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Original Research Article

A Comparative Evaluation of Continuous Wave and Pulsed Wave Diode Low Level Laser Therapy on Orthodontic Tooth Movement-A Split Mouth Study

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Abstract

Introduction: Low level laser therapy (LLLT) also known as photobiomodulation, is a treatment that uses low-level lasers or light-emitting diodes (LEDs) to change cellular function and is a clinically well accepted tool in shortening the duration of Orthodontic treatment which is beneficial to the orthodontists as long treatment duration is associated with increased risks of white spot lesions, gingival inflammation, decalcification and root resorption. Low-level laser therapy (LLLT) is reported to accelerate orthodontic tooth movement. Both pulsed (PW) and continuous wave (CW) modes are available in LLLT devices, which provide with a wide range of therapeutic options. The relative influence of CW and PW on Orthodontic tooth movement has not been fully studied. So the purpose of this study was to determine the effects of CW & PW on the effect of OTM. ***Materials & Methods****:* This split-mouth design study was carried on 20 patients requiring extraction of first premolars in maxillary arch. Upper Left quadrant canine was irradiated to Continous wavelength (CW) LLLT and upper right quadrant canine was irradiated with Pulsed wavelength (PW) LLLT. Gallium Aluminum Arsenide (GaAlAs) semiconductor diode laser with a wave length of 810 nm was used in two different modes. Laser Irradiation and the Traction Force of 150gm was applied on reaching 19x25 stainless steel wire at various intervals T0, T3, T6.Digital vernier caliper was used on study models as well as direct intraorally to measure the rate of canine retraction at each interval. ***Results****:* Data was subjected to various statistical tests- Kolmogorov Smirnov test, student t-test, one way ANOVA test. The rate of canine retraction was 6.58 mm at T0 (starting point) to 4.61 at T6 (6 weeks interval) in continuous wave(CW) group (p=0.0001) while in Pulsed wave (PW) group it was 6.56mm at T0 to 2.94 mm at T6 (p=0.0001). ***Conclusion****:* The rate of canine retraction was greater in the quadrant which was irradiated with pulsed wavelength (PW) as compared to continuous wavelength (CW). More rapid tooth movement was seen between 3-6 week intervals.

Keywords: Chemical injury, ocular emergencies, Amniotic Membrane, Holi balloon, amniotic membrane transplantation, bandage contact lens.

INTRODUCTION

Low-level laser therapy (LLLT) is an effective non-invasive method to prompt wound healing, bone repair, and modeling after surgery. LLLT has been suggested to play a role in accelerated tooth movement. These biostimulatory effects of LLLT facilitates the turnover of connective tissues and accelerates the bone remodeling process by stimulating osteoblast and osteoclast proliferation and function during orthodontic tooth movement [1].

The wavelengths of light used for LLLT fall into an ‘‘optical window’’ at red and NIR wavelengths (600–1070 nm) Effective tissue penetration is maximized in this range, as the principal tissue chromophores (hemoglobin and melanin) have high absorption bands at wavelengths shorter than 600 nm. Wavelengths in the range 600–700 nm are used to treat superficial tissue, and longer wavelengths in the range 780–950 nm, which penetrate further, are used to treat deeper-seated tissues. Wavelengths in the range 700–770 nm have been found to have limited biochemical activity and are therefore not used [2].

Both pulsed (PW) and continuous wave (CW) modes are available in LLLT devices, which provide

medical practioners with a wide range of therapeutic options. The relative influence of CW and PW on cellular response has not been fully studied. Until now, comparative studies have shown conflicting results. No difference between these delivery modes was reported in an experiment by Al-Watban and Zhang [3]. While some agreement has emerged on the best wavelengths of light and a range of acceptable dosages to be used (irradiance and fluence), there is no agreement on whether continuous wave or pulsed light is best and on what factors govern the pulse parameters to be chosen. However, recently, some authors have observed no acceleration in OTM after application of LLLI [4, 5].

The published peer-reviewed literature reviewed between 1970 and 2010 concluded that there is some evidence that pulsed light does have effects that are different from those of continuous wave light [6]. The explanation to this was given as Pulsed light offers numerous potential benefits because there are "quench periods" (pulse OFF times) following the pulse on times, pulsed lasers can generate less tissue heating. In instances where it is desirable to deliver light to deeper tissues increased powers are needed to provide adequate energy at the target tissue. This increased power can cause tissue heating at the surface layers and in this instance pulsed light could be very useful. Whereas continuous wavelength causes an increase in temperature of the intervening and target tissues or organ, pulsed light has been shown to cause no measurable change in the temperature of the irradiated area for the same delivered energy density.

The effectiveness of PW or CW LLLT remains unclear and no consensus has been established regarding the appropriate parameters and experimental design of LLLT. Understanding the characteristics and limitations of the bio stimulation caused by LLLT would lead to broader clinical implications in orthodontics in addition to the control of tooth movement rate. Hence the purpose of this study was to investigate and compare the effect of pulse wavelength (PW) with continuous wavelength (CW) LLLT in expediting the Orthodontic tooth movement.

MATERIAL & METHODS

All procedures performed were in accordance with the ethical standards of the institutional research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. The permission & protocol for conducting study was obtained from the Ethical committee of Rajarajeswari Dental College & Hospital, Bangalore No: RRDCHET/01ORTHO/2018.

The patients with the following criteria were selected: Inclusion Criteria: 1) Clinical indication for bilateral maxillary first premolar extraction followed by individual canine retraction. 2) Healthy periodontal status. 3) Good oral hygiene 4) Age group 15-28 years. Exclusion Criteria:- 1) Signs of systemic illness 2)Undergoing any medical treatment that could interfere in the orthodontic tooth movement (NSAIDs, anti-inflammatories or antibiotics) 3) Undergone orthodontic treatment previously 4) Pregnancy.

Gallium Aluminum Arsenide (GaAlAs) semiconductor diode laser (iLas; Biolase, Irvine, Calif) with a wave length of 810nm with two modes– Continuous and pulsed wave frequency was used in the study. The study sample included 20 patients aged (15-28 years) undergoing Orthodontic treatment. It was a split mouth study. After first premolar extraction, just before maxillary canine retraction, left quadrant of upper jaw was subjected to CW low level laser therapy around the canine and right quadrant of upper jaw was subjected to PW low level laser therapy around the canine. In both the groups one half will serve as the PW laser side and other half as CW laser side.

An Orthodontic loading force was delivered to the canines on both the sides simultaneously on the same day. Patients were called for low level laser therapy on day 1(T0), weeks (T3) and 6 weeks (T6). Impressions for casts were taken at intervals T0, T3, T6 and the rate of canine movement was recorded. The distance between mesial cusp tip of the first molar and cusp tip of canine for both the sides in maxillary arch was recorded in millimeters using digital caliper in all the models as well as in patients mouth directly and the mean was derived for difference between the two recording methods,. The rate of canine retraction was determined by dividing distance travelled with time elapsed.

It was a triple blinded study wherein one operator irradiated the canines with LLLT at all the three visits and the measurements at each visit were recorded by another operator who was blinded for CW and PW laser side. The patient was also not aware of which quadrant was CW and PW irradiated. Written consents were taken from the patients informing about study.

The sites which were irradiated at the canine region both buccally and palatally were: 1.Distal aspect of apical third 2.Mesial aspect of apical third 3.Center of middle third 4. Distal aspect of cervical third 5. Mesial aspect of cervical third. Each area was exposed to LLLT for 16 seconds with dose of 2.5J per cm^2 on each side (buccal and lingual). The time to complete the laser application was 16-18 minutes per side. A force of 150g was used for canine retraction on both the sides, in protocol with the McLaughlin, Bennet and Trevisi (MBT system) [7]. For avoiding the carry-across effect of the two wavelengths of laser beam on the other quadrant a plastic shield was used as a barrier having

the same wavelength as the laser, as was used in another study [8] as well.

STATISTICAL ANALYSIS

The Statistical software, namely SPSS 22.0, and R environment ver.3.2.2 were used for the analysis of the data and Microsoft Word and Excel have been used to generate graphs, tables etc**.** Kolmogorov Smirnov test, independent t test, dependent t and repeated measures of ANOVA test were used for analyzing the data.

Sample size:20

Hypothesis testing for two means (equal variances)
Standard deviation in the Continuous wave group= S1 = 0.2954
Standard deviation in the pulsed wave group =S2 = 0.3158
Mean difference between groups = 0.3812
Effect size =1.24738219895288
Alpha Error (%) = 5
Power (%)= 80
Sided = 2
Number needed (n) = 20 in each group should be taken

Sample size formula

$$n = \frac{2S^2(z_{1-\alpha} + z_{1-\beta})^2}{d^2}$$

Where, $Z_{1-\alpha}$= Z-value for α level (1.96 at 5% α error or 95% confidence)

$Z_{1-\beta}$ = Z-value for β level (1.8420 at 20% β error or 80% power)

d=Margin of error=0.3812, S=Pooled SD= (S1+S2)/2

RESULTS

The canine movement was seen over a period of 6 weeks and assessed at T0,T1,T3,T6 intervals. There was no patient attrition seen during the study. There was a normal distribution of canine retraction rate values among the continuous (CW) and pulsed wave (PW) group individually (Table 1).

The retraction of the canines exposed to the pulsed wave was greater as compared with the continuous wave side in inter group comparison, which was also found to be statistically significant (Table 2). The average increase in the rates of tooth movement was seen from T0-T1, T0 - T3, T0- T6 in both the groups but was more seen in the pulsed wavelength (PW) group as compared to continuous wavelength (CW) which was statistically significant as well (p=0.0001). The greater canine retraction was seen in T3 -T6 interval (Table 3, Figure 1).

Table 1: Normal Distribution of canine retraction scores after irradiation with LLLT at different treatment time intervals (T0,T1,T3,T6) in two groups (Continuous wave and Pulsed wave) by Kolmogorov Smirnov test

Time intervals	Continuous wave		Pulsed wave	
	Z-value	p-value	Z-value	p-value
T0	0.1740	0.2000	0.1630	0.2000
T1	0.1430	0.2000	0.2340	0.1290
T3	0.2490	0.0800	0.1840	0.2000
T6	0.2670	0.0410	0.1890	0.1818
T0-T1	0.1580	0.2000	0.2550	0.0650
T0-T3	0.1640	0.2000	0.1640	0.2000
T0-T6	0.2500	0.0780	0.1290	0.2000

Table 2: Inter group Comparison of Continuous wave and Pulsed wave group with respect to canine retraction after laser irradiation at different time intervals by independent t test.

Time intervals	Continuous wave		Pulsed wave		t-value	p-value
	Mean	SD	Mean	SD		
T0	6.58	0.45	6.56	0.47	0.1078	0.9153
T1	6.43	0.44	5.66	0.65	3.0877	0.0063*
T3	5.72	0.50	4.27	0.63	5.7254	0.0001*
T6	4.61	0.41	2.94	0.40	9.2768	0.0001*
T0-T1	0.15	0.05	0.90	0.46	-5.0677	0.0001*
T0-T3	0.86	0.27	2.29	0.54	-7.5163	0.0001*
T0-T6	1.96	0.28	3.62	0.32	-12.2131	0.0001*

*p<0.05 considered as significant

Table 3: Comparison of different time intervals with rate of canine retraction after laser irradiation in two groups (Continuous wave and pulsed wave) by dependent t and repeated measures of ANOVA test

Groups	Changes from	Mean Diff.	SD Diff.	% of Effect	t-value	p-value	Effect size
Continuous wave	T0-T1	0.15	0.05	2.23	8.7832	0.0001*	0.9600
	T0-T3	0.86	0.27	13.03	10.1484	0.0001*	
	T0-T6	1.96	0.28	29.86	21.8938	0.0001*	
Pulsed wave	T0-T1	0.90	0.46	13.68	6.1002	0.0002*	0.9650*
	T0-T3	2.29	0.54	34.95	13.3916	0.0001*	
	T0-T6	3.62	0.32	55.14	35.7462	0.0001*	

***p<0.05**

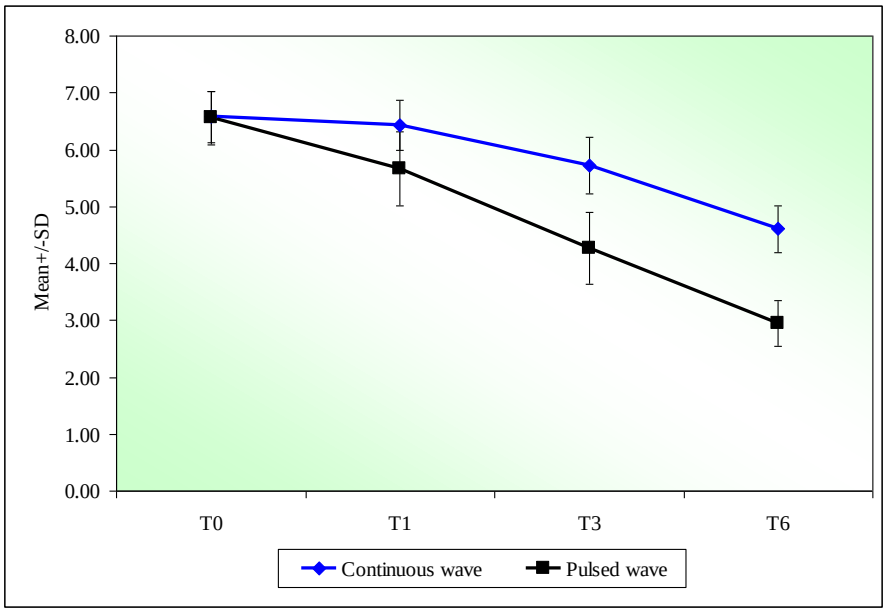

Figure 1: Comparison of two groups (Continuous wave and Pulsed wave) with rate of canine retraction after laser irradiation at different time intervals (T0,T1,T3,T6)

DISCUSSION

In this study, Gallium Aluminum Arsenide (GaAlAs) semiconductor diode laser with a wave length of 810 nm was used in two modes– Continuous and pulsed wavelength mode.. This was a split mouth study where right maxillary quadrant canine was irradiated with pulsed wavelength (PW) and left maxillary quadrant canine was irradiated with Continuous wavelength (CW) just before starting the individual canine retraction at various intervals. The study revealed greater rate of canine retraction in right maxillary quadrant where pulsed wavelength mode (PW) was irradiated as compared to the left quadrant canine which was irradiated with continuous wavelength mode (CW). The study also revealed that the rate of tooth movement was more after 3 weeks onwards in both the groups but certainly the rate of canine retraction was more in the pulsed mode group (PW).

The results of this study are partially concurrent with the result of the study [9] performed on rats which revealed that both continuous and pulsed wave laser irradiation led to faster Orthodontic tooth movement equally while as present study revealed that pulsed wave laser leads to faster tooth movement.

A study [10] revealed that Pulsed optical energy was more efficacious than the CW mode in stimulating collagen production in a suction blister model. Pulsing patterns had a more favourable impact on the ability of fibroblasts to produce collagen de novo than comparative conditions of continuous wave, Pulsed 50% duty cycle, and millisecond pulsing domains. Short and intermittent light delivery enhance cellular event. An in vitro investigation [11] was done to determine the effect of pulse frequencies of low-level laser therapy (LLLT) on bone nodule formation in rat calvarial cells. It was observed that the type of cell death differed between pulsed (apoptosis) and continuous wave (necrosis) irradiation, as a greater amount of the sensitizer entered the cells during pulsed irradiation than continuous wave irradiation, causing a different type of DNA damage. It was concluded that low-frequency pulsed laser irradiation significantly stimulates bone formation, it is most likely that the pulse frequency of LLLT is an important factor affecting biological responses in bone formation [11].

A study revealed [12] that pulsed light (peak power densities of 750 mW/cm^2) administered for 120 seconds produced no neurological or tissue damage, whereas an equal power density delivered by continuous wavelength (for the same number of seconds) caused marked neurological deficits. The higher peak powers that can be safely used by pulsing light can overcome tissue heating problems and improve the ability of the laser to penetrate deep tissues achieving greater treatment depths.

Kim *et al*., [13] reported a higher rate of tooth movement over a period of 2 months in dogs when using a pulsed mode which is in agreement with the results of our study wherein the pulsed mode has greater tooth moment. Yoshida *et al*., [14] also stated that laser units show more bio-stimulatory response when functioning in pulsed mode, but Bradley *et al*., [15] used the continuous mode effectively. The first study [16] to carry out on humans on the effect of low-intensity laser therapy on orthodontic tooth movement showed that irradiated canines were retracted at a rate 34% greater than the control canines over 60 days which is in agreement with present study.

The limitation of the present study was that gender wise; age wise sample was not taken into account. Other variables like brushing frequency, masticatory muscle activity, skeletal growth patterns affecting the Orthodontic tooth movement were not taken into account. Future studies with above variables should be taken into consideration and along with mandibular arch orthodontic tooth movements and different laser wavelengths should be included in the studies.

CONCLUSION

The above study concluded that LLLT in both modes – Continuous (CW) and pulsed (PW) can accelerate the rate of canine retraction. Pulsed wavelength (PW) is more effective in accelerating the tooth movement as compared to continuous wavelength (CW). The tooth movement gets expediated between 3rd to 6th week of the LLLT in both the groups but is seen more in the pulsed wavelength group. So the pulsed wavelength (PW) mode of LLLT can be effectively used in expediating the Orthodontic tooth moment.

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