

Effectiveness of using a Vibrating Device in Accelerating Orthodontic Tooth Movement: A Systematic Review and Meta-Analysis

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ABSTRACT

Objective: The aim of current systematic review was to evaluate the efficiency of the vibrating devices in accelerating orthodontic tooth movement.

Methods: A systemic unrestricted search was done in three electronic databases up to July 2018. A manual search was also performed. Eligibility criteria included Randomized clinical trials (RCTs), quasi randomized clinical trials and prospective controlled trials (CCTs) comparing the rate of the tooth movement with and without vibrating devices. The study characteristics and data extraction of the vibrating device group and control group were performed by two reviewers independently.

Results: Seven articles were eligible to be included in the qualitative analysis. Three of them were included in meta analysis. One hundred and five patients received vibrating device to accelerate orthodontic treatment while forty-nine patients received sham device and seventy-eight patients were control group.

Conclusion: There was no significant difference between vibrating devices group and control group. There is no evidence that vibrating appliances are effective in acceleration of orthodontic tooth movement.

KEYWORDS: Acceleration, orthodontics, tooth movement, vibration

Received : 30-08-18.
Accepted : 24-10-18.
Published : 14-02-19.

INTRODUCTION

RATIONALE

Orthodontic tooth movement (OTM) is a process of mechanically-induced bone modeling where new bone is formed on the tension side and resorption on the compression side of the periodontal ligament.^[1] One of the shortcomings of orthodontic treatment is a long time treatment. Shortening of the treatment time through accelerating OTM is a current challenge in the mainstream orthodontic literature.

Among physical approaches that were implemented to accelerate (OTM) was low-energy laser level, magnetic fields, and direct electric current. However, these approaches were not a panacea, and many side effects were reported such as local pain, severe root resorption, and drug-induced side effects.^[2]

A new vibrating device; AcceleDent (OrthoAccel Technologies, Houston, Texas) has been introduced in the market targeting increasing the rate of tooth movement by enhancing bone remodeling using pulsating forces. Invented

by Dr. Jeremy Mao, it is intended to be used by a patient in conjunction with fixed orthodontic appliances or removable sequential aligner treatment for 20 min/day. It vibrates at a frequency of 30 Hz and has force amplitude of 20 g.

Enhancement of the rate of (OTM) was reported by some studies after the use of vibrating devices.^[3] It was thus concluded that the AcceleDent device is a useful adjunct to orthodontic treatment.

The prolonged time of orthodontic treatment especially in extraction cases become a major challenge which is not yet settled. The hypothesis was to resolve this challenge using vibrating devices, which will decrease the treatment time and thus improve the quality of orthodontic care and improve patient compliance.

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How to cite this article: Elmotaleb MA, Elnamrawy MM, Sharaby F, Elbeialy AR, ElDakroury A. Effectiveness of using a vibrating device in accelerating orthodontic tooth movement: A systematic review and meta-analysis. J Int Soc Prevent Communit Dent 2019;9:5-12.

Access this article online	
Quick Response Code: 	Website: www.jispcd.org
	DOI: 10.4103/jispcd.JISPCD_311_18

OBJECTIVE

The aim of the current systematic review was to evaluate the efficiency of the vibrating devices in accelerating OTM.

MATERIALS AND METHODS

PROTOCOL REGISTRATION

This systematic review was done following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement.^[4] The protocol was registered at the Evidence-Based Center, at our faculty (Registration number: 14-2018).

ELIGIBILITY CRITERIA

The inclusion and exclusion criteria for selecting the articles were represented in Table 1.

INFORMATION SOURCES, SEARCH STRATEGY, AND STUDY SELECTION

The search was carried out using the following database: PubMed, Google Scholar, Lilacs until July 2018. The search was done in English language only. To supplement the searches (European Journal of Orthodontics, American Journal of Orthodontics and Dentofacial Orthopedics, the Angle Orthodontist, and Seminars in Orthodontics and a National Library of Medicine US and library of congress) were searched manually for relevant articles.

The main topics and terms used for the search were:

1. Vibrational stimulation OR resonance vibration OR vibration OR AcceleDent

2. Rapid OR acceleration OR speed OR rate OR short
3. Tooth movement OR tooth retraction
4. Orthodontics OR orthodontic
5. 1 and 2 and 3 and 4.

Two reviewers (M.A and M.N) made the assessment of studies for inclusion in the review. When the two reviewers disagreed, a third reviewer (F.S) was consulted to make the final decision.

STUDY SELECTION AND DATA COLLECTION

A data extraction form was developed, and data were extracted independently by the two reviewers (M.A, M.N). A third reviewer (F.S) was consulted when there was a disagreement between the two reviewers to arrive at a resolution. The collected data included: study design, sample size, age, gender, type of vibrating appliance, the method used to measure tooth movement, methods to measure root resorption, duration of using the appliance in days, time of using appliance per day, settings of appliance, and efficiency of the appliance.

RISK OF BIAS IN INCLUDED STUDIES

The quality of the included studies was evaluated by two reviewers (M.A) and (M.N) using Cochrane's risk of bias tool.^[5] When lack of consistency was observed, a third author (F.S) was consulted to arrive at a resolution.

The Cochrane risk of bias tool was used for assessment of the included randomized clinical trials (RCTs). An overall unclear/high risk of bias was given to the study if one criterion from the seven criteria was assessed as unclear/high risk of Bias.

SUMMARY OF MEASURES AND SYNTHESIS OF RESULTS

The treatment interventions, treatment protocols, place of research, patients, methodology, and outcome measures were assessed to evaluate the amount of heterogeneity of the included trials. From the statistical point of view,^[6] heterogeneity was first evaluated visually and then mathematically. The mean differences (from baseline to 8 weeks) and their standard deviations were extracted and this difference used in the analysis.

The data were pooled to provide an estimate of the effectiveness of using AcceleDent aura using the random-effects model as it takes into account the expected statistical heterogeneity of included studies.

Review Manager (RevMan) Version 5.3. (Copenhagen, Denmark, Europe): The Nordic Cochrane Centre, The Cochrane Collaboration, 2014 was used to perform a meta-analysis. The weighted mean differences of irregularity index between AcceleDent and control groups were performed using the inverse-variance

Table 1: The selection criteria that were applied for the inclusion and exclusion of the studies in the review

	Inclusion criteria	Exclusion criteria
Participant	Subject with permean dentition who require orthodontic treatment	Subject with systemic diseases, syndromes, temporomandibular disorders, dental pathologies Patients had previous orthodontic treatment Animal studies
Intervention	Use of vibrating device	Studies using vibrating appliance only
Comparator	Orthodontic treatment without any acceleration methods	
Outcomes	Acceleration of tooth movement Root resorption	
Study design	RCTs Quasi-randomized clinical trials Prospective CCTs	Retrospective studies Case reports Comments Letters to the Editor Narrative reviews

RCTs: Randomized clinical trials, CCTs: Controlled clinical trials

meta-analysis. I^2 statistic was used to test the extent of heterogeneity between studies, in which $I^2 = 25\%$, 50% , and 75% indicated low, medium, and high heterogeneity, respectively.

RISK OF BIAS ACROSS STUDIES

The protocol of this systematic review included a visual inspection of a generated contour enhanced funnel plot if 10 or more studies met the inclusion criteria.

RESULTS

STUDY SELECTION

Two hundred and eighty-eight articles were identified through our search [Figure 1]. After the elimination of the external and internal duplicates, only thirty articles were included. After reviewing titles and abstracts, only 11 articles were included.

After retrieval of full text, it was found that one article was a case report and another two articles were coherent studies with no control group and one retrospective study. Accordingly, only seven articles were included in this systematic review. Meta-analysis was conducted on three articles only.

CHARACTERISTICS OF STUDIES

All included studies were RCTs according to eligibility criteria. Five out of the six studies were done on the lower arch; two of them were nonextraction, and the other two were an extraction of the first lower premolars while the last two were done on the upper arch.

Three studies used the lower incisor index to evaluate the rate of OTM as primary outcome while two studies evaluated the rate of canine retraction in cases with an extraction of the upper first premolar. Only one study evaluated the root resorption as a primary outcome. Six studies used AcceleDent appliance while only one evaluated tooth masseuse appliance. The extracted data of the included articles are presented in Table 2.

RISK OF BIAS ASSESSMENT

The Cochrane Risk of Bias Tool was used for assessment of the seven included RCTs [Figure 2]. Blinding of the patients was only reported in three studies (Woodhouse *et al.*,^[7] DiBiase *et al.*^[8] and DiBiase *et al.*^[9] as they included sham appliance group and was judged as low risk of bias and the other studies were considered high risk of bias. Pavlin *et al.*^[10] were funded from

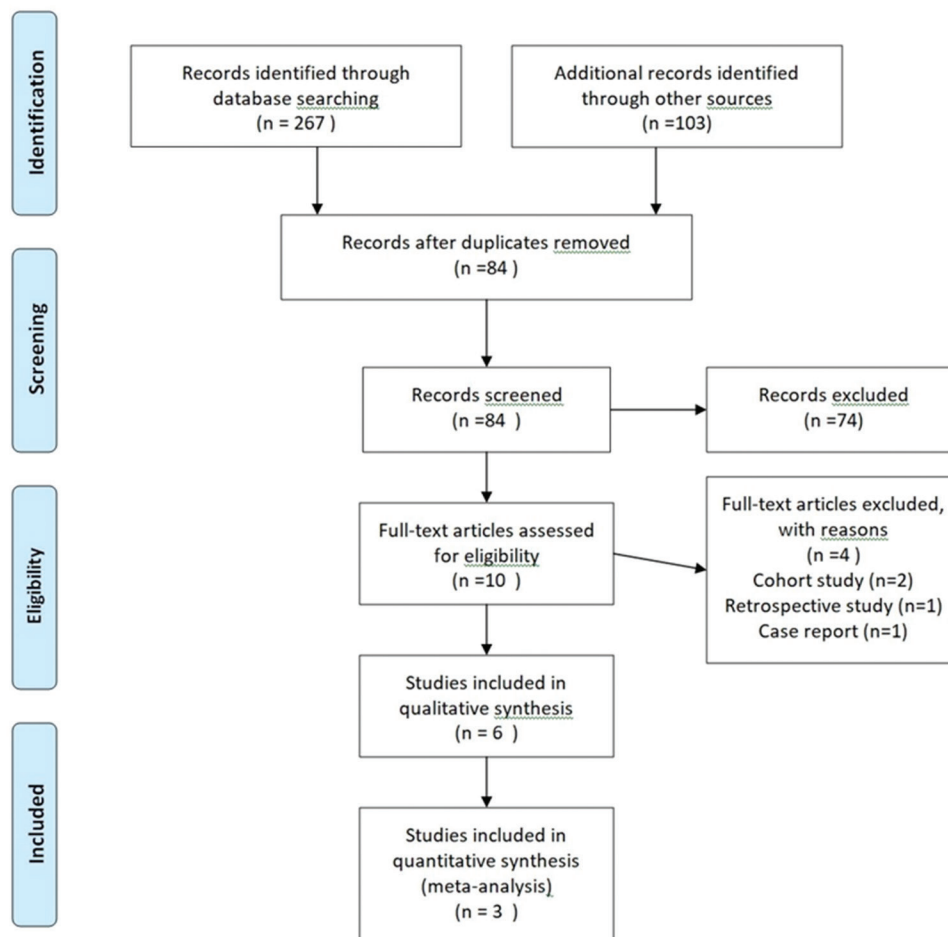


Figure 1: Systematic reviews and meta-analyses flow chart

Table 2: The extracted data of the included articles

Study	Settings	Ethical approval	Design	Sample size	Grouping	Age	Criteria	Type of device	Rate of vibration	Period of using the device in weeks	Time of wear of Minutes/day	Outcomes	Time point	Measurement	Fixed appliance used
Miles <i>et al.</i>	Private practice	Yes	RCT	66 26 male, 40 female	Control group (19 female, 14 male)	11-15 (13.1)	Children up to 16 years	16 Tooth -se	0.06 N	10	20	Irregularity index (mm) Vas score (discomfort)	For irregularity index (0, 5, 8, 10 weeks) For vas score (6-8 h, 1, 3, 7 days)	On study irregularity models	MBT prescription Slot 0.018
					Exp. group (21 female, 12 male)	No impaction or unerupted teeth									
Miles and Fisher	Private practice	Yes	RCT	40 14 Male, 26 female	Control group (12 female, 8 male) Exp. group (14 female, 6 male)	>16 (12.1)	1. Children up to age 16, 2. A fully erupted dentition from first molar forward, 3. Erupted or erupting second molars, 4. No missing or previously extracted permanent teeth, 5. Undergoing comprehensive orthodontic treatment with full fixed appliances, 6. A Class II malocclusion requiring extraction of 2 maxillary premolars but no mandibular extractions	Accele -dent	30 N	10	20	Irregularity index Anterior arch perimeter Discomfort (va score) Use of analgesic	On study models	MBT prescription Slot 0.018	

Contd...

Table 2: Contd...

Study	Settings	Ethical approval	Design	Sample size	Grouping	Age	Criteria	Type of device	Rate of vibration	Period of using the device in weeks	Time of wear Minutes/day	Outcomes	Time point	Measurement	Fixed appliance used
Woodhouse <i>et al.</i>	Multi-center	Yes	RCT	81 40 male, 41 female	Control group 27 Exp. group 29 Sham 25	>20	1. Under 20 years of age at treatment start; 2. No medical contraindications, including regular medication; 3. Permanent dentition; 4. Mandibular arch incisor irregularity; 5. Extraction of mandibular premolars as part of the orthodontic treatment plan	Acceludent	30 N	18	20	Irregularity index Alignment of teeth	T0 14 niti T1 18 niti Tf 19*25	On study models	MBT prescription Slot 0.022
Dibiase <i>et al.</i>	Multi-center	Yes	Rct	81 40 male, 41 female	Control group 27 Exp. group 29 Sham 25	>20	1. Under 20 years of age at treatment start; 2. No medical contraindications, including regular medication; 3. Permanent dentition; 4. Mandibular arch incisor irregularity; and 5. Extraction of mandibular premolars as part of the orthodontic treatment plan	Accele-dent	30 N	18	20	OIRR	To 14 niti start of treatment Tf 19*25 end of alignment	On periapical radiograph	MBT prescription Slot 0.022

Contd...

Table 2: Contd...

Study	Settings	Ethical approval	Design	Sample size	Grouping	Age	Criteria	Type of device	Rate of vibration	Period of using the device in weeks	Time of wear Minutes/day	Outcomes	Time point	Measurement	Fixed appliance used
Pavlin <i>et al.</i>	Single center	Yes	RCT	45 Gender not mentioned	Sham 22 Exp. 23	12-40	Age (12-40 years), required extraction of maxillary first premolar (s), space closure with maximum maxillary anchorage, 3 mm of extraction space after initial alignment, and good oral hygiene	Accelerated	30 N	Not mentioned From start of treatment	20	Rate of canine retraction per month	Every month	Direct in the patient mouth	MBT Slot 0.022
Miles <i>et al.</i>	Private practice	yes	RCT	40 14 male, 26 female	Control group 19 female, 14 male) Exp. group 21 female, 12 male)	>16 (12.1)	1. Children up to age 16, 2. A fully erupted dentition from first molar forward, 3. Erupted or erupting second molars, 4. No missing or previously extracted permanent teeth, 5. Undergoing comprehensive orthodontic treatment with full fixed appliances, and 6. Class II malocclusion requiring extraction of 2 maxillary premolars but no mandibular extractions	Accelerated	30 N	10	20	Rate of canine retraction	At start of canine retraction and before end of space closure	On study models	MBT prescription Slot 0.018

RCT=Root canal treatment, MBT=MacLaughlin, Bennet, and Trevisi bracket system, OIRR=Orthodontically induced inflammatory root resorption

the manufacturer of vibration device and thus it was considered as a high risk of bias and also reported with incomplete outcome data.

INDIVIDUAL RESULTS OF THE STUDIES AND META-ANALYSIS

A total of 226 patients received fixed orthodontic appliance, 105 of them received vibrating device to accelerate orthodontic treatment while eighty patients were control group and 47 patients received sham device.

The Forest plot of the mean difference between the vibrating group and control group (no appliance) among the articles is presented in Figure 3.

The pooled meta-analysis with irregularity index failed to demonstrate that AcceleDent was more effective on irregularity index reduction than the control group as ($P = 0.49$), with a mean difference and confidence interval of -0.2 ($-1.69, 1.29$). Mean difference, the Random effect was used, heterogeneity was 0%.

EFFECT OF INTERVENTION

Primary outcome (rate of tooth movement)

Six out of the seven RCTs evaluated the effects of a different vibrating appliance on the rate of OTM. Three studies had a low risk of bias while four studies had a

high risk of bias. Five RCTs found neither clinical nor statistical significance in using vibrating devices to accelerate orthodontic treatment, while only one RCT^[10] which was a high risk of bias found that it significantly accelerated tooth movement.

The results from meta-analysis failed to demonstrate any efficiency in accelerating OTM when using vibrating devices in comparison to the control group.

SECONDARY OUTCOME

Root resorption

The effect of vibrating devices on orthodontically induced inflammatory root resorption (OIIRR) was investigated only in one RCT which had a low risk of bias. DiBiase *et al.*^[8] found no significant difference between the experimental group using AcceleDent vibrating device and sham group and control group at the start and end of the alignment stage.

DISCUSSION

SUMMARY OF EVIDENCE

The eagerness of the orthodontic community toward acceleration of OTM is rational. This is attributed to the reported evidence that the average time for orthodontic treatment is 24 months. Hence, the acceleration of tooth movement and the reduction of the orthodontic treatment time is an attention-grabbing research topic.

The nonsurgical mechanical or physical approaches for accelerating (OTM) have gained a great popularity in the orthodontic market due to their noninvasive nature. The vibrating devices got more attraction with the clinicians to be used as adjunctive to orthodontic treatment. The molecular basis behind the acceleration of (OTM) using the vibrating devices is stimulating more expression of receptor activator of nuclear factor- κ B ligand and osteoblast formation in the periodontal ligament thus accelerating bone remodeling.^[11]

On this systematic review, we focused on one of the recently introduced devices for acceleration of OTM using vibrating devices. Our search revealed two

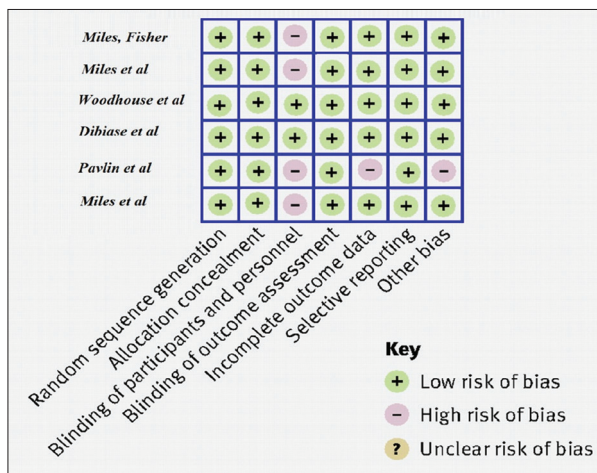


Figure 2: The Cochrane risk of bias tool for the assessment of the six included randomized clinical trials

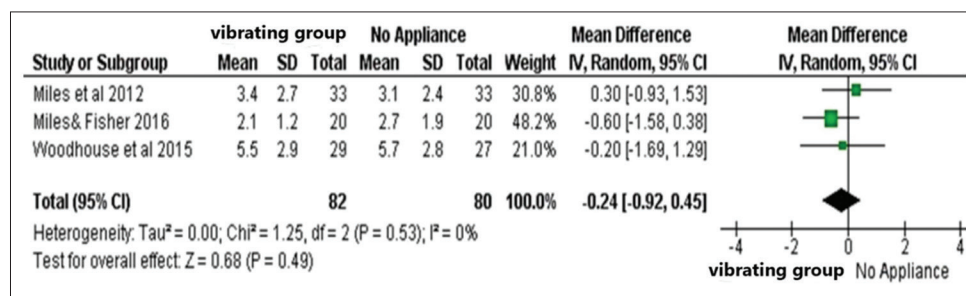


Figure 3: The forest plot of the mean difference between the vibrating group and control group (no appliance) among the articles

commercially available types of vibrating devices; tooth masseuse vibrating device (0.06 N and 111 Hz) and AcceleDent vibrating device (0.2 N and 30 Hz). The systematic search resulted in six RCTs; five of them were concerned by an acceleration of OTM, and only one studied the effect of vibration on OIIRR.

AcceleDent was used in five studies (which is more commercially available in the market) and only one study used tooth masseuse. Woodhouse *et al.*,^[7] DiBiase *et al.*,^[8] and DiBiase *et al.*^[9] were a different part of the same RCT and also Miles and Fisher^[12] and Miles *et al.*^[13] were different parts from the same RCT.

Four studies measured the alignment of the lower anterior teeth using little's incisor index, and two studies used the upper canine retraction as a model for testing the efficiency of the vibrating device after first premolars extraction.

Despite the widespread use of the vibrating devices, Miles *et al.*,^[13] Miles and Fisher,^[12] Woodhouse,^[7] DiBiase *et al.*,^[9] and Miles *et al.*^[14] found that using vibration is not significant for accelerating OTM. On the contrary, Pavlin *et al.*^[10] found that AcceleDent increases the rate of tooth movement when applied as an adjunct to orthodontic treatment.

The secondary outcome (OIIRR) was investigated by DiBiase *et al.*,^[8] they used periapical film at start and end of treatment to measure (OIIRR), they concluded that AcceleDent has no impact on (OIIRR).

One of the strengths of statistical pooling of the results in a meta-analysis is the ability to combining several studies and thus more data so increasing the overall statistical power to detect an effect. Our meta-analysis included three studies, and the results revealed low-quality evidence that vibrating devices accelerate tooth movement.

LIMITATION

1. The search did not take into consideration the difference in Gender
2. All of the studies evaluated only short period of orthodontic treatment only about 4 months of total orthodontic treatment time which range from 18 to 24 months in average, no studies evaluated the vibrational intervention on the total treatment time
3. In our systematic review, language restriction may be also an additional limitation in the search.

CONCLUSIONS

Up-to-date, there is no evidence that vibrating appliances are effective in an acceleration of OTM.

FINANCIAL SUPPORT AND SPONSORSHIP

Nil.

CONFLICTS OF INTEREST

There are no conflicts of interest.

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