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Effect of Mechanical Vibration on the Rate of Orthodontic Tooth Movement

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Abstract:
Objective: The purpose of this split-mouth trial was to evaluate the efficiency of mechanical vibration on the rate of orthodontic tooth movement. **Subjects and methods**: Thirteen patients (9 females, 4 males; mean age 16.55±2.54 years) who required both maxillary first premolar extraction and bilateral maxillary canine distalization were selected in this study. Each Patient was randomly assigned to either the experimental side that used a mechanical vibration device (a modified **Gillette Fusion ProGlide**) or the control side that did not receive a vibration. Miniscrews were used in each side to support anchorage and closed-coil nickel-titanium springs with 150 g of force were used to retract the canines. Vibration of 133 Hz، was applied on the buccal surface of maxillary canine **10 mins** twice daily for **12 week** at the vibration side. The outcome was the rate of canine retraction measured using 3D digital models superimposed from the baseline (T0) to 4 weeks, 8 weeks and 12week (T1, T2 and T3). All date were analyzed and evaluated by Student t-test. **Results:** Eleven subjects remained in the trial at start of canine retraction. The mean rate of tooth movement (TM) was 0.956±0.10 mm/month for control sides versus 0.912±0.12mm/month for experimental side, which was not statistically significant difference at any of the timepoints. Regarding to (TM) mean values of control and vibration sides at T1 was (0.59±0.13 mm Vs 0.55±0.14 mm), at T2 (0.92±0.19 mm Vs 0.98±0.23 mm) and at T3 (1.32±0.16 mm versus 1.20±0.18 mm) respectively. **Conclusion:** The results of this study have shown that the use of mechanical vibration had no effect on the rate of tooth movement.
Key Words: Mechanical vibration, Orthodontic tooth movement, Canine retraction, Acceleration

Introduction

Orthodontic tooth movement (OTM) is a result of a mechanically induced biological response to external interference in the physiological equilibrium of the dentofacial complex. A tooth can be moved within the periodontal space by generating a compression side, where the periodontal ligament (PDL) exhibits disorganization and diminution of fiber production seemingly as a result of vascular constriction, and a tension side, where a growth in cell replication of PDL occurs by stretching PDL fiber bundles

The use of supplemental vibrational force has been advocated as a method of speeding up orthodontic tooth movement. This involves the application of low-level vibration directly to the dentition as it is subjected to orthodontic force. The basic principle underlying orthodontic tooth movement is the ability of alveolar bone to respond with remodeling after the application of external force.(1)

There is a clinical study which found that both the amounts of space closure and canine distalization of the vibration group were significantly higher than those of the control group. The rotor frequency was measured to be 113 Hz using an optical tachometer. This was over 50% higher than what was eventually transmitted to the vibrator terminal or maxillary canine (50 Hz). So their study was suggested to vibrate the tooth of relevance at higher frequency within the mild zone for reasonably higher PDL response.(2) Therefore, the present study aimed to use a higher frequency by using another vibratory device, and changing the duration time of application.

Subjects and Methods

I) Study design:

This study was a split-mouth design; the experimental side was allocated by randomization for studying the effect of mechanical vibration on orthodontic tooth movement in cases indicates maxillary first premolar extraction and maxillary canine retraction.

Clinical procedures:

Each patient in the sample received the following procedures:

a) Preparatory phases

1. Ready-made molar bands were selected, fitted and cemented on the first molars using glass ionomer cement. The brackets, MBT prescriptions 0.022 slot bracket system were bounded to the tooth surface using orthodontic light cured composite resin. Hooks were attached on upper canine brackets by laser welding. After that, all patients received a straight wire appliance on their upper and lower arches except the upper first premolars.. Based on the severity and degree of crowding, the upper archwire sequences in the initial alignment and leveling phase was selected for every case until reaching S.S archwire. "0.016 x 0.022"
2. Buccally and bilaterally between upper 2nd premolar and 1st molar, the self-drilling TADs (1.8 x 8mm) were inserted. The ligature wire that bilaterally connected from the TAD to the upper 2nd premolar brackets was used as indirect anchorage. Then, the upper

archwire was removed and the patient was referred for extraction of the upper 1st premolars.

3. Promptly following upper 1st premolars extraction, the stainless steel ligature wire 0.012" was utilized to stabilize both anterior and posterior segments, then the NiTi wire 0.017" x 0.025" was fitted. To ensure integral healing of the socket, the canine retraction was started after six months of extraction,[4]
4. Once the alignment and leveling phase was completed (just before canine retraction), an alginate impression (T0) was made for upper arch, then stainless-steel archwire 0.017" x 0.025" was used.
5. Bilateral measurement of the distance between the TAD and the hook attached to the canine was recorded. According to the distance measured and by using an orthodontic tension meter force gauge, the nickel-titanium closing coil springs applying 150gm were selected. To begin the canine retraction, the two coil springs were stretched and bilaterally inserted between the TAD and the attached hook on the upper canine (T0).

b) Vibration Procedure and device:

1. Based on the study revealed by **Liao**[2] ***et al*** that apply a higher frequency within mild zone to vibrate the tooth. The optical tachometer was used to measure the vibration frequency which was nearly 8000RPM (about 133Hz) and the measurement was done at Mechanical Engineering College, Mansoura University.
2. To assure total compliance with applied vibration, all patients were visited daily on the 1st week.
3. Otherwise, all patients were informed to apply mechanical vibration on one side as experimental side (either the left or right), while the other one was used as control side.
4. The buccal surface of canine was vibrated **10 mins** twice daily for **12 week**, by a modified **Gillette Fusion ProGlide** Vibrating machine which was modified by Eng. Mohammed Alssilmi.
5. The head of Gillette Fusion was removed and the constructed metal tip was coated with hot glue stick (ethylene-vinyl acetate) to protect the surface of the tooth.

II) Statistical methods:

Data were fed to the computer and analyzed using IBM SPSS Corp. Released 2013. IBM SPSS Statistics for Windows, Version 22.0. Armonk, NY: IBM Corp. Qualitative data were described using number and percent. Quantitative data were described using mean, standard deviation for parametric data after testing normality using Shapiro–Wilk test. Significance of the obtained results was judged at the (0.05) level.

Data analysis

Quantitative data between groups:

Parametric tests:

- Student t-test was used to compare 2 independent groups

Results

Table (1): Comparison of the rate of tooth movement at specific time points between control & experimental sides.

Time Points	**Control n=11**	**Experimental n=11**	**test of significance**
T1	0.592±0.135	0.554±0.141	t=0.648 p=0.524
T2	0.927±0.199	0.980±0.230	t=0.574 p=0.573
T3	1.323±0.165	1.202±0.188	t=1.59 p=0.128
Total	2.87±0.33	2.74±0.40	t=0.844 p=0.408
Rate of TM/month	0.956±0.109	0.912±0.135	t=0.844 P=0.408

t:Student t test , p:probability, parameters described as mean±SD

This table show that there is no statistically significant difference between control & experimental groups regarding TM mean values at T1 , T2 and T3.Mean TM was 0.592 versus 0.554 at T1 , 0.927 versus 0.980 at T2 , 1.323 versus 1.202 and mean total was 2.87 versus 2.74 , respectively. Mean rate of canine retraction was 0.956 versus 0.912 for control and experimental groups.

DISCUSSION

In this clinical study, the rate of tooth movement in the control groups was 0.95±0.10mm/month versus 0.91±0.13 mm/month in the vibration groups. Both the total and monthly tooth movement rates were not statistically significant between the two groups. These are consistent with studies by **Miles** et al.[5], **DiBiase** et al.[6], **Siriphan** et al.[7] and **Taha** et al.[8] who didn't show in statistically significant in orthodontic tooth movement by using a vibrational device. However, this study was in contrast to those reported studies by **Pavlin** et al.[9], **Leethanakul** et al[10] and **Liao** et al.[2] who observed increased tooth movement by the application of vibration.

In the study conducted by **Taha et al**., the total amount of tooth movement was (1.12± 0.22 Vs 1.39±0.36 mm) at T1 in control and vibration groups respectively. These results is in contrast to the present study which the total amount of tooth movement was (0.59± 0.13 Vs 0.55±0.14 mm) at T1 in control and vibration groups respectively. On the other hand, the results of the present study were close to the study conducted by **Alkebsi** et al[11]. which the total amount of tooth movement was (0.67±0.34 Vs 0.65±0.26 mm) at T1 in control and vibration groups respectively. This probably is due to that canine retraction mechanics in (**Taha et al study**) were applied 1-2 weeks after extraction which considered a surgical insult that can increase the inflammatory markers.

In the present study, the results about canine rotation showed no significant differences between control and vibration groups (p > 0.05). These results agree with those of **Siriphan** et al. However, the amount of rotation between the same groups was great at baseline (T0) and 12 week after canine retraction (T3). This may be attributed to that the use of loose SS ligatures for canine retraction which made the canines rotation at the end of canine retraction. The reason that the present study use loose SS ligatures was to reduce the friction between the bracket slot and the wire as mentiond by Thorstenson and Kusy [12]

gland tumors form approximately 2-5% of

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