 13-15, 23-25, 13-16 and 23-26.

There are few limitation of the study, the sample size of the study was small, also the study was done for a short span of time. Orthodontic Tooth movement requires more time to obtain the desired results. Moreover the study was done using 125 Hz Frequency only and with 15 mins time duration. Further studies with different frequency and long span of time are required to show variable results.

CONCLUSION

The projected study found a potentially favorable impact of supplemental vibrational force on the rate of orthodontic tooth movement in growing patients. The results disclosed significant difference between experimental and control side at various time intervals and concluded that high-frequency vibratory stimulation along with fixed orthodontic appliance can reduce treatment time expeditiously in growing patients. The rate of orthodontic tooth movement was significantly higher on the experimental side as compared to control side from T0-T1 and T0-T2 when measured from 13-15, 23-25, 13-16 and 23-26. Commercially available battery powered toothbrushes with 125 Hz frequency used for 15 minutes/day (splits into 5 minutes three times a day), can be used efficiently to accelerate the orthodontic tooth movement. The use of battery powered toothbrushes did not display any discomfort to the patients.

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Conflict of interest: None declared
Ethical approval: The study was approved by the institutional ethics committee

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