Original Article

Effectiveness and importance of powered tooth brushes in tooth movement

Sridhar Kannan[1], Sajna Fassul[1], Ashish Kumar Singh[1], Nitin Arora[1], Abhita Malhotra[1], Neeraj Saini[1]

[1]Department of Orthodontics, Manav Rachna Dental College, Faridabad, Haryana, India

Abstract

Introduction: Effectiveness of vibratory stimulus from a commonly available battery-powered tooth brush in accelerating orthodontic tooth movement was tested by a randomized controlled split-mouth study. **Materials and Methods:** Twenty-three subjects with bimaxillary protrusion, requiring extraction of all first premolars and requiring maximum anchorage, were chosen. After initial leveling and aligning, miniscrews were placed between the first molar and the second premolar in the maxillary right and left quadrants and loaded with 150-g nickel–titanium closed-coil springs for individual canine retraction. Additional 5 min of vibratory stimulus thrice daily was applied on the experimental side. The mean treatment duration was 3 months. **Results:** There was no significant difference of means of the canine distal movement between the experimental and the control sides ($P = 0.70$). **Conclusion:** Application of vibratory stimulus with powered tooth brush during canine retraction was not seen to have an acceleratory effect on orthodontic tooth movement.

Keywords: Accelerated orthodontics, cyclic forces, orthodontic tooth movement, vibration

Introduction

Orthodontic treatment duration as per evidence-based researches takes on an average 2 years and this is influenced by variables such as patient cooperation, severity of malocclusion, biological considerations, and treatment considerations like extraction decisions or need for orthognathic surgery.

Keeping up the pace with the century, many techniques to increase the rate of tooth movement were introduced. These techniques fall into surgical and nonsurgical categories.

Corticotomy, micro-osteoperforation, accelerated osteogenic orthodontics (AAO), distraction of the dento-alveolus, or the periodontal ligament[1] are the surgical techniques and they facilitate tooth movement by regional acceleratory phenomenon.[2,3] Patients are less receptive to these methods due to the invasiveness of these procedures.

Nonsurgical methods are pharmacological approaches such as electromagnetic fields,[4] electrical currents, laser irradiation,[5] and resonance vibration.[6]

Among the nonsurgical interventions, resonance vibration has gained popularity and is already commercially available as AcceleDent[7] due to its noninvasiveness, portability, and ease of use. It acts by the enhanced RANKL expression in the periodontal ligament. A century-old concept of Wolff's law describes how the function affects bone morphology. Bone density increases with strain and the dearth of any stress signals is the key etiology for bone fragility in bed-ridden patients or children with cerebral palsy. Vibrational appliances apply intermittent forces at a rapid rate and thus could initiate stress-induced changes.

Address for correspondence: Dr. Sridhar Kannan, Department of Orthodontics, Manav Rachna Dental College, Sector 43, Aravalli Hills, Faridabad - 121 003, Haryana, India. E-mail: sridhar.mrdc@mrei.ac.in

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Key descriptors of vibration devices are frequency, amplitude, and direction (frequency is measured in Hertz and amplitude measured in millimeter); the low-intensity vibration has acceleration <1g (gravitation of earth) and high frequency (>25–50 Hz) and this was seen to be the most beneficial for enhancing bone density.[8,9] In the field of medicine, focus was given to increase bone mass and rate of remodeling in patients with osteoporosis, women after menopause, astronauts, and cerebral palsy patients through whole body vibrations of 30, 45, and 90 Hz.[10-12]

Kopher and Mao[13] found that applying cyclic forces to craniofacial bones in growing rabbits enhances sutural growth. This concept was introduced into the field of orthodontics to accelerate tooth movement by Nishimura *et al.* with cyclic forces of 60 Hz.

Success of such studies with vibratory devices launched AcceleDent® (OrthoAccel Technologies, Inc. Houston, TX, USA) that delivers 30 Hz vibratory frequency for 20 min daily with the support of multiple studies and approval from Food and Drug Administration. AcceleDent® claims that the device exerts force of only 0.25 cN (0.003 g acceleration) which is 300 times less than 1g that was established as the safe standard for not causing any deleterious effects to bone.

Leethanakul *et al.*[14] in 2015 investigated on patients the effect of application of vibratory stimuli with electric tooth brush (125 Hz rotating and vibrating head) and found an increased secretion of interleukin 1β during canine retraction indicative of accelerated tooth movement.

On the contrary, the randomized controlled trial (RCT) by Miles *et al.*[15] with 111 Hz frequency showed vibration to be ineffective in accelerating tooth movement. Kalajzie *et al.*[16] demonstrated cyclic forces at 30 Hz to have inhibitory action.

Initial degree of irregularity in tooth position was proved to be the most important factor determining the rate of movement by Woodhouse *et al.* in an RCT.[17]

The effect of the mechanical vibration in general and of different frequency ranges on orthodontic tooth movement still remains unclear due to the varying results from the previous researches. The objectives of the study were to assess the amount of canine retraction on the experimental and control sides and compare the two. The aim of this study was to analyze the effect of vibratory frequency of a powered toothbrush on the amount of canine retraction.

Materials and Methods

The split-mouth RCT was conducted after getting clearance from the Institutional Ethical Committee. The sample size was calculated as 23, using GPower Software (version 3.0) for an alpha of 0.05, power of 95%, and effect size of 0.8. Class I bimaxillary protrusion patients of age group 18–25 years requiring all four first premolar extractions and individual canine retraction were selected and randomly allocated to the experimental and control groups using random tables. Patients with any medical or dental conditions that in the opinion of the investigator could impact study results or patients with impacted tooth other than the third molars were excluded from the study.

Treatment protocol

The treatment protocols adopted for the study are represented by a flowchart in Figure 1. The maxillary and mandibular teeth were bonded with preadjusted appliance (3M Gemini Series™ MBT) 0.022 × 0.028" slot. Leveling and alignment phase was completed before the insertion of miniscrews and initiating retraction and the first bicuspid extractions of both the sides were done on the same day, at least 3 months before retraction to allow bone fill.

Miniscrew implant (tomas® Dentaurum) used to obtain direct anchorage was positioned interdental to the second premolar and first molar, and retraction of the canine was done using NiTi 150 g closed-coil springs (G and H®) stretched between the canine and implant. The arch wires used for retraction were 0.019 × 0.025" stainless steel wire left in place for 1 month for making them passive and the posterior teeth were consolidated as a single unit with 0.010" ligature wire in figure-of-eight pattern.

Stimulation with electric tooth brush Oral B CrossAction® Power Dual Clean was applied only on the experimental side canine. The frequency of these tooth brushes used was evaluated by using a tachometer. The study period was 3 months with daily application of the powered tooth brush lightly held against the labial surface of experimental side for 5 min, after every meal, three times daily.

Figure 1: Flowchart describing treatment protocol of the study

Patients were asked to maintain a daily diary where they had noted each use of the device (schedule disruption if any and duration of usage). Monitoring of the patients was combined with the regular monthly visit; the springs, implants, and arch wires were checked for any damage and batteries were provided for the electric tooth brush.

All patients and families were informed of the purpose and methodology of the study, and consent was taken.

Measurement of amount of tooth movement

Models were made before extraction, after first premolar extraction but retraction not started yet (T0), 1 month after starting of canine retraction (T1), 2 months of canine retraction (T2), and 3 months of canine retraction (T3). The amount of canine retraction was measured in relation to the ipsilateral third rugae, which is stable.

The palatal plug was made as per the technique given by Limpanichkul *et al.*[18] on the first model of each patient. Each distance was measured three times in a week and the mean value was used for data computations by a single investigator who performed all the measurements using digital calliper to an accuracy of 0.01 mm.

Statistical analysis

SPSS software version 21 was used. Normality of the data was checked by Shapiro–Wilk test. The level of statistical significance was set at 0.05. Descriptives of tooth movement on control and experimental sides at different points of time were measured using paired *T*-test. Test of within-subjects effects due to treatment, time, and interaction between treatment and time was done using two-way repeated measures of analysis of variance (ANOVA) test.

Results

Comparison of the mean amount of canine retraction among the two intervention groups at different points of time is given in Table 1.

A two-way repeated measures of ANOVA was conducted that examines the effect of treatment and time level on tooth movement. No statistically significant interaction could be found between the effects of treatment and time on tooth movement ($F = 0.051$, $P = 0.938$) and this is represented in Table 2.

The mean difference of the accumulative distance of canine distal movement between the control side and the experimental side for 3 months was 0.009 mm (standard deviation = 0.0108, 95% confidence interval: 0.0038–0.0056), as shown in Table 3.

The mean tooth movement significantly increased from T1 to T2 and from T2 to T3 [Figure 2a] among both experimental and control sides. Figure 2b and c represent the increase in mean tooth movement on the experimental side compared to the control side at all points of time (T1, T2, and T3). But this difference failed to reach the level of statistical significance.

Table 1: Comparison of mean amount of canine retraction among the two intervention groups at different points of time

Intervention	Month 1		Month 2		Month 3	
	Mean	SD	Mean	SD	Mean	SD
Experiment	0.322	0.046	0.629	0.069	0.877	0.088
Control	0.316	0.038	0.624	0.068	0.871	0.084

SD: standard deviation

Discussion

The field of orthodontics has been evolving and its pace is more now than ever before; hastiness is the need of the hour and we are aiming toward a faster treatment goal. Patients may be willing to pay for faster treatment, but their willingness to undergo invasive techniques such as corticotomy or PAOO is much less, and hence the researches are directed toward less invasive options such as low-level laser, light therapy, and vibration devices like AcceleDent®. In Indian circumstances, a much cheaper alternative would benefit the masses, and powered tooth brush with its vibratory motion, economic price, and wide spread availability was thus considered.

The quest for the magic wand in orthodontic treatment thus surrounds us with a multitude of studies, all with contradictory outcomes. Earlier studies[6] targeted animals, and one of them found upto 30% accelerated tooth movement in monkeys, with the use of vibrational stimulus. Kau *et al.*[19,20] showed that AcceleDent® accelerates tooth movement in both the arches and tooth moved by 2–3 mm; however, these studies did not have adequate sample size and controls.

The study design adopted for the randomized clinical trial conducted in our department was similar to another study[14] which used powered tooth brush, but all attempts have been made to negate the shortcomings observed in that previous trial. A split-mouth design was advocated to eliminate any bias arising from the biological differences between the experimental and control groups. The sample size was taken as 23 for a power of 95%, whereas the previous study had only 15 patients.

The stages of orthodontic treatment as outlined and implemented by the pioneers of our disciple are to first align and level the arches, then correction of molar relationship and space closure which is followed by finishing. The master study did not follow a clinically feasible procedure since after premolar extractions space closure was started without leveling and alignment. The time frame of initiation of canine retraction was just 2 months after premolar extraction, which could have led to overlapping of a regional acceleratory phenomenon as the cause for the acceleration of tooth movement. To control these limitations, the

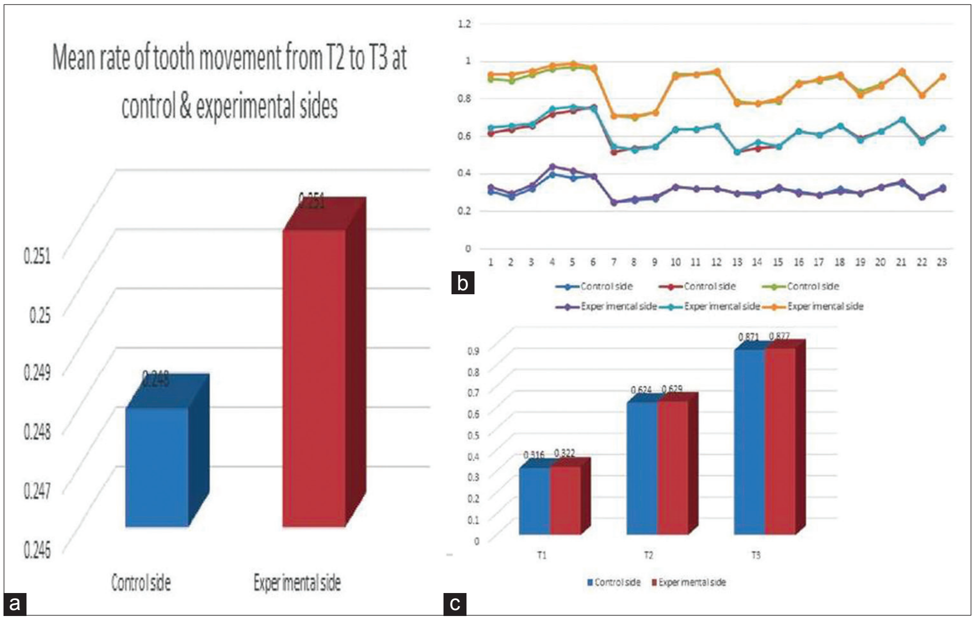

Figure 2: (a) Intergroup comparison of rate of tooth movement from T2 to T3 among control and experimental sides. (b) Line graph showing observations of control and experimental sides at different points of time (T1, T2, and T3). (c) Barchart showing mean tooth movement on control and experimental sides at different points of time

Table 2: Test of within-subjects effects due to treatment, time, and interaction between treatment and time using two-way repeated measures of ANOVA test

Tests of within-subjects effects							
Source		Type III sum of squares	df	Mean square	F	Sig.	Partial Eta-squared
Treatment	Greenhouse-Geisser	0.001	1.000	0.001	3.941	0.053	0.113
Error (treatment)	Greenhouse-Geisser	0.004	22.000	0.000			
Time	Greenhouse-Geisser	7.118	1.344	5.297	1643.577	<0.0001	0.987
Error (time)	Greenhouse-Geisser	0.095	29.564	0.003			
Treatment × time	Greenhouse-Geisser	4.348E−006	1.822	2.387E−006	0.051	0.938	0.002
Error (treatment × time)	Greenhouse-Geisser	0.002	40.078	4.647E−005			

ANOVA: analysis of variance

Table 3: Comparison of difference of means of distance (mm) of canine retraction between the experimental and control sides during the 3-month study period

Mean difference between control and experimental sides	SD	*P*	95% CI	
			Lower bound	Upper bound
0.009	0.0108	0.704	-0.0038	0.0056

SD: standard deviation; CI: confidence interval

study designed by us followed the correct treatment sequencing of leveling alignment followed by retraction of canines started at least after a period of 6 months following extraction. Also, the bilateral maxillary premolars were extracted on the same day.

Mini-implant used in our study would have ensured 100% anchorage conservation, whereas no additional anchorage reinforcement methods were used in a study by Leethanakul *et al*. The mechanism for canine distalization used by Leethanakul *et al*. consisted of a power arm fabricated from 0.021 × 0.025" stainless steel arch wire attached to the mesial end of each canine bracket. Echains provided the retraction force both palatally and bucally which could have resulted in lack of force consistency. The disadvantage of this method was overcome by the use of 150 g NiTi closed-coil springs in our study.

Cochrane review[21] of manual versus powered tooth brushes 2003 and 2005 reports confirmed that powered tooth brushes are as safe to use as manual toothbrushes and that powered tooth brush with rotation oscillation action is more efficient than the other alternatives available like the powered tooth brushes with back and forth motion or side-to-side technology. The digital tachometer was used to test the frequency of these powered tooth brushes and was found to be between 100 and 105 Hz. This vibrational frequency had been quoted by Alikhani *et al*.'s study to be advantageous over other frequencies. Alikhani *et al*.[22] had concluded from their study that bone deposition with 30 and 200 Hz frequency was similar (10% and 12%, respectively) and increase in bone volume to 100 and 60 Hz was similar (19% and 17%, respectively).

Statistical difference between the experimental and the control sides was none in our trial, although a statistically insignificant increase was noted with the powered tooth brush. This study thus agrees with two recent RCTs; one RCT concluded that AcceleDent® as an adjunctive aid had no influence on initial tooth movement or on the time needed for final alignment. The other RCT by Miles[23] also did not find any evidence showing increase in anterior arch perimeter on using AcceleDent® with fixed mechanotherapy; neither was there a relief in the discomfort felt by the patient. Miles *et al.*[15] had published another study with the device Tooth Masseuse and found no significant benefit with vibration.

The Cochrane review[24] to conclude the effects of vibratory frequency on acceleration of tooth movement commented on the lack of availability of well-controlled studies, making the review inconclusive, at that point of time.

This study is at odds with the previous study using powered tooth brush, where experimental canine had faster tooth movement than the control canine (mean, 2.85 ± 0.17 mm vs. 1.77 ± 0.11 mm, respectively; $P < 0.001$). With the use of the AcceleDent®,[25] another study reported a 48% increase in the rate of canine retraction in the vibration group over the control group (mean difference of 0.37 ± 0.22 mm).

Miles *et al.*[26] also found that AcceleDent® Aura appliance has no effect on the rate of maxillary premolar extraction space closure. This finding was congruent to our study.

Cyclic vibration if proved to accelerate tooth movement could play a very important role in decreasing the overall time taken for the orthodontic treatment. It is crucial to determine the exact range of frequency beneficialto orthodontics and allow the majority of orthodontic patients to reap the benefits of cyclic vibration, by making it reach them through simpler inexpensive means like that of a powered tooth brush.

Further studies should address the optimal frequency levels required for maximum benefit, the ideal duration for which these appliances should be used, and whether these have any deleterious adverse effects.

Conclusion

The results of this study did not show either a statistical or clinically significant difference in the rate of tooth movement on the experimental side to advocate the use of vibrational device as an adjunct to accelerate tooth movement during space closure.

Further well-designed and rigorous RCTs with longer follow-up periods are required to determine whether vibrational devices result in a clinically significant reduction in the duration of orthodontic treatment, without any adverse effects.

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Conflicts of interest

There are no conflicts of interest.

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