Research Paper

Comparative evaluation of the effect of vibratory stimuli using sonic tooth brush on the rate of tooth movement- Randomized control trial.

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ABSTRACT
AIMS AND OBJECTIVES: *To evaluate the effect of a defined vibratory stimuli using sonic toothbrush on rate of orthodontic tooth movement at each time intervals till 6 months.Comparison of overall mean rate of tooth movement between experimental and control group.To quantify the mean brushing time in one day per month with rate of tooth movement.Correlation of the remaining amount of space with the rate of tooth movement.*
MATERIAL AND METHODOLOGY: *A double blinded study included patients requiring upper first premolar extraction on both sides. The patients were divided randomly into two groups' experimental group and control group. MBT brackets with 0.22 slots were used for enmasse retraction. The recordings was done at the beginning of retraction phase till 6 months of space closure. The patients in Experimental group were instructed to use sonic toothbrush with vibrating bristles for stimulation and to hold the tooth brush for 30 sec on each tooth on labial and lingual surfaces of anterior teeth for two times a day. The duration of brushing was recorded in a monthly chart given to the patient. A series of models from each subject were used to assess the amount of tooth movement relative to a stable landmark of ipsilateral lateral end of the third rugae. The lateral end of third rugae will be extended towards extraction space. Measurements was taken from canine tip to the extended lateral end of third rugae.The rate of Orthodontic tooth movement was calculated.*
RESULTS: *The difference in the rate of tooth movement between both the groups was seen at T3,T4 and T5.The rate of orthodontic tooth movement was found to be 0.89mm/month for experimental group and 0.53mm/month for control group. The rate of tooth movement in experimental group was uniform till space closure whereas for control group it gradually decreased.The correlation between the mean brushing time in one day per month with the rate of tooth movement showed weak correlation.Negative weak correlation was found between the remaining amount of space present and the rate of tooth movement.*
CONCLUSION: *Vibration stimuli produced by sonic tooth brush accelerates the rate of orthodontic tooth movement in retraction stage. There is faster tooth movement in experimental group after the third month of space closure.*

I.   INTRODUCTION

Today, many people receive orthodontic treatment which brings about better occlusion, improved oral function and harmonized facial appearance. However, a perplexing challenge that has not been completely solved in clinical orthodontics, is prolonged treatment time (on average 2-3 years).

Orthodontic tooth movement (OTM) is generated by the coupling of bone resorption on the compressed side of the periodontal ligament (PDL) and through bone formation on the stretched side of the PDL as a consequence of therapeutic mechanical stress.

In the literature, no consensus has been reached about orthodontic treatment time. A recent systematic review revealed mean treatment time with fixed appliances of 19.9 months. However, there was significant variation among studies (with mean values ranging from 14 to 33 months), and the quality of treatment outcomes was not assessed.[6] The cases which were assessed under the American Board of Orthodontics (ABO) standards, one-phase orthodontic treatment mean time was 24.6 months. [1, 2]

A number of attempts have been made to create different approaches both preclinical and clinically in order to achieve quicker results.Thus, accelerating orthodontic tooth movement and the resulting shortening of the treatment duration would be quite beneficial.

Methods to accelerate orthodontic tooth movement can be broadly studied under the following categories:

1. Drugs. (Vitamin D, prostaglandins, PTH)
2. Surgical Methods. (Corticotomy, microosteoperforations, peizoceison, distraction osteogenesis)
3. Physical/ Mechanical stimulation methods. (Vibrations, low level laser therapy)

However, pertinent results are inconclusive, and some are unreliable, which may bias clinicians' understandings and mislead clinical practice.

Various studies have reported that short durations of low magnitude, high frequency resonance vibration combined with orthodontic tooth movement without additional tissue damage to humans. Vibrations are said to be noninvasive and is effective to reduce treatment time. A number of in vivo and in vitro studies have suggested mechanical vibration which can affect the bone metabolism and increase rate of tooth movement.

Promising rates of tooth movement were described in initial articles involving vibrational forces applied to human subject for 20 minutes per day.[6]It was stated that the Little irregularity index was reduced in both arches with the effect of vibratory stimulation at a much faster rate.[7].

Till date Low level mechanical oscillatory signals were not routinely used because of their high cost and complex technological design. Thus there was a need to use a device which is simple, cost effective and easily available which could reduce orthodontic treatment time.

Leethanakul et al reported that with light orthodontic force, application of vibratory stimuli using electric toothbrush (Colgate Motion-Multi Action) with rotating and vibratory head with frequency (125 Hz) enhanced the secretion of interleukin 1 beta in GCF and accelerated orthodontic tooth movement. [14]Thus there is a need to do further research where using vibrations produced by sonic tooth brushes can accelerate tooth movement. The aim of this study to evaluate the effect of vibration stimuli given by sonic tooth brush on rate of orthodontic tooth movement.

AIM AND OBJECTIVE:
➢ To evaluate the effect of vibratory stimuli using sonic tooth brush on rate of orthodontic tooth movement.

SOURCE OF DATA
➢ The sample size estimated was 16,considering droupouts a sample size of 20 was taken for the study, including males and females with age between 15 and 40.

STUDY DESIGN
➢   Experimental prospective study design
➢   samples were obtained from patients who required orthodontic treatment and done the assessment ,quantification and comparison of the rate of space closure of two groups,the study design is an experimental prospective study ,with the power of 80% and alpha error of 5%

INCLUSION CRITERIA
◉   Age:15-40 years
◉   Patients with bilateral upper 1st premolar extractions are included.

⊙   Patients with maxillary protrusion with minimal or no crowding with minimum of 3mm space left are included.

EXCLUSION CRITERIA
⊙   Patients with periodontal problems are not included.
⊙   Patients with poor oral hygiene.
⊙   Patients having systemic diseases are included.

II.   METHODOLOGY

•   20 orthodontic patients with upper bilateral first premolar extraction were randomly divided using coin flip method into 2 groups (10 patients in each groups)

➢   Group A(Experimental group)
➢   Group B(control group)
⊙   MBT brackets with 0.22 slots were used for enmasse retraction and all the retraction force was kept standard for both control and experimental group measured using dontrix guage.
⊙   The assessment was done at the beginning of retraction phase and the experimental group was using JSB HF27 surround toothbrush with vibrating bristles.(100Hz) for stimulation.(Figure 1)

Figure 1

⊙   The patients were instructed to hold the tooth brush for 30 sec on each tooth on labial and lingual surfaces of anterior teeth for total of 12 mins two times a day till space closure. This was carried out along with routine oral hygiene procedure.(Figure 2)

Figure 2

⊙ The participants were given a chart in which they had to record the date ,time and duration of brushing time and was asked to report every appointment.(Figure 3)

SUNDAY		MONDAY		TUESDAY		WEDNESDAY		THURSDAY		FRIDAY		SATURDAY	
1		**2**		**3**		**4**		**5**		**6**		**7**	
MORN	NIGHT	MORN	NIGHT	MORN	NIGHT	MORN	NIGHT	MORN	NIGHT	MORN	NIGHT	MORN	NIGHT
START TIME:	START TIME:	START TIME:	START TIME:	START TIME:	START TIME:	START TIME:	START TIME:	START TIME:	START TIME:	START TIME:	START TIME:	START TIME:	START TIME:
STOP TIME:	STOP TIME:	STOP TIME:	STOP TIME:	STOP TIME:	STOP TIME:	STOP TIME:	STOP TIME:	STOP TIME:	STOP TIME:	STOP TIME:	STOP TIME:	STOP TIME:	STOP TIME:
DUR:	DUR:	DUR:	DUR:	DUR:	DUR:	DUR:	DUR:	DUR:	DUR:	DUR:	DUR:	DUR:	DUR:
8		**9**		**10**		**11**		**12**		**13**		**14**	
MORN	NIGHT	MORN	NIGHT	MORN	NIGHT	MORN	NIGHT	MORN	NIGHT	MORN	NIGHT	MORN	NIGHT
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15		**16**		**17**		**18**		**19**		**20**		**21**	
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22		**23**		**24**		**25**		**26**		**27**		**28**	
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DUR:	DUR:	DUR:	DUR:	DUR:	DUR:	DUR:	DUR:	DUR:	DUR:	DUR:	DUR:	DUR:	DUR:
29		**30**		**31**									
MORN	NIGHT	MORN	NIGHT	MORN	NIGHT	MORN	NIGHT	MORN	NIGHT	MORN	NIGHT	MORN	NIGHT
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DUR:	DUR:	DUR:	DUR:	DUR:	DUR:	DUR:	DUR:	DUR:	DUR:	DUR:	DUR:	DUR:	DUR:

Figure 3

Measurement of the Amount of Tooth movement
⊙ A series of models from each subject was used to assess the amount of tooth movement relative to a stable landmark of ipsilateral lateral end of the third rugae.(Figure 4)

Figure 4

⊙ The lateral end of third rugae was extended towards extraction space.
⊙ Measurements was taken from canine tip to the extended lateral end of third rugae.(Figure 5)

Figure 5

⊙   One investigator blinded to the experiment measured all models with digital caliper for accuracy.
⊙   The rate of space closure was calculated according to the formula
⊙   Rate=[the distance of T1-the distance of T2]divided by the time between T1 and T2
Measurements will be taken from beginning of retraction till 6 months

III. RESULTS:

Table 1: Comparison of mean average time duration for retraction during the study period

Comparison of mean average time duration for retraction b/w Experimental & Control group using Independent Student t Test						
Time	Groups	N	Mean	SD	Mean Diff	P-Value
T0-T1	Exp.	8	29.25	5.47	-1.63	0.47
	Control	8	30.88	2.90		
T1-T2	Exp.	8	32.00	4.34	0.88	0.65
	Control	8	31.13	3.14		
T2-T3	Exp.	8	29.38	5.42	1.75	0.47
	Control	8	27.63	3.89		
T3-T4	Exp.	8	29.75	3.20	0.00	1.00
	Control	8	29.75	3.85		
T4-T5	Exp.	7	29.14	5.15	-0.48	0.86
	Control	8	29.63	5.45		
T5-T6	Exp.	4	32.00	2.16	2.00	0.44
	Control	8	30.00	4.63		

➢   Table 1 depicts the comparison of average mean time of retraction in between both the groups during the study period.
➢   The test results demonstrated a relative variation in the mean duration of time for retraction between experimental and control group. But yet, the experimental group showed successful retraction at T4-T5 (n=1) and T5 – T6 (n=4) as compared to the control group.

Table 2:Comparison of mean rate of tooth movement (in mm)/month b/w Exp. and Control groups

Comparison of mean rate of tooth movement (in mm/month) b/w Exp. and Control groups at diff. time intervals using Independent Student t Test						
Time	Groups	N	Mean	SD	Mean Diff	P-Value
T1	Exp.	8	1.117	0.624	0.085	0.74
	Control	8	1.032	0.321		
T2	Exp.	8	0.941	0.678	0.062	0.84
	Control	8	0.879	0.481		
T3	Exp.	8	0.995	0.569	0.487	0.04*
	Control	8	0.508	0.231		
T4	Exp.	8	0.774	0.240	0.386	0.002*
	Control	8	0.388	0.143		
T5	Exp.	7	0.694	0.147	0.333	<0.001*
	Control	8	0.361	0.120		

***- Statistically Significant**

Table 2 depicts the comparison of mean rate of tooth movement between experimental and control group at each month. The comparison was done using Independent Student t Test.

➢   Comparing both the groups with independent student test showed that there was statistically significant difference in the rate of tooth movement at T3,T4 and T5 with P value 0.04,0.002 and <0.001.

Table 3:Comparison of Overall mean rate of tooth movement between experimental and control group.

Comparison of Overall mean rate of tooth movement (in mm/month) b/w Exp. and Control groups using Independent Student t Test						
Parameter	Groups	N	Mean	SD	Mean Diff	P-Value
Overall Mean Rate	Exp.	8	0.865	0.307	0.334	0.01*
	Control	8	0.531	0.118		

***- Statistically Significant**
Table 3 depicts Comparison of overall mean rate of tooth movement between experimental and control group using Independent Student t test was done.The experimental group showed mean rate of tooth movement as 0.86 ±0.030mm/day whereas in control group it was 0.5±0.11+mm/month. The overall mean rate of tooth movement (in mm) is significantly higher in experimental group as compared to control group at P=0.01.

Table 4: Comparison of mean rate of tooth movement at different time intervals in Experimental group.

Comparison of mean Rate of tooth movement (in mm/month) between diff. time intervals in Experimental group using Repeated Measures of ANOVA Test					
Time	N	Mean	SD	Min	Max	P-Value
T1	7	0.934	0.376	0.20	1.35	0.26
T2	7	0.854	0.683	0.36	1.92	
T3	7	1.023	0.608	0.63	2.31	
T4	7	0.808	0.236	0.56	1.15	
T5	7	0.694	0.147	0.53	0.94	

Table 4 depicts the intragroup comparison between different time intervals in experimental group using Repeated measures of ANNOVA test.In experimental group the mean rate of tooth movement that T1 was 0.934±0.376mm/month,T2 was 0.085±0.68mm/month,T3 was 1.02±0.60mm/month,T4 was 0.80±0.23mm/month,T5 was 0.69 ±0.14mm/month.The test result demonstrates that the mean rate of tooth movement (in mm) does not has any significant difference b/w different time intervals in experimental group.
Note: The number of patients assessed for intra group comparison is (N=7), as 1 Patient was completed with retraction at T5 time interval.

Table 5:Comparison of mean rate of tooth movement between different time intervals in control group.

Comparison of mean Rate of tooth movement (in mm/month) between diff. time intervals in Control group using Repeated Measures of ANOVA Test						
Time	N	Mean	SD	Min	Max	P-Value
T1	8	1.032	0.321	0.56	1.62	
T2	8	0.879	0.481	0.00	1.54	
T3	8	0.508	0.231	0.21	0.74	0.001*
T4	8	0.388	0.143	0.26	0.62	
T5	8	0.361	0.120	0.19	0.55	

*** - Statistically Significant**

Table 5 depicts the intragroup comparison of rate of tooth movement in different time intervals in control group using Repeated Measure ANOVA test.The mean rate of tooth movement at T1 was 1.032±0.32mm/month,at T2 was 0.87±0.48mm/month,T3 was 0.508±0.23,T4 was 0.388±0.14mm/month,T5 was 0.361±0.12mm/month.The test results showed that there was significant decrease in the mean rate of tooth movement (in mm) between different time intervals in control group at P=0.001.

Table 6:Multiple Comparison of mean rate of tooth movement between different time intervals in control group.

Multiple comparison of mean Rate of tooth movement (in mm/month) b/w diff. time intervals in Control group using Bonferroni's post hoc Test					
			95% CI for the Diff.		
(I) Time	(J) Time	Mean Diff. (I-J)	Lower	Upper	P-Value
T1	T2	0.153	-0.448	0.754	0.21
	T3	0.524	-0.059	1.107	0.02*
	T4	0.644	0.16	1.127	0.01*
	T5	0.670	0.16	1.18	0.01*
T2	T3	0.371	-0.165	0.907	0.04*
	T4	0.491	-0.296	1.278	0.07
	T5	0.517	-0.291	1.326	0.07
T3	T4	0.120	-0.289	0.529	0.18
	T5	0.146	-0.336	0.629	0.12
T4	T5	0.026	-0.207	0.26	0.78

*** - Statistically Significant**

➢ Table 6 depicts Multiple Comparison of Mean rate of tooth movement using Bonferroni's post hoc test showed that the difference in mean rate of tooth movement of T1 with T2 ,T3,T4 and T5 was 0.153mm/month,0.52mm/month,0.644mm/month and 0.67mm/month.
➢ Multiple comparison of mean difference revealed that the mean rate of tooth movement significantly reduced from T1 to T3 [P=0.02], T4 [P=0.01] & T5 [P=0.01], followed by a significant decrease in mean rate of

tooth movement between T2 & T3 at P=0.04, with borderline significance with T2 & T4 and T2 & T5, both at P=0.07.

Table 7:The Correlation to assess the relationship between Rate of tooth movement and mean brushing time/day at different time intervals in experimental group.

Pearson Correlation test to assess the relationship between Rate of tooth movement and mean brushing time / day at different time intervals in Experimental Group						
Group	Variable	T1	T2	T3	T4	T5
Exp.	R & B	0.18	0.12	0.23	0.22	0.20
	P-Value	0.67	0.77	0.59	0.60	0.64

➤ Table 7 depicts the relationship between rate of tooth movement and mean brushing time/day at different time intervals in experimental group using Pearson Correlation test .The coreelation at T1 was0.18 which is very weak correlation,at T2 was 0.12 which showed very weak correlation,T3 was 0.23 which was weak correlation,T4 was which was weak correlation and at T5 was 0.20 which was weak correlation.

➤ The test results demonstrate that there exists a very weak to weak positive correlation between the rate of tooth movement and mean brushing time / day at different time intervals in experimental group.
➤ However, the relationship between the 2 variables was not statistically significant

Table 8:Assessment of the relationship of rate of tooth movement and amount of remaining space in experimental group.

Pearson Correlation test to assess the relationship between Rate of tooth movement and amount of remaining space (in mm) in Experimental Group						
Group	Variable	T1	T2	T3	T4	T5
Exp.	R & S	-0.57	-0.48	-0.72	-0.29	-0.27
	P-Value	0.14	0.23	0.04*	0.47	0.51

*** - *Statistically Significant*
Note: R - Rate of Tooth movement (in mm)
S - Amount of remaining space (in mm)
Table 8 depicts The relationship between rate of tooth movement and amount of remaining in experimental group using Pearson Correlation test.It was found that the correlation at T1,T2,T3,T4 and T5 was -0.57,-0.48,-0.72,-0.29 and -0.27.
The test results demonstrate that there exists a strong negative correlation between the rate of tooth movement and amount of space remaining (in mm) at T4 time interval in experimental group at P=0.04. Similar weak to moderate correlation between other time intervals, however the relationship between 2 variables was not statistically significant.

Table 9: Assessment of the relationship of rate of tooth movement and amount of remaining space in control group.

Pearson Correlation test to assess the relationship between Rate of tooth movement and amount of remaining space (in mm) at different time intervals in Control Group						
Group	Variable	T1	T2	T3	T4	T5
Control	R & S	-0.15	-0.10	-0.42	-0.24	-0.01
	P-Value	0.72	0.81	0.31	0.57	0.97

Note: R - Rate of Tooth movement (in mm)
S - Amount of remaining space (in mm)

➢ The relationship between rate of tooth movement and amount of remaining in control group using Pearson Correlation test.It was found that the correlation at T1,T2,T3,T4 and T5 was -0.15,-0.10,-0.42,-0.24 and -0.01.

➢ The test results demonstrate that there exists a very weak to moderate negative correlation between the rate of tooth movement and amount of space remaining (in mm) at different time intervals in control group.

➢ However, the relationship between the 2 variables was not statistically significant.

IV. DISCUSSION

Accelerated orthodontics have lead a way to reduce orthodontic treatment time.This has been the goal of patient as well as orthodontists for many years.Accelerated tooth movement with invasive methods and cumbersome heavy instrument have been used in the past years.Most of the orthodontist and patients are looking for a method which is effective and can be used in daily routine and easily available.

The present study being invivo study maximum care was taken to record the uniform time in between each measurements as 30 days.

.In the present study, the comparison of mean rate of tooth movement occuring between each measurements between control and experimental groups showed statistically significant difference at T3, T4 and T5.The difference in the rate of tooth movement between two groups at T1 and T2 was not statistically significant. This might be attributed to the regional acceleratory phenomenon(RAP). In the present study, even though no vibratory stimulation was given in control group the rate of tooth movement was comparableto that in experimental group due to Regional acceleratory phenomenon acting in the both the groups at T1 and T2.The RAP phenomenon reduced in control group after T2 but in experimental group even though there was reduction in RAP phenomenon the vibratory stimuli produced by sonic tooth brush maintained the regional acceleratory phenomenon after T2..This implies that vibratory stimuli produced by sonic tooth brush increased the rate of tooth movement at T3,T4 and T5.

This is in contrast with the results of study done by Mohammad Azeem et al, where the author calculated the rate of canine retraction till 3 months of space closure. It was a split mouth study and the participants were instructed to use the powered tooth brush for 20 mins a day on experimental side. [57] Shalu et al did a study on effect of powered tooth brush of frequency 60 Hz to check for rate of canine retraction for three months and found that vibration stimuli does not effect in acceleration. The author calculated for only three months whereas in the present study the acceleration of tooth movement occurred after the 3rd month of the study. [58]

The present study observed the overall average mean rate of tooth movement in experimental group was 0.8mm/month whereas for control group it was 0.5mm/month for the duration of six months in both the groups.In the present study it was observed that the rate of retraction was faster in experimental group with the space closure happening by the end of 5th or 6th month whereas for the control group the rate of retraction was going on even after 6 months of the study. This implies that the space closure did not complete in control group even after 6 months.The average rate of tooth movement increased with the effect of vibratory stimuli produced by sonic tooth brush leading to decrease in the duration of retraction.

Similar studies were done by use of vibrating device, Dubravko Pavlin did a study to assess the effect of low level cyclic loading on rate of orthodontic tooth movement. Orthodontic tooth movement was significantly higher for the AcceleDent group with 1.16mm/month compared to 0.79 mm/month in the control group, with the mean difference of 0.37mm/month [44]. Similar results were found in our study where vibration produced by sonic tooth brush the mean rate was 0.8mm/month compared to control group with 0.5mm/month this showed that there was increased rate of orthodontic tooth movement. This is in correlation with the study done by Leethanakul did a study in which the author used sonic tooth brush with frequency of 150 Hz on interleukin -1 beta levels and rate of orthodontic space closure. The results showed that there was enhanced secretion of interleukin -1 beta in vibratory group thus enhancing the rate of orthodontic tooth movement during space closure. In our study also we found increase in rate of orthodontic tooth movement in vibratory group compared to control. The present study there was 62% faster mean rate of tooth movement per month in experimental group compared to control group.

In the present study the difference in the rate of tooth movement in experimental group between each time intervals was not statistically significant.This implies that the rate of tooth movement remained uniform with the use of the vibratory stimuli produced by sonic tooth brush till the end space closure.

Patient compliance is an important factor which has to be considered while giving the patient a device which needs to be used daily by the patient.Therefore,the present study tried to quantify the effect of brushing with the rate of tooth movement in the experimental group.The results showed very weak correlation between the two at T1 and T2 whereas weak correlation T3,T4 and T5.Future studies needs to be done with larger sample size to find the optimum brushing time as well as devices that can record the duration of using the brush can have maximum effect on the rate of tooth movement.

A study done by Chung how kau et al[62] evaluated patient compliance for the acceledent device .Patient compliance with the device was 67%. Also significant patient compliance was noted with the use of sonic tooth brush, The patients were given monthly chart to record the time and duration of use of the tooth brush. A study done by Sharon Gibbs[59] evaluated the acceptance rate of the patients with acceledent and found that the acceptance of AcceleDent when recommended with orthodontic treatment was documented over a three-month period (February-April 2011). Of the 35 patients who accepted treatment during that time, AcceleDent was offered to 16 patients (45%) and accepted by 10, resulting in an overall 63% acceptance rate.

V.   CONCLUSION:

The present study was done to evaluate the effect of defined vibratory stimuli using sonic tooth brush on the rate of orthodontic tooth movement. Within the limitations of the study following conclusions can be made:

1.The difference in the mean rate of tooth movement when compared in experimental and control group showed statistically significant difference at T3, T4 and T5.

2. The overall mean rate of tooth movement in experimental group was 0.89mm/month and for control group was0.53mm/month respectively. Indicating 62% faster rate of tooth movement in experimental group.

3. In the experimental group the rate of tooth movement remained uniform till the end of space closure whereas in control group it gradually decreased.

4. Correlation of mean brushing time with the rate of tooth movement in experimental group showed weak correlation between the two.

5. The correlation between the remaining amount of space present (mm) with rate of tooth movement showed weak negative correlation.

6. The vibratory stimulus produced by sonic tooth brush helps in acceleration of orthodontic tooth movement.

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