Original Article

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To Study the Effect of Vibrations on Pain and Rate of Anterior Teeth Alignment: An Invivo Study

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ABSTRACT

Introduction – This clinical study was undertaken to compare the rate of anterior teeth alignment and discomfort in patients treated with conventional and passive self ligating brackets along with an indigenously designed functional and dummy orthodontic vibration device.

Materials and Methods – 36 patients were selected for fixed orthodontic treatment and randomly divided into 6 groups- MBT and SLB with vibration(30 Hz,25g), MBT and SLB(control groups), MBT and SLB with dummy device(placebo groups). Little's irregularity index for lower anteriors was evaluated at start of treatment (T0), at 6 weeks (T1) and 12 weeks (T2). Pain was scored on a visual analogue scale (VAS) at 1 hour after archwire insertion and 2 hours after insertion within which time patients had used their allotted devices.

Results – There was no significant difference in irregularity between groups at T0. Significant alleviation of crowding was seen in the MBT groups subjected to vibration compared to control and placebo MBT groups ($p=0.05$). However this difference in resolution of irregularity was not statistically significant between the SLB group with vibration and placebo and control groups. The reduction in pain was found to be statistically significant by the use of vibration device at all appointments ($p<0.001$).

Conclusion - The vibration device was more effective for initial alignment in the MBT group compared to SLB group. Pain was significantly reduced in both MBT and SLB groups by vibration therapy.

Key words: Accelerated tooth movement, vibrations, pain.

INTRODUCTION

One of the biggest problems faced by a patient undergoing orthodontic treatment is the long duration of treatment which can range from several months to years, depending upon the severity of malocclusion. This is not received well by many adult patients prompting them to seek other alternatives. Besides the discomfort and difficulty in maintaining proper oral hygiene, prolonged treatment exposes the patient to risks including root resorption, caries, periodontal disease and diminishes patient cooperation.[1]

Treatment modalities that decrease treatment time without compromising the outcome are an active area of research in orthodontics today. These methods can be broadly classified as biological (drugs), surgical approaches and physical/mechanical stimulation.

The use of drugs to speed up orthodontic tooth movements has been extensively investigated, although most of these are animal studies and only few human trials are available due to the other systemic effects of these drugs[2,3]

Classical surgical techniques of Periodontally Accelerated Osteogenic Orthodontics (PAOO) such as corticotomy[4] and piezocision[5] have been quite effective in decreasing treatment time yet they have limited patient acceptance due to their invasiveness and side effects. Studies aimed towards the ongoing search for non invasive techniques have shown evidence that the application of physical therapies such as vibration[6], low level lasers[7] and direct electric current[8] can stimulate and accelerate bone formation and probably bone remodelling. Orthodontic tooth movement, brought about by the application of light continuous forces that induce bone formation and remodelling, can possibly be accelerated by the application of cyclic (vibrational) force, with the advantage of reducing the overall treatment time. They have also been shown to reduce relapse, pain and root resorption caused due to orthodontic forces.

Many enterprises such as AcceleDent™, OrthoAccel Technologies have come up with daily use vibration devices promising faster orthodontic treatment and reduced pain by

delivering mechanical stimulation to the dentition.

Though initial studies have demonstrated vibration to be quite effective in reducing orthodontic pain, more recent reviews have shown variable results with high risk bias[9,10]. There is no adequate research that includes control group(no device group) and placebo group (dummy, non-working identical device) which provides conclusive reports on the effect of vibration device in orthodontic treatment. No in vivo study has been conducted that compares the amount of tooth movement and pain relief achieved by vibration when used with conventional brackets, self ligating brackets and control groups. This study compares self ligating and TWIN BRACKET appliances with vibration device, a placebo dummy device and a control group where no such device was given. A plethora of orthodontic vibration devices are commercially available, but their cost factor and availability in the Indian market is a major drawback. So for the purpose of this study, an orthodontic vibration device was indigenously designed.

AIM

To compare the rate of mandibular incisor alignment and pain threshold in patients treated with conventional twin brackets and passive self ligating brackets along with an indigenously designed orthodontic vibration device.

OBJECTIVE

1. To determine the amount of anterior teeth alignment using an orthodontic vibration device with conventional brackets.

2. To determine the amount of anterior teeth alignment using an orthodontic vibration device with passive self ligating brackets.

3. To compare the amount of anterior teeth alignment between vibration, control and placebo groups.

4. To compare pain experience in vibration, control and placebo groups.

MATERIALS AND METHODS

MATERIALS

The materials required for the study including TWIN BRACKET(mbt prescription) and passive self ligating bracket(SLB) kits (0.022 inch slot, mbt prescription) and 0.014", 0.016" NiTi wires for initial alignment. Two types of devices were customized: Functional vibration device and Dummy device. The two devices were identical to each other in all aspects except that the dummy device did not vibrate on activation. Digital calipers were used for all measurements on stage models.

The sample size was calculated using the **Gpower software**. The power of the study was taken to be 80% and Confidence Interval (C.I.) of 95% was taken. The sample size was estimated to be a minimum of 6 per group. So, the total sample size was estimated to be 36.

These 36 subjects were later randomly divided into 6 groups of 6 each.

INCLUSION CRITERIA

1. Lower anterior crowding of mild to moderate degree according to Little's Irregularity Index.[11]
2. No initial therapeutic intervention planned involving intermaxillary or intraoral appliances including elastics, lip bumper or headgear.
3. Healthy, compliant and motivated patients ready to participate in the study.
4. Patients who were to be treated non extraction and without any IPR.

EXCLUSION CRITERIA

1. Previous history of orthodontic treatment, trauma.
2. Prosthetic replacements or large restorations in anterior teeth.
3. Presence of active periodontal or systemic disease.

METHODOLOGY

The duration of study was 3 months in which initial alignment of the mandibular arch was evaluated. Patients were informed about the study and their consent for participation was taken.

All patients were randomly divided into six groups :

Group 1, treated with conventional brackets along with orthodontic vibration device,

Group 2, treated with self ligating brackets along with orthodontic vibration device,

Group 3, (control group) participants undergoing treatment with conventional brackets did not use any vibration device

Group 4, (control group) participants undergoing treatment with self ligating brackets did not use any vibration device.

Group 5, (placebo group) participants undergoing treatment with conventional brackets used dummy vibration device

Group 6, (placebo group) participants undergoing treatment with self ligating brackets used dummy vibration device

Group 1, 2, 5 and 6 members were provided with the respective vibration device (functional/ dummy) prior to beginning of anterior teeth alignment. They were educated about the device and were instructed to use it for 20 minutes (preferably around the same time) each day for the duration of the study. The subjects were blinded to the allocation of the devices.

The orthodontic vibration device (Figure 1) was designed specifically for the purpose of this study. It vibrates with a

relatively low frequency of 30Hz and delivers a force of 25g. A built-in timer automatically turns off the device after 20 minutes of activation. A button is provided to manually turn off the device if required. It has a rechargeable battery with a standard AC adaptor. Color coded lights indicate active or charging status of the device.

The device comprises 2 main parts:

The body houses the battery and main circuitry of the device. Patients place the device on a hard stable surface when using it so as not to dampen the vibrations (Figure 2).

The mouthpiece is the active part which vibrates once the device is switched on. The mouthpiece is custom made according to the archform of the individual and is fabricated from stiff bioacrylic material. The patient has to bite on the mouthpiece and clean it after every use.

Usage protocol: Patients in the functional device group are to use the device for 20 minutes, 1 hour after arch wire placement on the day of appointment and 20 minutes each day during the three months of study

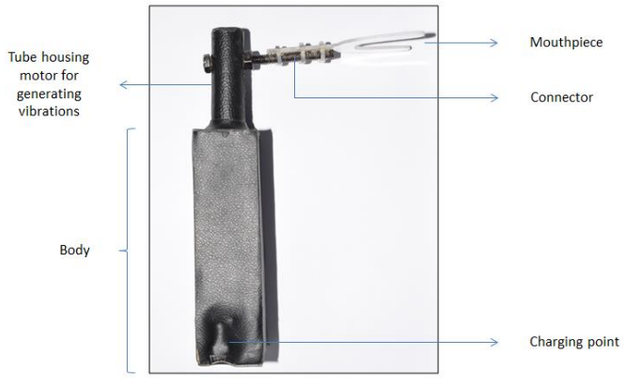


Figure 1 – The orthodontic vibration device.

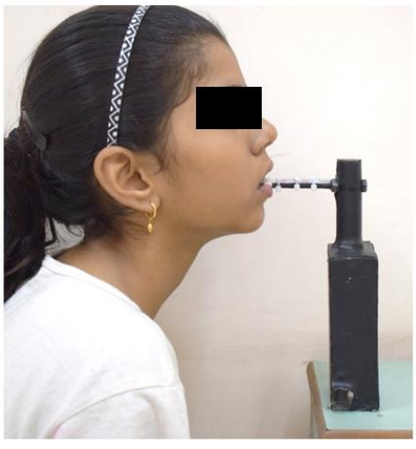


Figure 2 – depicting the hands free usage of the device.

Banding and bonding was commenced with TWIN BRACKET brackets in Groups 1, 3 and 5, SLB in groups 2, 4 and 6. In all groups 0.014 NiTi was inserted for the first 6 weeks (one and half months) and 0.016 NiTi for next 6 weeks (one and half months). The wire was ligated with 0.010 inch stainless steel ligature wires in the TWIN BRACKET appliance.

Time of observation was extended from T_0 to T_2 where

T_0= first archwire placed.

T_1=appointment at one and half month.

T_2=appointment after 3 months.

Alginate impressions were taken at all 3 stages and models made to evaluate the correction of crowding using Little's Irregularity Index (LII).

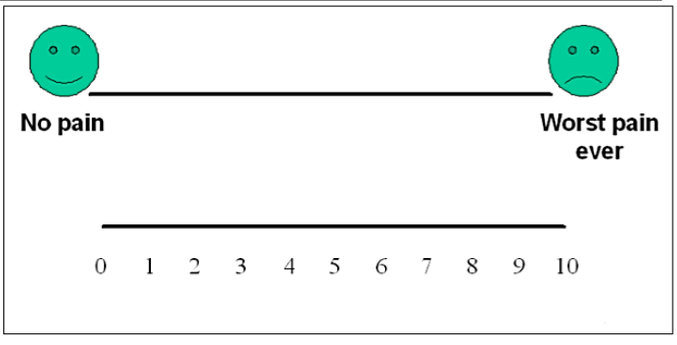
All participants were asked to complete a pain scale survey after the archwire placement. The visual analogue scale (VAS) contained a series of 10 scales on which the patient marked the degree of discomfort (none to worst pain imaginable)(Figure 3). The first reading for all patients was taken 1hour after archwire placement before device usage. Following this, patients in vibration and placebo groups used their devices for 20 minutes and marked their pain scores after 40 minutes of device usage (2 hours after archwire placement). Patients allocated to control groups marked their pain score 2 hours after archwire insertion. All patients were directed not to take any pain medication.

Data for pain scores was recorded as under-

At T_0 appointment : T_0'= pain at 1hr, T_0" = pain at 2hrs

At T_1 appointment : T_1'= pain at 1hr, T_1" = pain at 2hrs

At T_2 appointment : T_2'= pain at 1hr, T_2" = pain at 2hrs



RESULTS

The data collected was entered in the excel sheet using Microsoft Excel Software. Then this data was transferred to Statistical Package for Social Sciences (SPSS) version 21 for analysis. Presentation of data was done using Tables and Graphs. Normality of data related to interval or ratio variables was checked by Shapiro Wilk test. As data followed the normal distribution, parametric tests of significance were used. Paired t test for comparison of means of two dependent groups was used. One way ANOVA test followed by post hoc tukey's test for pairwise comparison was used to compare the means of more than two groups. The level of significance was set at 0.05.

The data for statistical analysis was measured from study models taken at T0,T1 and T2. The Little's Irregularity index(LII) was measured to determine resolution of crowding at each stage and has been summarized in Table 1 and 2. Groupwise comparison of Little's index at T0 found the difference to be insignificant, showing that mean baseline irregularity was more or less uniform for all groups (Table 1). The application of vibrations was found to significantly improve resolution of crouding in the TWIN BRACKET group compared to its control and placebo counterparts. Howerever, this resolution of crowding failed to reach the level of significance for SLB groups compared to its control and placebo groups(Table 2).

Groupwise comparison of VAS scores for pain at T0 in the first hour of archwire insertion was found to be statistically insignificant; mean pain for participants in all groups was

Table 1 : Groupwise comparison of Little's index at T0

	N	Mean	Std. Deviation	Std. Error
Group 1	6	4.400	1.6050	.6552
Group 2	6	4.650	.7714	.3149
Group 3	6	3.433	1.4376	.5869
Group 4	6	4.683	.7910	.3229
Group 5	6	3.883	.8612	.3516
Group 6	6	4.367	.9158	.3739
Total	36	4.236	1.1253	.1876
P value	0.359 NS			

Table 2 : Groupwise comparison of little index from baseline to T1 and T2

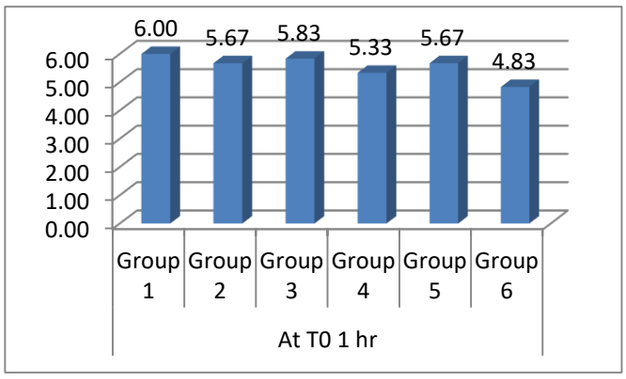
		N	Mean	Std. Deviation	Std. Error	P VALUE
LITTLE INDEX at T1 from baseline	Group 1	6	1.9333	.45019	.18379	0.295 NS
	Group 2	6	1.6000	.46043	.18797	
	Group 3	6	1.4500	.42778	.17464	
	Group 4	6	1.6500	.40373	.16482	
	Group 5	6	1.3833	.47504	.19394	
	Group 6	6	1.5333	.24221	.09888	
	Total	36	1.5917	.42586	.07098	
LITTLE INDEX at T2 from baseline	Group 1	6	3.3000	1.05641	.43128	0.050 S
	Group 2	6	3.6167	.66458	.27131	1-3 S
	Group 3	6	2.4667	.73121	.29851	1-5 S
	Group 4	6	3.0000	.40988	.16733	
	Group 5	6	2.6000	.51381	.20976	
	Group 6	6	3.00	.31	.15	
	Total	36	2.9889	.73008	.12168	

similar. (Graph 1). The application of vibrations significantly reduced the pain in both TWIN BRACKET amd SLB bracket groups at all appointments, while the pain increased from 1 hr to 2 hrs in the placebo and control groups (Graph 1,3,5 vs Graph 2,4,6)

No significant difference was seen in the values of LII at T0 when compared groupwise using One way ANOVA test ($p>0.05$). Thus mean LII score of all groups at T0 was similar.

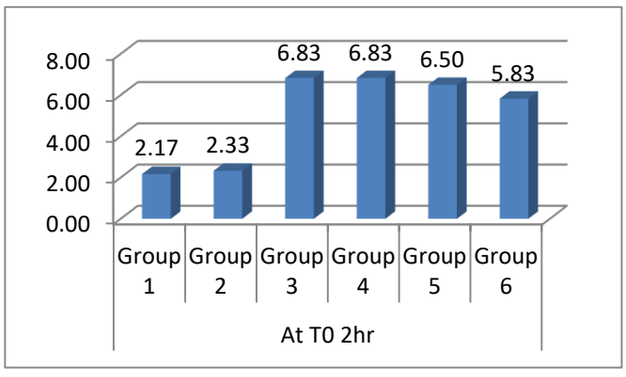
Statistically significantly results observed in group 1 when compared with group 3 and 5, showing better resolution of crowding in TWIN BRACKET with vibration group compared to TWIN BRACKET control and placebo groups. Whereas there was no significant difference in relieving of crowding in the self ligation group with or without vibration device

Graph -1: Groupwise comparison at T_0'



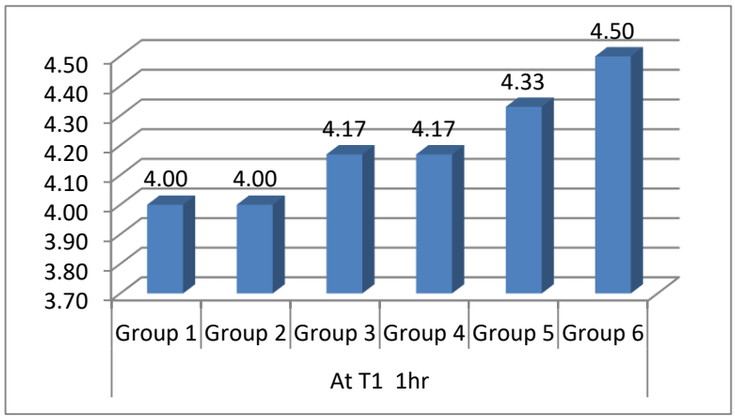
Pain at T_0' is found to be statistically insignificant. The mean pain perceived at T_0' in all groups was similar.

Graph -2 : Groupwise comparison at T_0"



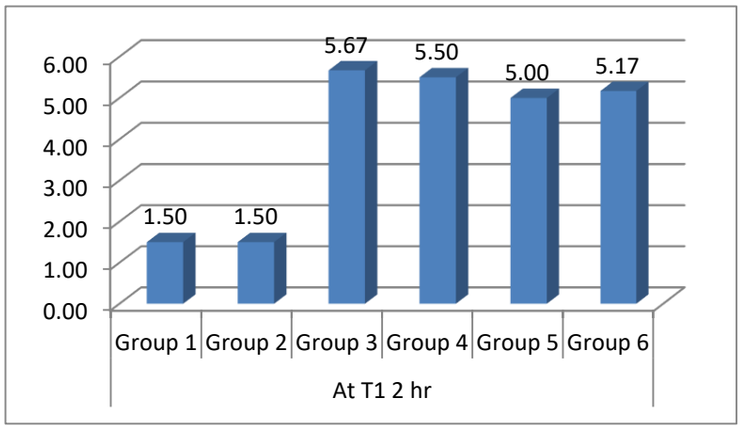
Pain at T_0" is found to be significantly lower in the TWIN BRACKET and SLB groups with vibration compared to control and placebo group.

Graph -3 : Groupwise comparison at T_1'



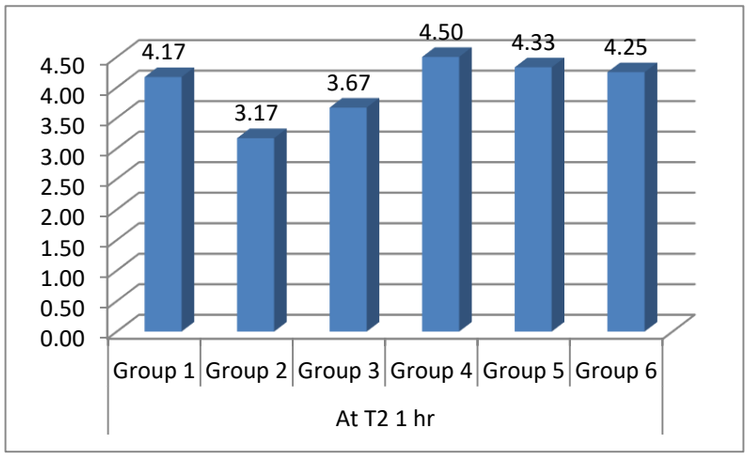
Pain at T_1' is found to be statistically insignificant. The mean pain perceived at T_1' in all groups was similar.

Graph -4 : Groupwise comparison at T_1"



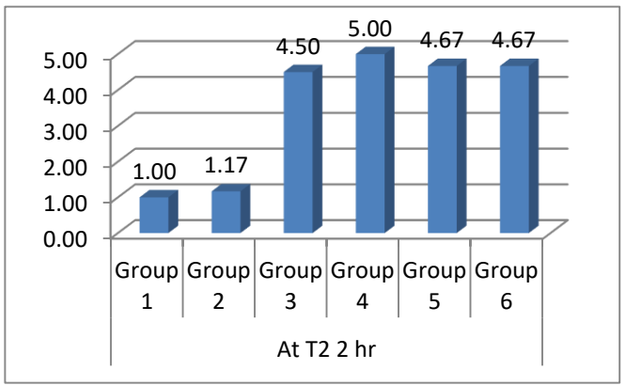
Pain at T_1" is found to be significantly lower in the TWIN BRACKET and SLB groups with vibration compared to control and placebo group.

Graph -5 : Groupwise comparison at T_2'



Pain at T_2' is found to be statistically insignificant. The mean pain perceived at T_2' in all groups was similar.

Graph -6 : Groupwise comparison at T_2"



Pain at T_2" is found to be significantly lower in the TWIN BRACKET and SLB groups with vibration compared to control and placebo group.

DISCUSSION

Shapiro et al[12] reasoned that pulsatile forces can accelerate tooth movement which is associated with the generation of piezoelectric charges when stress is applied and released. However, the effect of these vibrations on dentition was still inconclusive and this study was therefore undertaken to determine the effects of vibration on orthodontic tooth movement. This study was therefore undertaken to determine the effects of vibration on orthodontic tooth movement. The data collected was analysed. Groupwise comparison of Little's index at T0 found the difference to be insignificant, showing that mean baseline irregularity was more or less uniform for all groups (Table 1). Another groupwise comparison of VAS scores for pain at T0 in the first hour of archwire insertion was found to be statistically insignificant; mean pain for participants in all groups was similar. (Graph 1) No effect of vibrations on increasing the rate of tooth movement was observed in the self ligation group. However, there was a significant improvement in the rate of tooth movement by application of vibrations in the TWIN BRACKET group (Table 2).

This discrepancy in the result between the vibration groups could be explained by the stick slip phenomenon. By decreasing the friction between bracket and arch wire, vibrations can effectively increase the rate of tooth movement as shown in studies by Seo et al[13] and Olson et al.[14] Hence it might be considered that the conventional bracket group with greater frictional forces exhibited significantly better alignment on application of vibrations that could overcome the notching in the archwire and resistance to sliding by virtue of the slip stick phenomena whereas the self ligating brackets with already passive archwires and reduced friction were not affected significantly by the vibrations.

Further, on comparison, the difference in alignment achieved by SLB and TWIN BRACKET control groups and SLB and TWIN BRACKET placebo groups was statistically insignificant. (Table 2) Previously, Harradine[15] had reported the self ligating brackets to be superior to conventional brackets. However, the results of this study are congruent with those of Miles et al[16] and Fleming et al[17] who found no difference between the two during initial alignment.

Even though the subjects were unaware of the presence of dummy devices, the absence of vibration in the false device was noticed by many. Even then, the awareness would have no effect on the rate of alignment of the teeth. The difference in the alignment between the TWIN BRACKET vibration and placebo groups was found to be significant whereas there is no significant difference between the control and placebo groups. In SLB groups, no statistically significant difference is seen between vibration, control and placebo groups. (Table 2)

In contrast to studies by Pringle et al[18], the results of the present study showed no significant difference in the pain experienced by patients in the TWIN BRACKET and SLB control groups (Graph 1, 3 and 5). However these results conform to studies done by Fleming et. Al[19] that show bracket type had no influence on pain perception.

Significant alleviation of pain was found in vibration groups while it was not found to be so in patients in placebo and control groups (Graph 1vs 2, 3 vs 4 and 5 vs 6). Wendy et al[20] have also reported similar observations of pain reduction by vibration in their studies, however, miles et al and woodhouse et al had different results. The presence of a placebo group ensured that any possibility of a placebo effect from the device influencing the pain results was dismissed. A mean increase in pain was observed in control and placebo groups at 2 hours after wire placement which has been demonstrated in various studies.

The available literature suggests that the effect of vibration on dental tissues is variable and might be changed by altering the frequency or even the amplitude of the cyclic loading. These along with the various biological variables and metabolic differences might be a reason for the conflicting results.

One limitation of the study was patient compliance. The duration of usage of the device could not be quantified. The incorporation of a timer to record the duration for which the device has been used per day would be a significant improvement. Secondly the sample size was small and the duration of the study was relatively short. Future trials can be designed bearing in mind the abovementioned limitations to arrive at more reliable outcomes. Orthodontic vibration devices and self ligating brackets are expensive. Currently with so much ambiguity surrounding this topic, it remains to be seen if the

results justify the cost.

CONCLUSION

The study concluded the following -

- The vibration device significantly improved the rate of resolution of lower anterior crowding when used with twin brackets for 3 months.
- There was no significant improvement in correction of lower incisor crowding in self ligation braces with vibration device.
- The vibration device was highly effective in relieving pain in patients undergoing orthodontic treatment with both self ligation and twin brackets during initial alignment phase.

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