Original Article

Evaluation Of The Effectiveness Of Combined Photobiomodulation And Piezocision On the Rate Of Orthodontic Tooth Movement. A Randomized Control Trial.

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Abstract:

Aim: To assess and compare the efficiency of tooth movement in patients subjected to piezocision and photobiomodulation as part of a split-mouth clinical experiment, and to combine their effects in order to derive a synergetic effect if any.Methods: 24 subjects requiring bilateral first premolar extractions were selected for the study. The study had a split mouth design with patients subjected to either piezocision, photobiomodulation or a combination of the two techniques in one quadrant and the opposite quadrant served as the control. Piezocision was carried out by placing vertical interproximal incisions on the mesiobuccal and distobuccal aspect of the maxillary canine, whereas photobiomodulation was carried out at ten sites, five on the buccal aspect and five on the palatal aspect with a total energy of 10J in the period between the three weeks. Results: There was no statistically significant difference observed in terms of accelerated tooth movement between piezocision, photobiomodulation or combination of the two techniques and the conventional technique.

Conclusion: Although no statistically significant findings were derived, a synergistic effect was observed with the combined effect of piezocision and photobiomodulation showing an enhanced effect. Increased rate of tooth movements were observed in both piezocision and photobiomodulation group with lowest effect seen in the photobiomodulation group.

Keywords: Accelerated orthodontics, synergestic effects,Flapless piezocision, Low Level Laser therapy

Bangladesh Journal of Medical Science Vol. 22: Special Issue 2023 Page : 138-147
DOI: https://doi.org/10.3329/bjms.v22i20.66322

Introduction:

A certain demerit of orthodontic treatment is its increased treatment time. This has led to patients interrupting the treatment or declining it together. The average orthodontic treatment lasts 18-24 months and carries with it an increased risk of gingivitis, caries and root resorption[1,2,3]. This led to several studies being conducted to decipher methods to accelerate tooth movements and decrease treatment time. Several researchers have introduced low-friction self-ligating brackets (SLB) systems with claims to reduce treatment time and provide efficient orthodontic treatment. However recent studies denote that the treatment time is not significantly reduced when SLB were used[4,5]. Corticotomy was introduced by Wilko in 2001 as a surgical method which would reduce treatment time. This method was a combination of corticotomy surgery followed by alveolar bone grafting. Benefits such as decreased root resorption and improved post-orthodontic stability were observed. However, this method proved invasive and was not widely accepted

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due to its aggressive nature [6,7].In 2009, Dibart introduced a minimally invasive surgical approach termed piezocision wherein micro-incisions were placed on the bucco-labial aspect by means of a piezo-electric knife. Initial studies reported a high degree of patient acceptance and reduced post-surgical discomfort [8,9].

In recent years, low-level laser therapy (LTTT) or photobiomodulation therapy (PBMT) has gained traction as a non-invasive tool which has the potential to accelerate tooth movements.

As a result of photobiomodulation, deoxyribonucleic acid (DNA) and ribonucleic acid (RNA) are synthesized more rapidly, which increases cellular mitotic activity. Consequently, it affects bone remodelling and facilitates tooth movement by activating osteoclasts, osteoblasts, and fibroblasts. A detailed study of its sutural bone regeneration activity was undertaken by Saito and Shimizu[10]. In addition, an analgesic effect was demonstrated by PBMT.

The goal of this study was to clarify the impact of peizocision and low-intensity lasers on orthodontic tooth movement. A further investigation combining the two techniques was carried out to demonstrate a synergistic effect if any.

Objectives of the Study:

General objective:

To assess and contrast the efficiency and biomechanical impacts of piezocision and photobiomodulation as part of a split-mouth clinical experiment, and to combine their effects in order to derive a synergetic effect if any.

Specific Objectives:

1. To perform analysis and comparison of the rate and the efficacy of canine retraction in one quadrant when using piezocision, photobiomodulation or a combination of the two techniques against conventional fixed orthodontic mechanotherapy.

Materials and Methodology:

This randomised clinical trial was carried out on patients reporting to the Department of Orthodontics, Indira Gandhi Institute of Dental Sciences (IGIDS). Patients were enrolled in the study only after obtaining written informed consent. A total of 24 patients were nominated for this study.

Inclusion Criteria:

- Patients of age group 18-25 years
- Patients with Angle's Class I/ Class II div 1 malocclusion with anterior crowding (>5mm) or bimaxillary protrusion necessitating extraction of premolars.
- Individuals with healthy periodontium.
- Individuals with a full set of permanent dentition up to the second molar.

Exclusion Criteria:

- Patients who refused to give their consent either orally or in writing.
- Patients with poor oral hygiene, active periodontal diseases and smoking habit.
- Patients with systemic illness, neuromuscular disease or debilitating diseases.
- Patients with a previous history of orthodontic treatment or surgical treatment.
- Individuals with a history of dental and facial trauma.
- Individuals with mouth-breathing or tongue-thrusting habits.

- Patients in the active growth phase
- Individuals with odontogenic pathologies, transpositions, and gross decay.
- Individuals with congenital anomalies, and facial asymmetry.
- Patients who require orthognathic surgery due to severe skeletal and dentofacial abnormalities.

Sampling Procedure:

The participant selection was founded on the inclusion and exclusion criteria. The participants were then randomly allotted to 3 groups with 8 patients in each group.

Randomization:

Randomization was done using computer-based sequence generation using an online platform (randomizer.org).

Interventional Procedures:

The fixed appliance was bonded and canine retraction was carried out after 20 weeks by varying procedures as per the groups.

Peizocision:

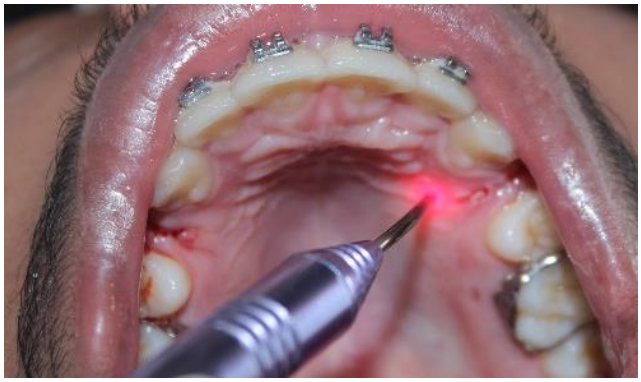
The surgical procedure was carried out on local anaesthesia using a no. 15 surgical blade. Two vertical interproximal incisions were made on the mesiobuccal and distobuccal aspects of the maxillary canines. The mesial and distal interdental papillae of the maxillary canine were located 5mm gingival to the vertical interproximal incisions, which were 10mm long and 3mm deep.A peizocision knife was used to perform the cortical alveolar incisions. Archwires were ligated and the patient was recalled after 2 weeks.

Figure 1:Piezocision technique

Photobiomodulation:

A total of 10 irradiations, 5 on the buccal aspect and 5 on the palatal aspect, were performed. 2 irradiation doses were given on the mesial and distal aspects of the cervical third of the root.2 irradiation doses were given on the mesial and distal aspects of the apical third of the root.1 irradiation dose was given on the middle third of the canine, lateral incisor and central incisor of the experimental side and an irradiation dose was given between the contact points of the maxillary canine and 2nd premolar.

The total energy was 10J in the period between the 3 weeks (1, 21, 42, 63). A 19x25 stainless steel archwire was ligated and the model analysis was done on the 84th day for the estimation of the rate of tooth movement.



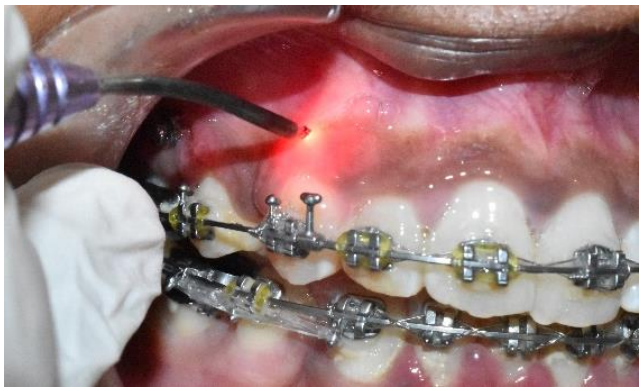


Figure 2: Photobiomodulation technique

Anchorage loss was evaluated after every 2 months until the completion of space closure.

Figure 3: The combination of the piezocision and photobiomodulation techniques

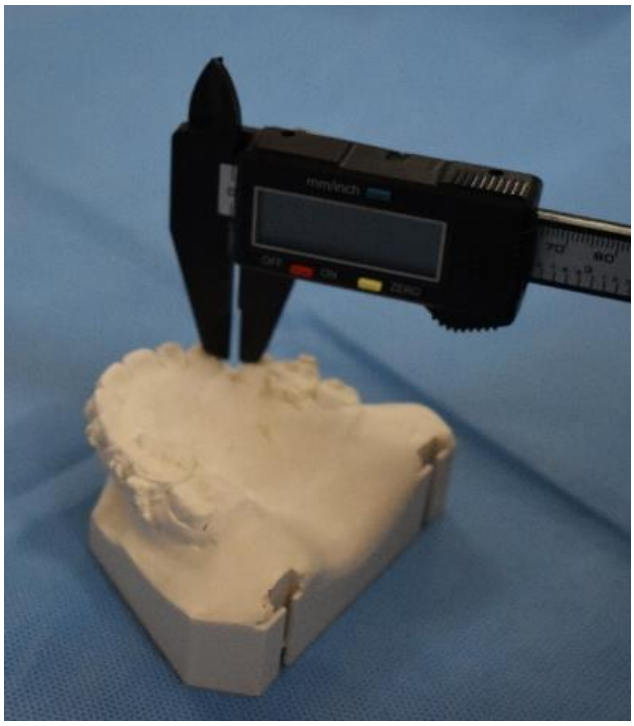


Figure 4: Model analysis carried out using a vernier calliper

Results:

This randomised clinical trial was carried out on patients reporting to the Department of Orthodontics, Indira Gandhi Institute of Dental Sciences (IGIDS) after obtaining informed consent. This trial was performed to assess the effect of piezocision, photobiomodulation and a combined effect of the two techniques on the rate of tooth movement using a split-mouth study design. Three study groups were formed based on the interventional procedures used.

Group 1: Individuals subjected to the use of peizocision in one quadrant and conventional fixed mechanotherapy in the opposite quadrant.

SAMPLE	VARIABLE	T1	T2	T3
N1	Control Quadrant	0.48	0.54	0.61
	Experimental Quadrant	0.66	0.58	0.63
N2	Control Quadrant	0.66	0.61	0.68
	Experimental Quadrant	0.82	0.69	0.72
N3	Control Quadrant	0.58	0.57	0.61
	Experimental Quadrant	0.82	0.61	0.64
N4	Control Quadrant	0.46	0.53	0.57
	Experimental Quadrant	0.82	0.57	0.59
N5	Control Quadrant	0.93	0.83	0.75
	Experimental Quadrant	0.82	0.83	0.77
N6	Control Quadrant	0.47	0.59	0.57
	Experimental Quadrant	0.82	0.65	0.61
N7	Control Quadrant	0.7	0.8	0.67
	Experimental Quadrant	0.82	0.67	0.69
N8	Control Quadrant	0.62	0.73	0.75
	Experimental Quadrant	0.82	0.79	0.72

Table 1: Tabulation representation of the rate of tooth movement in patients subjected to piezocision and conventional canine retraction technique

Group 2: Individuals subjected to the use of photobiomodulation in one quadrant and conventional fixed mechanotherapy in the opposite quadrant.

Group 3: Individuals subjected to the combined use of peizocision and photobiomodulation in one quadrant and conventional fixed mechanotherapy in the opposite quadrant.

Statistical analyses were performed using IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp. The results of continuous measurement are presented as mean & standard deviation (SD) and categorically as frequency & percentage. Inferential statistics such as ANOVA was employed for the comparison of the three groups and post-hoc Tukey was applied to check for variances among any two groups which were found significant in ANOVA. An Independent t-test was employed for the purpose of comparation between the two groups. A p-value less than 0.05 was considered to be statistically significant.

SAMPLE	VARIABLE	T1	T2	T3
N1	Control Quadrant	0.45	0.53	0.61
	Experimental Quadrant	0.5	0.59	0.63
N2	Control Quadrant	0.6	0.59	0.63
	Experimental Quadrant	0.68	0.66	0.71
N3	Control Quadrant	0.58	0.57	0.61
	Experimental Quadrant	0.61	0.61	0.64
N4	Control Quadrant	0.44	0.5	0.61
	Experimental Quadrant	0.53	0.55	0.59
N5	Control Quadrant	0.83	0.67	0.61
	Experimental Quadrant	0.97	0.77	0.77
N6	Control Quadrant	0.47	0.53	0.61
	Experimental Quadrant	0.57	0.59	0.63
N7	Control Quadrant	0.7	0.8	0.67
	Experimental Quadrant	0.79	0.97	0.69
N8	Control Quadrant	0.62	0.73	0.61
	Experimental Quadrant	0.73	0.79	0.77

Table 2: Tabulation representation of the rate of tooth movement in patients subjected to photobiomodulation and conventional canine retraction technique

SAMPLE	VARIABLE	T1	T2	T3
N1	Control Quadrant	0.45	0.53	0.61
	Experimental Quadrant	0.5	0.59	0.63
N2	Control Quadrant	0.6	0.59	0.63
	Experimental Quadrant	0.68	0.66	0.71
N3	Control Quadrant	0.58	0.57	0.61
	Experimental Quadrant	0.61	0.61	0.64
N4	Control Quadrant	0.44	0.5	0.61
	Experimental Quadrant	0.53	0.55	0.59
N5	Control Quadrant	0.83	0.67	0.61
	Experimental Quadrant	0.97	0.77	0.77
N6	Control Quadrant	0.47	0.53	0.61
	Experimental Quadrant	0.57	0.59	0.63
N7	Control Quadrant	0.7	0.8	0.67
	Experimental Quadrant	0.79	0.97	0.69
N8	Control Quadrant	0.62	0.73	0.61
	Experimental Quadrant	0.73	0.79	0.77

Table 3: Tabulation representation of rate of tooth movement in patients subjected to the combination of piezocision and photobiomodulation technique and conventional canine retraction technique

	N	Mean	Standard Deviation	Skewness	
					Standard Error
Conventional canine retraction rate at T1	8	.6125	.15719	1.176	.752
Conventional canine retraction rate at T2	8	.6500	.11916	.661	.752
Conventional canine retraction rate at T3	8	.6512	.07298	.364	.752
Canine retraction rate with piezocision technique at T1	8	.7950	.13191	.376	.752
Canine retraction rate with piezocision technique at T2	8	.6738	.09441	.719	.752
Canine retraction rate with piezocision technique at T3	8	.6712	.06312	.253	.752
Valid N (listwise)	8				

Table 4: Descriptive statistics of Group 1 consisting of patients subjected to piezocision and conventional canine retraction technique

Group Statistics					
	Group 1	N	Mean	Standard Deviation	P value
T1	Conventional canine retraction technique	8	.6125	.15719	**.739**
	Piezocision technique	8	.7950	.13191	
T2	Conventional canine retraction technique	8	.65	.119	**.252**
	Piezocision technique	8	.67	.094	
T3	Conventional canine retraction technique	8	.65	.073	**.617**
	Piezocision technique	8	.67	.063	

Table 5: Comparison of conventional canine retraction technique and piezocision technique at T1, T2 and T3

	N	Mean	Standard Deviation	Skewness	
					Standard Error
Conventional canine retraction rate at T1	8	.5862	.13479	.682	.752
Conventional canine retraction rate at T2	8	.6150	.10744	.793	.752
Conventional canine retraction rate at T3	8	.6425	.06840	.655	.752
Canine retraction rate with photobiomodulation technique at T1	8	.6950	.15856	.415	.752
Canine retraction rate with photobiomodulation technique at T2	8	.6912	.14227	1.167	.752
Canine retraction rate with photobiomodulation technique at T3	8	.6762	.06989	.340	.752
Valid N (listwise)	8				

Table 6: Descriptive statistics of Group 2 consisting of patients subjected to

photobiomodulation and conventional canine retraction technique

Group Statistics					
	Group 2	N	Mean	Standard Deviation	P value
T1	Conventional canine retraction technique	8	.59	.135	**.576**
	Photobiomodulation technique	8	.70	.159	
T2	Conventional canine retraction technique	8	.62	.107	**.434**
	Photobiomodulation technique	8	.69	.142	
T3	Conventional canine retraction technique	8	.64	.068	**.849**
	Photobiomodulation technique	8	.68	.070	

Table 7: Comparison of conventional canine retraction technique and photobiomodulation technique at T1, T2 and T3

Descriptive Statistics					
	N	Mean	Standard Deviation	Skewness	
					Standard Error
Conventional canine retraction rate at T1	8	.6575	.15989	.495	.752
Conventional canine retraction rate at T2	8	.6425	.10951	.361	.752
Conventional canine retraction rate at T3	8	.6238	.10084	-.245	.752
Canine retraction rate with a combination of piezoelectric and photobiomodulation techniques at T1	8	.8450	.13191	.376	.752
Canine retraction rate with a combination of piezoelectric and photobiomodulation techniques at T2	8	.7212	.09775	.591	.752
Canine retraction rate with a combination of piezoelectric and photobiomodulation techniques at T3	8	.7238	.06567	.213	.752
Valid N (listwise)	8				

Table 8: Descriptive statistics of Group 3 consisting of patients subjected to combination of piezoelectric and photobiomodulation techniques and conventional canine retraction technique

Group Statistics					
	Group 3	N	Mean	Standard Deviation	P value
T1	Conventional canine retraction technique	8	.66	.160	**.355**
	Combination of piezoelectric and photobiomodulation technique	8	.84	.132	
T2	Conventional canine retraction technique	8	.64	.110	**.787**
	Combination of piezoelectric and photobiomodulation technique	8	.72	.098	
T3	Conventional canine retraction technique	8	.62	.101	**.368**
	Combination of piezoelectric and photobiomodulation technique	8	.72	.066	

Table 9: Comparison of conventional canine retraction technique and combination of piezoelectric and photobiomodulation techniques at T1, T2 and T3

Discussion:

Orthodontists have constantly been seeking new methods to accelerate orthodontic tooth movements, thereby reducing overall treatment time and enhancing treatment outcomes.

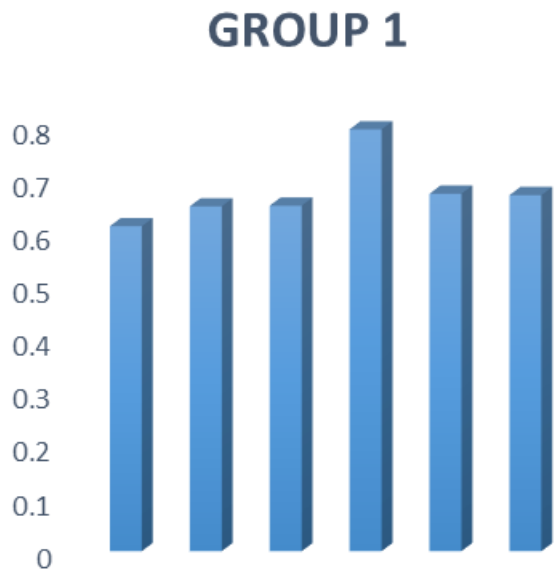
Surgical methods such as corticotomy were met with resistance due to their invasive nature, need for flap elevations and post-surgical discomfort. In addition, corticotomy may lead to the formation of dehiscence and increased tooth mobility. A novel approach to enhance tooth movement was a minimally-invasive surgical technique termed as piezocision. Minor incisions were placed in the cortical alveolar bone and gingiva with a piezo surgical knife. Several benefits such as reduced patient discomfort were noted, which led to its popularity and widespread acceptance.

In recent years, laser therapy in dentistry has gained traction as a non-invasive procedure to enhance orthodontic tooth movement. Numerous research trials have demonstrated that low-level laser therapy decreases pain and improves patient comfort.

The present study was conducted to appraise the influence of piezocision, low-level laser therapy and the combined effect of the two, on the rate of tooth movement. The study had a split-mouth design and conventional canine retraction mechanics were applied in one quadrant whereas the opposite quadrant was subjected to the experimental technique. This was done so as to reduce inter-individual variability in the rate of tooth movement.

Three groups were formed based on the interventional procedure with each group consisting of a sample size of 8. The patients were randomly assigned to the group using an online platform. The rate of tooth movement was analysed using model casts. The rate of tooth movement was estimated at three time periods, T1, T2 and T3.

In Group 1 consisting of individuals subjected to conventional fixed mechanotherapy in one quadrant and the use of peizocision in the opposite quadrant, it was observed that an increased overall mean rate of tooth movement was noted at T1 in the quadrant subjected to piezocision. A 0.18 increase in the mean rate was seen at T1 in the experimental side, whereas lowest overall mean rate was noted on the control side. Similar rates of tooth movement were noted on the control side and the experimental side at T2 and T3. However, no statistically significant difference was noted in the quadrant subjected to piezocision and the control side at T1, T2 and T3. Yi et al[11], in a systematic review published in 2017, reported that piezocision enhanced tooth movement in the short term, however, the evidence was weak. The increased rate of tooth movement may be due to the effect of the regional acceleratory phenomenon which causes transient bone demineralization and enhanced bone metabolism. A clinical study by Patterson et al[12] noted the increased risk of root resorption associated with the piezocision technique. In addition, iatrogenic trauma to the roots during placement of the surgical cuts was documented in several patients.



Graph 1: Graph depicting the mean rate of canine retraction in Group 1 patients

It was found in another systematic review conducted by Hourara[13] in 2019 that there was deficient evidence to support the hypothesis that piezocision would enhance the rate of tooth movement.

The present study had similar findings to a study conducted by Tuncer[14] wherein no significant results were noted between the piezocision-assisted and conventional canine retraction approaches. A recent split-mouth study conducted by Hawkins et al[15] in 2022 demonstrated no statistically significant results when comparing the orthodontic tooth movement on the piezocision and control side, furthermore patients experienced the pain related to the procedure.

The conclusions of the study show that piezocision has an immediate effect on the rate of tooth movement, however, this effect does not translate at T2 and T3. Moreover, this procedure may be uncomfortable and painful for the patient, so a more acceptable procedure is needed.

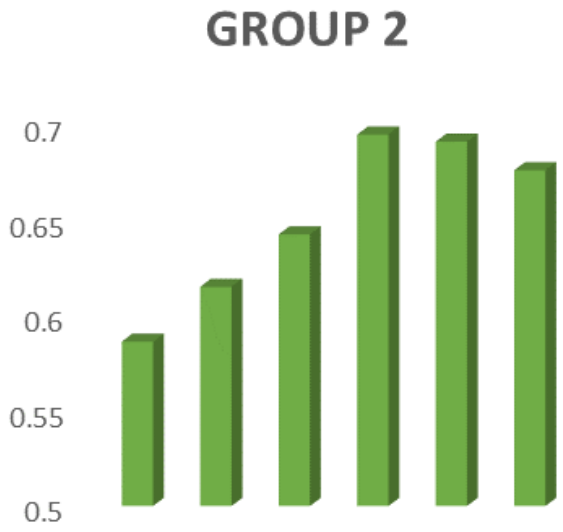
In Group 2, consisting of individuals subjected to conventional fixed mechanotherapy in one quadrant and the use of photobiomodulation in the opposite quadrant, it was observed that higher mean values of rate of tooth movement were noted in the quadrant subjected to low-level laser therapy. A 0.69 rate of tooth movement was observed on the experimental side at T1 and at T2. This was substantially higher when compared to the control but was found to be statistically insignificant. The rate of tooth movement decreased at T3 to 0.67. This was similar to the results demonstrated by Heravi, Morai and Ahrari[16] in 2014, wherein the rate of tooth movement was higher in the first month and declined in the second month.

Similar results were noted in a study conducted by Mistry[17] in 2020, wherein a similar split-mouth study design was employed. A higher rate of tooth movement was seen in the low-level laser therapy group however the differences were found to be not statistically significant.

Another study conducted by Limpanichkul et al[18] in 2006 which employed a GaAlAs laser at 25J/cm^2 demonstrated statistically significant differences in photobiomodulation-assisted and the conventional technique of canine retraction.

Cruz et al[19] conducted a study with 5J/cm^2 applied at 10 points and demonstrated a bio-stimulatory effect on the alveolar bone. A total of 10J was used in the present study, which may explain why there were no significant differences between the control and experimental groups.

Owing to the non-invasive nature of the procedure, the low-level laser therapy shows a great deal of promise, however, further research may be needed to decipher the precise dosage and wavelength required for optimal rate of orthodontic tooth movement.



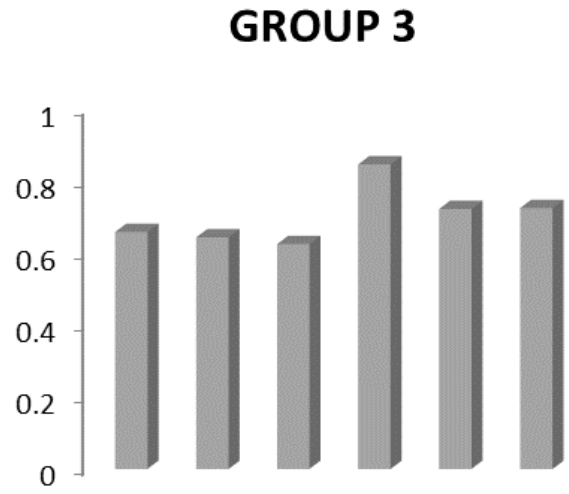
Graph 2: Graph depicting the mean rate of canine retraction in group 2 patients

In Group 3 consisting of individuals subjected to conventional fixed mechanotherapy in one quadrant and the combined use of peizocision and photobiomodulation in the opposite quadrant, it was observed that the experimental side had the highest rate of tooth movement compared to all the groups in the study. The highest rate was observed at T1 in the quadrant subjected to the combination of photobiomodulation and piezocision. A difference of 0.19 was noted on the experimental side, however, this was not found to be statistically significant. Similar results were noted in a study conducted by Abdelhameed and Refal[20] in 2018, wherein a combination of low-level laser therapy and microosteoperforation was used to augment the tooth movement. A noteworthy increase in orthodontic tooth movement was seen, with a 1.8-fold increase in the side subjected to the combination technique. This outcome may be due to the impact of laser therapy on the RANK/RANKL ligand and the RANK/OPG system which induces the process of osteoclastogenesis and the effect of microosteoperforation on the regional bone turnover.

Similar findings were demonstrated in a study by Moradinejad[21] in 2022, wherein piezocision and low-level laser therapy were assessed individually and in combination.

A greater rate of tooth movement was seen the combination group when compared to the groups whch were subjected to an isolated laser therapy and an isolated piezocision therapy.

The findings of the study demonstrate that low-level laser therapy and piezocision have a synergistic effect on each other when compared to piezocision and laser therapy as individual techniques. Several studies indicate that low-level laser therapy may cause a decreased pain perception in patients, whereas several patients complain of discomfort after the piezocision technique. A combination of these techniques may be effective, but further research is needed.



Graph 3: Graph depicting the mean rate of canine retraction in Group 3 patients

The weakest influence in accelerating orthodontic tooth movement was found in the laser group, whereas the greatest effect was seen in the group wherein the piezocision and laser therapy were used synergistically. These results are in agreement with the results demonstrated by Moradinejad et al[21].

Conclusions:

The findings of the study allow for the following deductions:

1. It was observed that the photobiomodulation therapy and piezocision had an enhanced effect on the degree of orthodontic tooth movement, however, these differences were not substantial.

2. The piezocision technique had a short term heightened impact on the rate of orthodontic tooth movement, whereas the photobiomodulation therapy had a sustained effect on the rate of tooth movement.

3. The findings of the study also demonstrated a synergistic effect of photobiomodulation therapy and piezocision on the rate of tooth movement with the highest rate of tooth movement seen in the group which combined the photobiomodulation and piezocision technique.

4. The photobiomodulation technique had the lowest effect on accelerated tooth movement, followed by the piezocision technique, followed by the combined effect of the photobiomodulation and piezocision.

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