Original Article

Powered toothbrushes: can they be used as a vibratory device for accelerating the rate of orthodontic tooth movement?

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ABSTRACT

Introduction: In recent time there is surge in application of various methods to accelerate orthodontic movement. The associated potential side effects of biological and surgical stimulus led to the popularization of noninvasive method in which vibratory stimulation had been reported to be effective in accelerating orthodontic tooth movement. Commercially available vibratory devices have shown contradictory results regarding their effect on increasing the rate of orthodontic tooth. Vibratory toothbrushes, as an alternative to provide vibratory stimulus has also showed positive results in increasing the rate of tooth movement.

Aim and objectives: To validate the efficacy of mechanical vibration through powered toothbrushes in accelerating the rate of orthodontic tooth movement..

Material and methods: This was a prospective controlled clinical trial; sample consisted of 25 patients within the age range of 15-25 years, undergoing fixed orthodontic treatment. Maxillary first premolars were extracted at least four month prior to canine retraction. A force of 150 gm. was delivered from active module tie for retraction of canine. Subjects were instructed to apply vibratory stimulus through powered toothbrush (60 Hz frequency) only on experimental site for 5 min at 8 hour interval every day, for three months and in fourth month no vibratory stimulus was given. Study models were made and distance of maxillary canine distal movement (mm) was measured with vernier caliper after every 4 weeks (each month) from beginning of the canine retraction.

Results: There was no significant difference in rate of orthodontic tooth movement after first, second and third month consecutively on comparison between control and experimental site. While fourth month showed less tooth movement of experimental side as compared to control side.

Conclusion: Our findings suggest that vibratory stimulation from powered toothbrushes had no effect on accelerating the rate of orthodontic tooth movement.

Key words: Vibratory stimulation, Powered toothbrushes, Rate of orthodontic tooth movement.

INTRODUCTION

Reducing the orthodontic treatment duration has recently become a subject of prodigious research. By accelerating the biologic response through increase in alveolar bone remodeling, we can increase the rate of tooth movement.[1-10] Piezoelectric theory states that when the stresses or forces are applied on the tooth, the adjacent alveolar bone bends, this leads to deformation of crystalline structure in bone and in its response piezoelectric signals are generated, thus producing osteogenic response and eventually causing tooth movement. Shapiro et al[10] suggested that to increase the rate of tooth movement, the orthodontic forces should not be continuous, since the piezoelectric charges are created only when stress is applied and released and should be cyclic in nature. In turn cyclic forces impact cells multiple times (frequency in Hz). Therefore, vibrational appliances could be effective in accelerating orthodontic tooth movement through stress-induced changes by applying intermittent forces.

Various researches have been conducted to find out the effectiveness of application of such cyclic forces via low frequency mechanical vibrations on alveolar bone to increase the rate of tooth movement. Nishimura et al.[11] has shown in Wistar rats that approximately 15% more tooth movement was achieved in 21 days by utilizing resonance vibration for 8 minutes per day. These findings have led to the development of several commercially available vibrational appliances for clinical use towards reducing the overall orthodontic treatment duration.

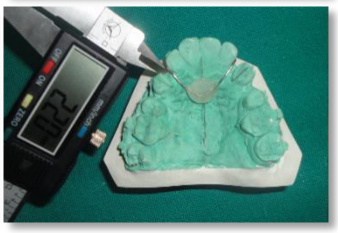
But, there are conflicting results about the effect of vibratory stimulus on increasing the rate of tooth movement. Peter Miles [12] (2016) found that during initial leveling and alignment phase in lower arch, there was no effect of Acceledent aura appliance on the rate of tooth movement as recorded by irregularity index. Whereas, Pavlin[13] et al showed that vibratory stimulus of 0.25N

(25g) at frequency of 30HZ when applied through Acceledent displayed increase in OTM. Leethankul [14] et al used powered tooth brush to apply vibratory stimuli during maxillary canine retraction and concluded that OTM was increased significantly on experimental side.

Thus, the aim of this study was to evaluate if vibratory stimulus through use of alternate device such as powered toothbrushes can increase the rate of tooth movement.






Objectives and hypothesis

1. To validate the efficacy of mechanical vibration through powered toothbrushes in accelerating the rate of orthodontic tooth movement.

2. To study the efficacy of vibratory toothbrushes in accelerating the rate of tooth movement.

This study was based on null hypothesis that with the use of vibratory toothbrush, there is no acceleration in rate of tooth movement.

Material and method

Participants

This was a prospective controlled clinical trial done in the Department of Orthodontics and Dentofacial Orthopaedics. Ethical committee approval was taken before conducting study. A detailed medical history was taken for each patient followed by a thorough clinical examination. Both the parents and the subjects were informed about the details of the study procedure and an informed consent was obtained from each patient or parents/guardians. Participants were informed that there is no obligation on them to participate in the study so only those eligible participants were selected who agreed to compliance were included in the study.

For the study eligibility following Inclusion Criteria were applied:

Patients age from 15-25 years,

Requiring maxillary or both arch bilateral first premolars extraction and space closure required.

Patient having good oral hygiene maintenance and brushes at least twice daily prior to the treatment.

Exclusion Criteria

1. Patient having any systemic disease, receiving analgesic therapy prior to onset of treatment.

2. Loss of any permanent tooth.

3. Patient having chronic periodontal disease.

INTEREVENTION

All the subjects were asked to continue their regular tooth brushing for 3-5 minutes, three times a day with conventional tooth brush. After cleaning the teeth patients were instructed to use vibratory toothbrush with frequency of 60 Hz (figure 1) only on experimental site for 5 min at an 8 hour interval every day (total 15 minutes per day) for first three months. In the fourth month no vibratory stimulus was given by powered tooth brush and they were told to do only conventional brushing on both the side.

Subjects were instructed not to clean their teeth with vibratory tooth brushes, rather they were told to use the toothbrush to apply mechanical vibration on labial (figure 2) and palatal surface of maxillary canine (figure 3) for 2.5 minutes on each surface. Extraction were done at least four months prior to canine extraction. After leveling and aligning of the upper arch with 0.014”, 0.016”, 0.018”, 0.20”, 17×25”and19×25”NiTi, Stainless steel 0.019×0.025 inch arch wire was placed along with active module tie from the molar hook onto the canine hooks bilaterally (figure 4) after calibrating the force to 150 gm. using a SomlyTec (France) gauge (figure 5).

Table 1. Mean, Standard deviation, Maximum scores, Minimum scores & Median scores of rate of tooth movement in control & experimental groups respectively at different time intervals

S.N.	STATISTICAL PARAMETERS	T 0 INITIATION		T0-T1 FIRST MONTH		T1-T2-SECOND MONTH		T2-T3 THIRD MONTH		T3-T4 FOURTH MONTH	
		CONT.	EXP.	CONT.	EXP.	CONT.	EXP.	CONT.	EXP.	CONT.	EXP.
1	MEAN	0	0	1.14	1.1	1.02	.87	.96	.84	.93	.77
2	STANDARD DEVIATION	0	0	.46	.37	.34	.32	.38	.28	.38	.16
3	MAXIMUM	0	0	1.83	1.93	1.61	1.46	1.79	1.27	1.66	1.13
4	MINIMUM	0	0	.34	.57	.39	.33	.41	.43	.43	.57
5	MEDIAN	0	0	1.22	1.01	1.03	.85	1.02	.79	.86	.73

SAMPLE SIZE

We assumed the normal rate of space closure on the control site as 1mm per month/side and on experimental site, the movement should be 1.5mm (a difference of 0.5mm) to be clinically significant. Expecting some dropouts, total of 30 potential subjects were selected for the study from the single center. Out of these 5 subjects declined to participate and so were excluded from the study.The eligible 25 subjects were given detailed information and informed consent was taken for participating in the study.

RANDOMIZATION & BLINDING

This was a split mouth design study in which all the 25 subjects were randomly selected by permuted block randomization (size of block 4) .The subjects were allocated to either side with 1:1 allocation (last subject was allotted to either group equally) .The method used for allocation concealment was opaque envelope method which was opened at the chair-side for prescribing vibratory tooth brush.

OUTCOMES

The amount of tooth movement for all samples was measured twice by the responsible investigator at a 4-week interval. Type 1 error analysis were used to assess intra observer accuracy and reliability, the data/observations were subjected in to SPSS (Statistical Package for Social Sciences) 22.0 version for analysis.

A Palatal plug was fabricated with 0.9 mm of stainless steel wire,a line was drawn from incisive papilla through median raphe and point of cusp tip of canine was marked than two reference wire were fabricated distal to canine on both side and there terminal end were embedded in acrylic plug (figure 6) distal movement of canine was measured with vernier caliper (least count of 0.01mm) every 4 weeks(1 month) from the beginning of the study till 16 week(4 month) (figure 7). The palatal plug covering a portion of the palatal rugae with reference wires was the reference device for all the study models of the same patient.[15]The base value was set by measuring the distance from the tip of the wire to the respective canine on the first model (T1). The plug was then transferred to subsequent casts (T2, T3& T4) and the distance that the canine has moved ismeasured once again from the cusp tip to the wire end and then subtracted from the base value.

STATISTICAL METHODS

The data/observations were subjected in to SPSS (Statistical Package for Social Sciences) 22.0 version for analysis. The unpaired/ independent "t"test and one way Anova test was applied to find the significant difference in rate of tooth movement between control & experimental group at different time point's at.05 level of significance.

The rate of tooth movement was observed by the two observer at different (four) time points for each patient in control group as well as in experimental group respectively and the mean scores of the two observers were taken into consideration in the study.

Table2. Comparison in the rate of tooth movement between experimental & control group at each time interval by unpaired "t" test.

S.NO.	TIME INTERVAL	PROBABILITY OFUNPAIRED"t" TEST B/W EXPERIMENTAL& CONTROL GROUP	SIGNIFICANCE
1	T0-T1 (first month)	.6889	P>.05 (N.S.)
2	T1-T2 (second month)	.1063	P>.05 (N.S.)
3	T2-T3 (third month)	.2114	P>.05 (N.S.)
4	T3-T4 (fourth month)	.0589	P>.05 (N.S.)

RESULTS

The results of the **Table1** show the mean, standard deviation, maximum scores, minimum scores & median scores of rate of tooth movement in control & experimental groups respectively at different time Interval.

Table 2. reveals the comparison in the rate of tooth movement between experimental and control group at each time interval. The unpaired "t" test showed that there was no significant difference in the rate of tooth movement between experimental and control group at first, second, third and fourth month of the study, at .05 level of significance.

Table 3 and 4 shows the One Way ANOVA tables for comparing the significant difference among different time interval within control and experimental groups.Results depicted that a significant difference was present within the control as well in experimental group at .05 level of significance in the amount of tooth movement between first month,second month,third month&fourth month when taken simultaneously. This indicates that in both control and experimental group there was uniform movement of teeth during each time interval.

Table 3. One way Anova test for comparing the significant difference among different time intervals for control group

Source of Variation	SS	Df	MS	F	P-value	F crit
Between Groups	21.274456	4	5.318614	43.37292824	1.80731E-22 P<.05 (sig.)	2.447236511
Within Groups	14.715024	120	0.1226252			
Total	35.98948	124				

DISCUSSION

This was a split mouth study; the attractiveness of the split mouth design is that it removes a lot of inter-individual variability there by increasing the power of study compared to whole mouth design . [16,17]

In this study, space closure via distal bodily movement of the maxillary canine tooth was done on adequately sized rigid arch wire (0.019x0.025") in 022" slot MBT bracket prescription. A force of 150g was delivered from active module tie on stainless steel wires to produce an average OTM of 1mm/month. The force level used in this study and the observed OTM were comparable to most of the studies reported in the literature13,14. Proffit[18] et al stated that accepted level of force of 150g has been reported to produce movement of 0.76-2.044mm/month, 150g of force represents the upper range of acceptable force level for single Tooth (e.g. canine) retraction to facilitate frontal resorption.[19,20,21]

In all the patients, vibratory toothbrush was given only for application of vibratory stimulus on the experimental side while routine brushing was advised on both the sides for the first three months and in the fourth month, the retraction force was continued but no powered toothbrush was used. This was mainly to analyze if any residual effects remains even after discontinuation of vibratory stimulus.

In a similar study conducted by Leethanakul[14] et al which had a same study design as ours stated that in combination with light orthodontic force and application of vibratory stimuli using an electric toothbrush enhanced the secretion of IL-1 b in GCF which significantly accelerated the orthodontic tooth movement.

In contradiction to this, our study showed that at all the four intervals, no statistically significant difference was seen in the rate of orthodontic tooth movement between the experimental and the control group. This result is in conjunction with the study of Woodhouse[22] et al, Miles[12] and Cochrane review by El-Angbawi[23].

Presently there is a lot of ambiguity regarding the effect of vibration on orthodontic tooth movement . Pavlin [13] et al stated that an average monthly rate of tooth movement of 1.16 mm/month was achieved when the AcceleDent appliance at frequency of 30 HZ was used for 20 minutes daily , corresponding to an increase of 48% in the rate of space closure compared to their control group.

adjunctive methods to accelerate tooth movement . Miles et al[28] also found that AcceleDent Aura appliance has no effect on the rate of maxillary premolar extraction space closure. Aljabaa et al[29] from its systematic review stated that vibration has no effect during orthodontic treatment. These finding were congruent to our study.

One of the reasons for such disparity in the results of vibrational devices could be explained on the basis of study by Olson[30] et al and Seo[31] where they showed an increase in rate of tooth movement with the help of vibrational appliance and explained that this may be due to stick slip phenomenon. According to this phenomenon, vibrational force application can enhance tooth movement with fixed appliances by reducing frictional resistance to sliding (stick slip phenomenon) between bracket and arch wire.

Our study indicates that vibrational stimulus through powered toothbrush may not help in accelerating the rate of orthodontic tooth movement. Multicentre randomized clinical trial study conducted by DiBiase et al[32] concluded that during orthodontic treatment , supplemental vibratory force neither affects treatment duration, space closure, final occlusal outcome nor total number of visits.[33]

Table 4: One way Anova test for comparing the significant difference among different time intervals for experimental group

Source of Variation	SS	Df	MS	F	P-value	F crit
Between Groups	17.487872	4	4.371968	63.47893845	1.01169E-28 P<.05 (sig.)	2.447236511
Within Groups	8.264728	120	0.068873			
Total	25.7526	124				

Recent studies [24,25] observed 2-3mm of tooth movement per month in AcceleDent group versus an average of 1mm in control group. These studies are very exciting regarding the advantages of vibratory devices, but critical appraisal of literature research had found contradictory results about the effect of vibratory stimulus on tooth movement however there are more evidences found for no effect of vibratory stimulus on orthodontic tooth movement.

In an animal study by Kalajzic[26] et al observed that Cyclical forces significantly inhibited the amount of tooth movement. Similarly animal study by Yadav[27]et al, investigating the effect of low-frequency mechanical vibration (LFMV) on the rate of tooth movement also found no difference in the rate of tooth movement between the different experimental groups. In a systemic review by El-Angbawi[23] concluded that there is insufficient evidence regarding the effect of non-surgical

It also should be noted that most of the studies done to evaluate the effect of vibration devices are either applied during canine retraction stage by sliding mechanics or during initial leveling and alignment stage. The multiple variables associated with this mechanics such as amount of force applied, friction etc. which we cannot overcome and have direct impact on rate of tooth movement, can be a probable reason for controversial results on this topic in the literature.

One of the limitations of our study was that we could not quantify the magnitude of pressure with which the powered tooth brushes were used. Secondly was compliance of patient since it was very difficult to determine whether subjects had used powered tooth brush as instructed although we had tried to persuade and motivate patients to do so.

Thus, it was observed that there is no effect of powered toothbrush on increasing the rate of tooth movement. So future multicentric studies with large sample studies should be conducted which may enlighten further on the effect of low level vibratory stimulus through vibratory toothbrush on the rate of orthodontic tooth movement.

CONCLUSION

1. The vibratory stimulation of 60Hertz applied for 5minutes, three times a day i.e. at every 8 hour interval, for three months did not have any significant effect in accelerating the rate of orthodontic tooth movement.

2. Vibratory stimulation from powered toothbrush has no significant effect in accelerating the rate of orthodontic treatment.

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