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Comparison Between the Effect of Low-Energy Laser Application and Piezocision on Acceleration of Orthodontic Tooth Movement

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Abstract

AIM: The aim of the study was to investigate the effectiveness of both low-energy laser application and piezocision as two separate methods in acceleration of tooth movement during canine retraction in comparison to conventional canine retraction.

PATIENTS AND METHODS: A split-mouth study design was done with two groups (A and B) of 10 patients each. In every patient, one side was used as a control side and the contralateral side received either low-level laser therapy (LLLT) (Group A) or piezocision (Group B). The evaluation data were gathered by intraoral measurements directly every 2 weeks, over a 3 months retraction period.

RESULTS: Group A illustrated a statistically significant difference between the study and control sides ($p < 0.001$); a total of 4.19 ± 0.5 mm canine retraction were achieved in the LLLT-assisted canine retraction side versus a 2.83 ± 0.2 mm total canine retraction in the control side. Group B illustrated a statistically significant difference between the study and control sides ($p < 0.001$); a total of 3.65± 0.4 mm canine retraction have been achieved in the piezocision-assisted canine retraction side versus a 2.79 ± 0.2 mm total canine retraction in the control side.

CONCLUSIONS: LLLT and piezocision techniques accelerated the rate of canine retraction during orthodontic treatment with the LLLT being slightly more effective.

Introduction

Orthodontic treatment usually requires a long duration of about 2–3 years, which increases the risk of tooth decay, root resorption, and loss of patient compliance and interest [1], [2]. Several methods were tested to enhance orthodontic tooth movement (OTM) and condense the treatment time. Variable surgical (corticotomy and piezocision) [3] and physical (electric current and LASER) methods were proposed [4].

Surgical corticotomy is one of the widespread and extensively used methods to accelerate OTM, manage anchorage, and facilitate easier molar movements. Different surgical corticotomy techniques were proposed by many researchers and regional acceleratory phenomenon (RAP) is believed to be the chief elementary effect of in accelerating OTM [5].

Nevertheless, corticotomy may not be accepted by many patients because it is still an invasive surgical method which may result in undesirable side effects such as bleeding, discomfort, and pain affecting patients' quality of life. Therefore, other surgical less invasive methods were proposed to lessen these side effects, one of which is piezocision which is a technique used for corticotomy done by a modulated ultrasonic frequency that permits highly precise and safe cutting of hard tissues. This technique triggers the production of cytokines that recruit osteoclasts to the region to enhance the rate of bone resorption. One of the major advantages of piezocision is that it does not require a lengthy accomplishment time nor any special training [6].

Since the production of the first LASER by Maiman in 1960, dental interest in lasers has been high and research has been continuing to improve dental treatment through laser application. The suitable and multipurpose nature of laser has encouraged orthodontists to use it in several applications as in diagnostic procedures, prevention of white spot lesions, bracket debonding, and minor surgical procedures such as gingivectomy and frenectomy [7].

Furthermore, soft laser therapy is a special category of laser application in orthodontic treatment. It is known as low-level energy laser therapy (LLLT) or as cold laser therapy. The discovery of the biostimulatory effect of LLLT in 1967 paved its way to be used in many indications, especially in the acceleration of OTM, retention protocols, and in pain reduction [8].

From all of the previously mentioned, it was beneficial to compare between piezocision as a less invasive surgical technique and LLLT as a non-invasive technique for acceleration of OTM. The aim of the study was to investigate the effectiveness of low-energy laser application or piezocision in accelerating tooth movement during canine retraction, compared to conventional canine retraction.

Patients and Methods

Twenty patients from both sexes with an age range of 15–25 years joined this study. Patients were selected from the Outpatient Clinic at the Department of Orthodontics, Faculty of Dentistry, Minia University. The inclusion criteria were healthy general medical condition, healthy periodontal condition, full unit Class II canine relation, severe crowding, and/or protrusion required extraction of the maxillary first premolars followed by canine retraction, normal shape, and structure of maxillary canines, no history of fillings or root canal treatment, and normal shape and structure of maxillary first molars. The study aim and detailed procedure were explained to the patients and/or guardians along with the potential side effects and informed consents were signed. All safety precautions were followed during LLLT and piezocision.

Pre-orthodontic records were taken for all the patients and analyzed (study casts, digital extra-oral and intra-oral photographs, and panoramic and lateral cephalometric radiographs). The sample was randomly divided into two groups, each contained 10 patients. A split-mouth study design was employed for each patient; in which one side served as control while the contralateral side was the study side. Assignment of patients and the choice of the side of intervention were done through a computer-generated randomization technique (www.random.org). In Group A: LLLT assessment was performed on the study side. In Group B: Piezocision assessment was performed on the study side.

First, the subjects were referred to an oral surgeon to extract the first premolars without squeezing of the socket. A healing interval of about 6 weeks was taken before the start of orthodontic treatment. Regular orthodontic treatment was initiated by bonding both arches with a fixed orthodontic bracket to achieve initial leveling and alignment (OrthoPro MBT, 0.022'slot, Orthoprodent, USA). After the full completion of leveling and alignment, it was determined when an arch wire sized 0.017 × 0.025 inch stainless steel could be inserted passively in the bracket slot, canine retraction was carried out in the control side directly on a miniscrew using closing coil spring.

The retraction force was 150 g as measured using a force gauge (Coprex, Swiss made). In Group A, the soft laser was applied using a laser machine (DenLase-810/7) with the following specifications:

Dimensions (W × H × D): 130 × 190 × 180 mm, weight: approx. 1.5 kg, display: LCD Touch Screen, cooling: Air cooling, wavelength: 810 ± 10 nm, output power: 0.5 w/cm^2 and operation modes: Continuous wave. The first application was at the beginning of a canine retraction, the second application was after 3 days from the beginning of canine retraction, the third application was after 1 week from the beginning of a canine retraction, and the fourth application was after 2 weeks from the beginning of canine retraction, then every 2 weeks over the 3 months period of the intervention. Application of laser was carried out from the buccal and palatal surfaces along the root of the canine using a specific lens for LLLT and biostimulation.

In Group B using Piezotome and piezosurgical knife – BS 1insert and BP blade 15, two verticals interproximal Piezocision cuts were placed (not including the free gingiva) on the mesio and distobuccal sides of the maxillary canines, piezocision cuts were performed 5 mm apical to the mesial and distal interdental papilla of the maxillary canines. Incision lengths were approximately 10 mm apically and the grooves in between the roots of the neighboring teeth were used as a guide for the cut lines. The incisions were made to a depth of 3 mm and a width of 3 mm. The cuts were placed only on the buccal side under copious saline irrigation (sodium chloride 0.9% w/v), then the area was sutured with an interrupted loop, non-resorbable Vicryl 4-0 black silk suture material. The sutures were left in place for 1 week and the patients were clinically checked every 2 weeks with a total of 5 times over 3 months. Data for the evaluation of each intervention were collected by direct intraoral measurements. The measurements were taken from the canine cusp tip to the mesiobuccal cusp tip of the maxillary 1st molar using digital intraoral caliper (IOS, China). Measurements were taken immediately before the beginning of canine retraction and every 2 weeks throughout the following 3 months.

The mean and standard deviation (SD) values were calculated for each group in each test. Data were explored for normality using Kolmogorov–Smirnov and Shapiro–Wilk tests and showed parametric (normal) distribution (split-mouth technique). Repeated measure ANOVA test was used to compare between more than 2 groups in related samples. Paired sample t-test was used to compare between two groups in related samples. Independent sample t-test was used to compare between two groups in non-related samples. The significance level was set at $p \leq 0.05$. Statistical analysis was performed with IBM® SPSS® Statistics Version 20 for Windows.

Results

Distance between canine tip and MB tip of first molar

Relation between low-level energy laser and control (Table 1, Figure 1)

a) 0 weeks

There was no statistically significant difference between laser and control groups where p = 0.696.

b) 2 weeks

There was a statistically significant difference between laser and control groups where p=0.006.

c) 4 weeks

There was a statistically significant difference between laser and control groups where p = 0.011.

d) 6 weeks

There was a statistically significant difference between laser and control groups where p < 0.001.

Table 1: The mean, SD values of distance between canine tip and MB tip of first molar (paired sample t-test)

Variables	Distance between canine tip and MB tip of first molar				
	Laser		Control		p-value
	Mean	SD	Mean	SD	
0 weeks	20.37	1.19	20.43	1.11	0.696 ns
2 weeks	19.10	1.31	19.75	1.19	0.006*
4 weeks	18.26	1.37	19.01	1.18	0.011*
6 weeks	17.48	1.06	18.62	1.15	<0.001*
8 weeks	17.03	1.11	18.31	1.10	<0.001*
10 weeks	16.62	1.14	17.79	1.11	<0.001*
12 weeks	16.13	1.18	17.20	1.57	0.007*

*Significant (p <0.05), ns: Non-significant (p> 0.05), SD: Standard deviation.

e) 8 weeks

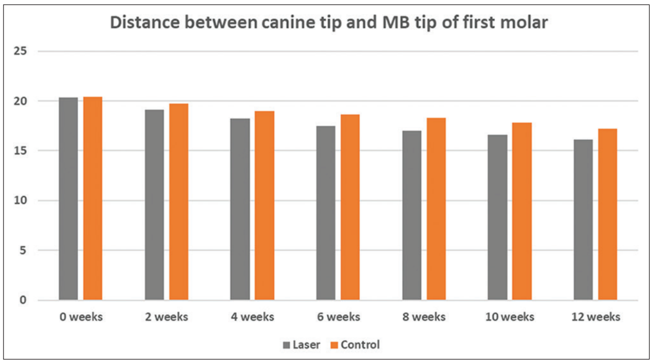
There was a statistically significant difference between laser and control groups where p < 0.001.

f) 10 weeks

There was a statistically significant difference between laser and control groups where p < 0.001.

g) 12 weeks

There was a statistically significant difference between laser and control groups where p = 0.007.



Relation between piezocision and control

a) 0 weeks

There was no statistically significant difference between piezocision and control groups where p = 0.787

b) 2 weeks

There was a statistically significant difference between piezocision and control groups where p = 0.030

c) 4 weeks

There was a statistically significant difference between piezocision and control groups where p = 0.015

Table 2: The mean, SD values of distance between canine tip and MB tip of first molar for piezocision group (paired sample t-test)

Variables	Distance between canine tip and MB tip of first molar				
	Piezocision		Control		p-value
	Mean	SD	Mean	SD	
0 weeks	20.45	0.71	20.51	0.99	0.787 ns
2 weeks	19.31	0.82	19.89	0.99	0.030*
4 weeks	18.48	0.76	19.28	0.95	0.015*
6 weeks	17.84	0.81	18.82	1.02	0.006*
8 weeks	17.51	0.89	18.55	1.02	0.007*
10 weeks	17.12	0.85	18.10	1.01	0.012*
12 weeks	16.77	0.86	17.72	0.98	0.010*

*Significant (p <0.05), ns: Non-significant (p> 0.05), SD: Standard deviation.

d) 6 weeks

There was a statistically significant difference between piezocision and control groups where p = 0.006.

e) 8 weeks

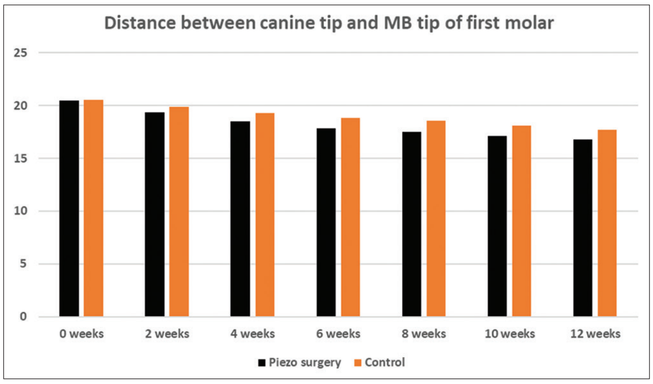
There was a statistically significant difference between piezocision and control groups where p = 0.007.

f) 10 weeks

There was a statistically significant difference between piezocision and control groups where p = 0.012.

g) 12 weeks

There was a statistically significant difference between piezocision and control groups where p = 0.010.



Relation between piezocision and laser (Table 3, Figure 3)

a) 0 weeks

There was no statistically significant difference between piezocision and laser groups where p = 0.847.

b) 2 weeks

There was no statistically significant difference between piezocision and laser groups where p = 0.674.

Table 3: The mean, SD values of distance between canine tip and MB tip of first molar (independent sample t-test) (repeated measure ANOVA)

Variables	Distance between canine tip and MB tip of first molar				
	Piezocision		Laser		p-value
	Mean	SD	Mean	SD	
0 weeks	20.45	0.71	20.37	1.19	0.847 ns
2 weeks	19.31	0.82	19.10	1.31	0.674 ns
4 weeks	18.48	0.76	18.26	1.37	0.666 ns
6 weeks	17.84	0.81	17.48	1.06	0.399 ns
8 weeks	17.51	0.89	17.03	1.11	0.297 ns
10 weeks	17.12	0.85	16.62	1.14	0.279 ns
12 weeks	16.77	0.86	16.13	1.18	0.185 ns
p-value	<0.001*		<0.001*		

*: Significant (p <0.05), ns: Non-significant (p> 0.05), SD: Standard deviation

c) 4 weeks

There was no statistically significant difference between piezocision and laser groups where p = 0.666.

d) 6 weeks

There was no statistically significant difference between piezocision and laser groups where p = 0.399.

e) 8 weeks

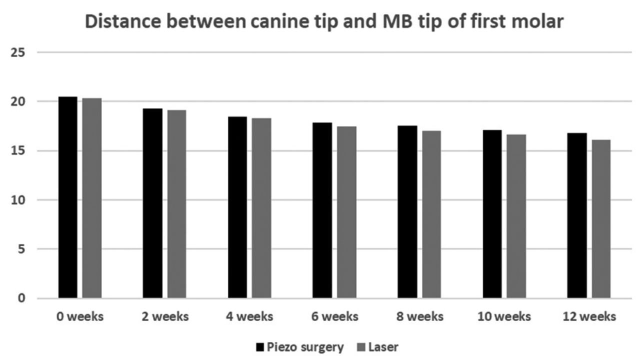
There was no statistically significant difference between piezocision and laser groups where p = 0.297.

f) 10 weeks

There was no statistically significant difference between piezocision and laser groups where p = 0.279.

g) 12 weeks

There was no statistically significant difference between piezocision and laser groups where p = 0.185.



Discussion

Many methods were presented throughout the literature for the retraction of canines regarding anchorage and the force used for retraction (amount, direction, and force decay). According to various studies, it is well known that titanium miniscrews give a quick and effective anchorage for canine retraction. Direct anchorage using miniscrew located between the 2nd premolars and 1st permanent molars was selected to remove any molar anchorage loss which may give false results during measurements [9], [10], [11].

Standardization of the method of canine retraction was also a necessity, so the usage of miniscrews was coupled with closing coil springs to provide a continuous 150 g of force. This force magnitude was supported by Barlow and Kula who in a systematic review, concluded that 200 g did not offer any added benefit in the rate of canine retraction compared to 150 g [12].

The results of direct intraoral measurements from Group A showed that the rate of canine retraction in the LLLT side was higher by nearly 1.5-fold in comparison to standard canine retraction over the 3 months period, which was in accordance with other studies [13], [14], [15]. The ability of LLLT to accelerate canine retraction can be explained by the effect of LLLT on the receptor activator of the nuclear factor-KB (RANK)/RANK ligand/osteoprotegerin system which is essential for osteoclastogenesis in animals and humans [16], [17], [18], [19]. On reviewing the literature, a vast heterogeneity was found in the protocol of LLLT application to accelerate OTM [2], [20]. Although some authors used a higher energy density (5:8 J/cm^2) as it provides less health hazard [13], [14], they used multiple points of application; on average five on the buccal and five on the palatal sides; each applied for 10 s [1], [15], [21]. On the other hand, less points of activation and a lesser time of application are provided by the LLLT since it is applied through a specific lens for bone biostimulation.

Regarding the frequency of laser application, four applications were used in the 1st month followed by two applications per month until complete canine retraction [1]. LLLT was used at 0, 3, 7, and 14 days and the same frequency of application was repeated either after 21 days or 30 days [13], [14]. Two more applications were added to the previous protocol that was applied before the start of anterior teeth retraction such that the total of six applications was as follows: 0, 3, 7, 14, 21, and 28 days [22].

Direct intraoral measurements' statistical analysis for Group B showed a significantly higher rate of canine retraction (p = 0.010); stressing on the efficiency of the technique as was also shown in previous research [13], [14], [15]. Clinically, the rate of canine retraction in the piezocision side was higher by nearly 1.4-fold in comparison to standard canine retraction over the 3 months period of treatment. The ability of piezocision to accelerate canine retraction can be explained by the effect (the RAP) as with the MOPs [19], [23], [24], [25], [26], [27]. Reviewing the literature, piezocision was placed vertically close to the canine to be retracted and as far as possible from the anchor teeth [23] the longer and the deeper the incisions, the more the effect of the RAP [28], [29], [30], [31]. There was no statistically significant difference between piezosurgery and LLLT groups (p = 0.185) [1], [4], [7]. However, low-level energy laser therapy laser group was faster by 0.1-fold than piezosurgery group.

In conclusion, both LLLT and piezocision techniques are proven to accelerate the rate of canine retraction during orthodontic treatment. LLLT application can accelerate the rate of canine retraction more than piezocision as compared to the standard canine retraction technique.

Conclusions

1. Low-level energy laser technique accelerated the rate of canine retraction during orthodontic treatment when compared to the standard canine retraction technique by 1.5-fold
2. Piezocision accelerated the rate of canine retraction during orthodontic treatment when compared to the standard canine retraction technique by 1.4-fold
3. Low-level energy laser technique accelerated the rate of canine retraction during orthodontic treatment slightly more when compared to piezocision (0.1-fold).

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