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THE EFFECT OF TWO LOW-LEVEL LASER IRRADIATION PROTOCOLS ON MOLAR ANCHORAGE LOSS (A RANDOMIZED CONTROLLED CLINICAL TRIAL)

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ABSTRACT

Objective: *Low-level laser therapy (LLLT) has been found to accelerate the rate of tooth movement, which in turn may aid in preserving posterior anchorage. However, one of the drawbacks of LLLT, is the high frequency of patient recall. The aim of the study was to evaluate and compare the amount of molar anchorage loss accompanying canine retraction, by employing two LLLT protocols, involving a high and a low application frequency.*

Materials and Methods: *Sixteen patients were enrolled, in which the therapeutic extraction of maxillary 1st premolars was required for orthodontic treatment, with subsequent canine retraction. Patients were equally and randomly divided into 2 groups. In Group A, LLLT was randomly administered to one side of the maxillary arch on days 0, 3, 7, 14, and then every 2 weeks, while in Group B, one side of the maxillary arch was randomly selected for LLLT application every 3 weeks. The administered LLLT was a Diode laser with a 980 nm wavelength. Canine retraction was carried out using closed-coil springs, with 150 grams of force, and the amount of mesial molar movement was checked every 3 weeks, over the 12-week study period.*

Results: *Equivalent amounts of mesial molar movements have been displayed with and without LLLT application, in both study groups. Also, no significant differences have been documented between the laser sides in groups A and B.*

Conclusion: *Molar anchorage has not been augmented by LLLT, whether applied with a high frequency, or with less frequent applications coinciding with the follow-up visits.*

INTRODUCTION

Several methods have been recently proposed to accelerate orthodontic tooth movement (OTM), in order to overcome the problem of prolonged orthodontic treatment, which has become a major concern for both patients and clinicians. Both surgical and non-surgical techniques have been proposed, and low-level laser therapy (LLLT) has been one of the suggested non-surgical adjuncts for the expedition of OTM(1).

Contradictory results have been reported regarding the acceleration efficiency of LLLT, with both positive(2-4), and negative(5-7) effects being documented. These conflicting results might be attributed to the difference in the laser application parameters used in each study, regarding the type, method of application, wave length, irradiation dose, and exposure time, since these parameters have a direct correlation to the clinical results of laser application(8).

Moreover, it has been suggested that the acceleration of OTM may also aid in preserving posterior anchorage during orthodontic treatment. However, this

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suggestion has not been advocated in some studies, such as the systematic review by Sivarajan et al(9), where insignificant differences have been reported regarding the amount of molar anchorage loss with and without micro-osteoperforations, which is a minimally invasive surgical method proposed for acceleration. On the other hand, Mheissen et al(10) in their systematic review, documented a significantly higher amount of mesial molar movement in the control groups, when compared to the piezocision groups in their enlisted studies, and they concluded that the amount of molar anchorage loss might be technique-related.

Regarding molar anchorage loss with LLLT, few studies have studied the impact of its application in conjunction with orthodontic treatment on molar anchorage loss. For example, Abd El-Ghafour et al(11), Mistry et al(6), and Al-Haj et al(12), measured amount of mesial molar movement with LLLT application, and reported insignificant differences between the laser and the control groups. However, the subject of anchorage loss is affected by several factors, such as the applied forces, and the anchorage preparation. Moreover, it can be related to the applied laser parameters, which are diverse, and relatively different in each study.

One of the major downsides of LLLT, is the high frequency of patient recall required for laser application with the traditional protocols reported in the literature. One of those protocols involves laser irradiation on days 0, 3, 7, 14, and then every 2 weeks(7, 13). Consequently, protocols requiring less patient recall have been advocated, such as that suggested by Garg et al(14), and Qamruddin et al(15, 16), in which LLLT irradiation has been applied every 3 weeks.

Accordingly, the aim of the study was to evaluate and compare the effect of two different LLLT application protocols on the amount of molar anchorage loss, accompanying canine retraction. One of the protocols involved laser application on days 0, 3, 7, and 14, then every 2 weeks afterwards. While the second protocol entails laser application every 3 weeks, coinciding with the regular follow-up visits.

MATERIALS AND METHODS

Study design:

The study was randomized controlled clinical trial, involving two parallel groups, one group testing each of the studied protocols. Moreover, both groups incorporated the split-mouth design, with one side representing the control group, and the contralateral representing the study group.

Study subjects:

Sixteen patients were enlisted in the study, in which the extraction of maxillary first bicuspids was recommended as a part of their orthodontic treatment plan, with an age range from 15 to 20 years. The sample size was calculated based on an alpha error of 5%, and an 80% study power. Ethical approval was obtained from the Ethics Review Committee of the Faculty of Dentistry, Alexandria University, Alexandria, Egypt (IRB:00010556–IORG:0008839). Patients were recruited from the outpatient clinic, Department of Orthodontics, Faculty of Dentistry, Alexandria University. The following eligibility criteria were considered during patient recruitment: healthy systemic condition with no chronic diseases, no previous orthodontic treatment, adequate oral hygiene, and a healthy periodontium. All patients were informed of the procedures, and signed informed consents.

In each of the study subjects, maxillary and mandibular fixed appliances were bonded (straight wire Roth appliance, 0.022×0.028 inch slot), followed by the referral for maxillary first premolars' extraction. The stage of leveling and alignment was then initiated and was considered complete after the passive placement of a 0.016×0.022 inch stainless steel archwire in all the maxillary teeth.

Before the onset of canine retraction, all 16 patients were randomly designated to either Group A or Group B (8 per group), for LLLT application. Randomization was carried out using a simple randomization technique, with an allocation ratio of 1:1. Randomization was repeated within each group to assign one side of the maxillary arch to be the "study", with the other side serving as the "control", in the split-mouth design. Canine distalization in all the study participants was performed using nickel-titanium (NiTi) closed-coil springs, stretched between the canine bracket hook and the hook on the molar tube, delivering a force of 150 grams.

Low-level laser administration:

A Diode laser (Wiser; Doctor Smile-Lambda Spa, Brendola, VI) was employed, for 8 seconds, in a continuous mode (980 nm wavelength, and 100 mW output power). The optical fiber tip (AB 2799; Doctor Smile-Lambda Spa) dispensed a beam size of 1 cm², and the irradiation was performed by positioning the optical fiber tip along the maxillary arch, in the canine region on the experimental side (1.5 cm as minimum on defocalization, as per manufacturer prescription). The total energy density applied per episode was 8 J/cm².

In Group A, patients received LLLT on days 0, 3, 7, 14, and every 2 weeks afterwards, whereas in Group B, LLLT was applied every 3 weeks on the experimental sides, throughout the 12-week study period. The laser beam was also held passively on the control sides of both groups, providing a placebo effect, as a part of the blinding process for the enrolled patients.

Measurement of molar anchorage loss:

Alginate impressions were taken before the onset of canine retraction, and repeated every 3 weeks, throughout the 12-week study period. Stone models were then fabricated and scanned using Sirona inEos X5 CAD/CAM lab scanner, producing 3D digital images of the dental models. Measurements were performed using AutoCAD version 2013.

Several landmarks were identified on the dental model, including the mid-palatal raphe, the most medial points on the third right and left rugae, and the central fossae of both maxillary right and left molars. Perpendicular lines were drawn from the medial points of the right and left third rugae, and the central fossae of both maxillary first molars, to the mid-palatal raphe. Mesial molar movement was calculated by measuring the distance between the molar lines and the third rugae lines bilaterally **(Figures 1, 2)**.

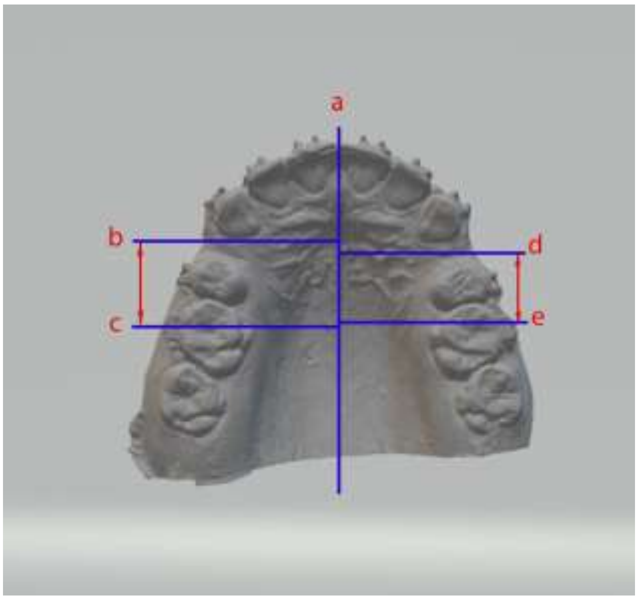

Figure 1: Landmarks were identified in the scanned image of the dental model for the measurement of the molar anchorage loss. **a.** Mid-palatal raphe. **b,d.** Lines corresponding to the medial ends of the third right and left rugae, respectively. **c,e.** Central fossae of the right and left maxillary first molars, respectively.

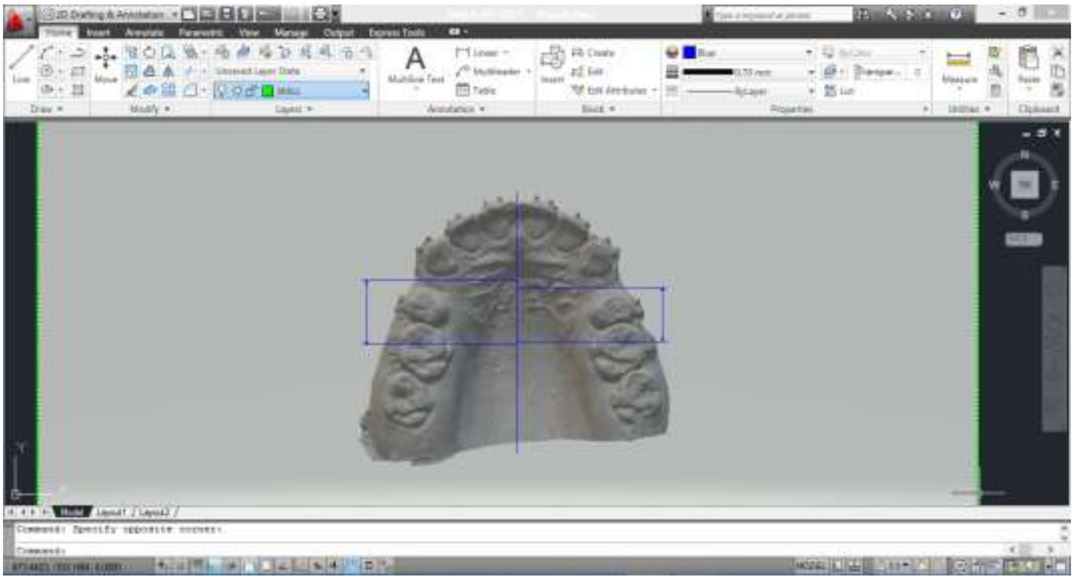

Figure 2: Landmarks were identified, and measurement of molar anchorage loss was carried out on AutoCAD.

Statistical analysis:

Statistical analysis was performed using IBM SPSS for Windows (Version 23.0). Mesial molar movement values showed normal distribution, so means, standard deviations (SD), and 95% confidence intervals (CI) were calculated, and parametric tests were used. Comparisons of molar anchorage loss between the two study groups were done using independent samples t-test, while comparisons between the laser and control sides in each group were done used paired t-test. Comparisons of mesial molar movement at different time intervals within each group separately were done using repeated measures ANOVA, followed by multiple pairwise comparisons using Bonferroni adjusted significance levels. Significance was set at p value <0.05.

RESULTS

The amount of mesial molar movement accounting for the resultant anchorage loss on the laser and control sides in Group A and Group B is depicted in **Table 1**. No significant differences have been documented in the amount of molar anchorage loss between the laser and control sides at all the measured time points, in both groups A and B. Also, the pattern of tooth movement in both study groups, on the laser and the control sides was relatively similar, with the greatest movement recorded at the 3rd week, the least at the 6th week, followed by a gradual increase over the remainder of the study period, till the 12th week.

In Group A, the total amount of mesial molar movement over the 12-week study period was reported to be 0.971 ± 0.07 mm on the laser side, and 0.985 ± 0.06 on the control side. As for Group B, the mean cumulative amount of anchorage loss at the end of the study period was 0.981 ± 0.07 mm on the laser side, and 0.982 ± 0.08 mm on the control side. Although the mean total amount of molar anchorage loss was slightly higher on the control sides in comparison with the laser sides in both study groups, however, this difference was not statistically significant.

In **Table 2,** a comparison between the laser and control sides in groups A and B regarding the amount of molar anchorage loss at the measured time points is represented. For Group A, no significant differences have been noted at all time intervals, on both the laser and control sides, with the exception of only 2 time points, which were between the 3rd and 6th weeks, as well as between the 6th and 12th weeks, where significant differences have been documented on both sides. In Group B, on the laser side, only 2 time points showed significant differences, which were between the 3rd and 6th weeks, and between the 3rd and 9th weeks, with the remaining time intervals showing insignificant differences. As for the control side, insignificant differences were registered at all time points, except between the 3rd and 6th weeks, and between the 6th and 12th weeks.

Table 1: Comparison of mesial molar movement (mm) between the laser and control sides at different time points in the two study groups.

		Laser side	Control side	Difference	95% CI	Paired t p value
		Mean ± SD				
Group A	**3 weeks**	0.272 ± 0.03	0.270 ± 0.02	0.002 ± 0.02	-0.01, 0.02	0.75
	6 weeks	0.212 ± 0.02	0.221 ± 0.02	-0.01 ± 0.03	-0.03, 0.02	0.46
	9 weeks	0.245 ± 0.03	0.244 ± 0.02	0.001 ± 0.02	-0.01, 0.02	0.87
	12 weeks	0.246 ± 0.01	0.250 ± 0.02	-0.004 ± 0.02	-0.02, 0.01	0.55
	Total	0.971 ± 0.07	0.985 ± 0.06	-0.014 ± 0.06	-0.06, 0.03	0.52
	RM-ANOVA p value	**<0.001***	**0.002***			
Group B	**3 weeks**	0.264 ± 0.02	0.266 ± 0.02	-0.002 ± 0.005	-0.006, 0.001	0.17
	6 weeks	0.219 ± 0.02	0.221 ± 0.03	-0.002 ± 0.02	-0.02, 0.01	0.71
	9 weeks	0.241 ± 0.01	0.244 ± 0.02	-0.003 ± 0.02	-0.02, 0.01	0.74
	12 weeks	0.247 ± 0.02	0.251 ± 0.02	-0.004 ± 0.02	-0.02, 0.02	0.68
	Total	0.981 ± 0.07	0.982 ± 0.08	-0.01 ± 0.02	-0.02, 0.02	0.89
	RM-ANOVA p value	**0.001***	**<0.001***			

SD: Standard deviation, **CI:** Confidence interval, **RM-ANOVA:** Repeated measures ANOVA
*statistically significant at p value <0.05

Table 2: Post-hoc pairwise comparisons of mesial molar movement at different time points within the laser and control groups of each study group.

Group	Timepoint	Compared to	P value Laser side	P value Control side
Group A	3 weeks	6 weeks	**0.004***	**0.03***
		9 weeks	0.22	0.16
		12 weeks	0.16	0.20
	6 weeks	9 weeks	0.18	0.17
		12 weeks	**0.02***	**0.01***
	9 weeks	12 weeks	1.00	1.00
Group B	3 weeks	6 weeks	**0.002***	**0.006***
		9 weeks	**0.03***	0.12
		12 weeks	0.73	0.12
	6 weeks	9 weeks	0.12	0.27
		12 weeks	0.15	**0.01***
	9 weeks	12 weeks	1.00	1.00

*statistically significant using Bonferroni adjusted significance level

Comparison between the laser sides in groups A and B regarding molar anchorage loss

No significant differences have been noted between the laser sides in both study groups at all time intervals **(Figure 3)**. Additionally, the cumulative molar anchorage loss over the 12-week study period was slightly higher on the laser side in Group B, in comparison with Group A, but this difference was statistically insignificant **(Figure 4)**.

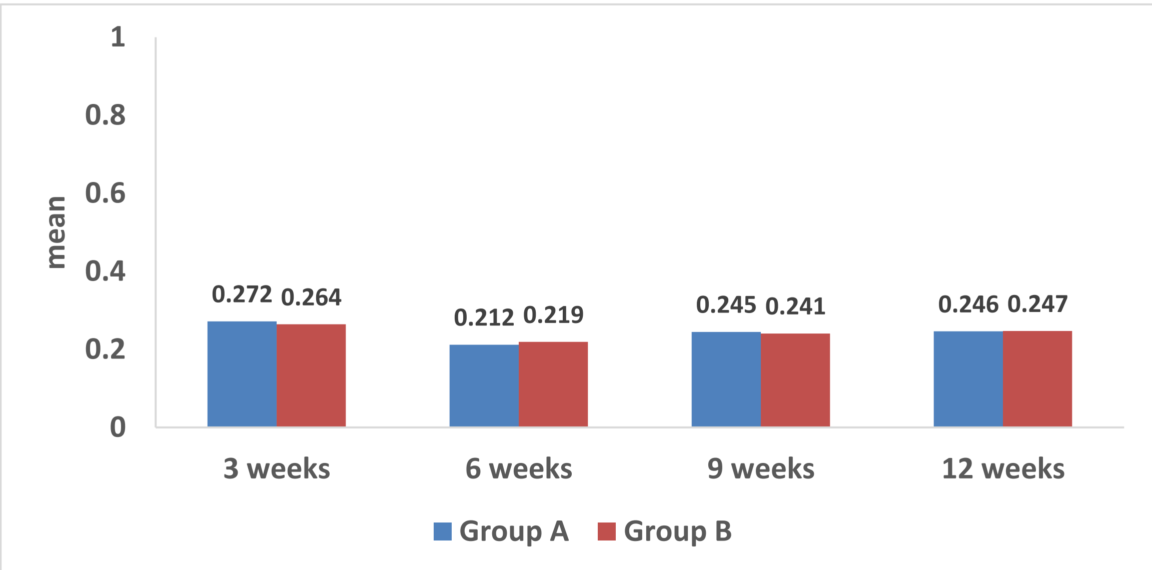

Figure 3: Molar movement (mm) in the two study groups at different time points (laser sides only).

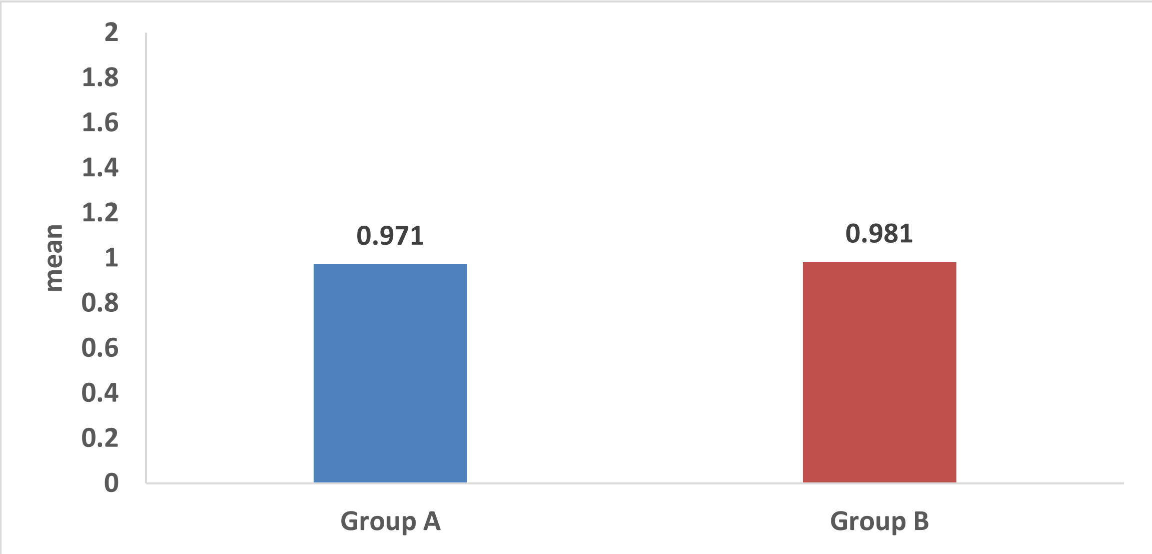

Figure 4: Total molar movement (mm) in the two study groups over the 12-week study period (laser sides only).

DISCUSSION

The aim of the study was to assess and compare the impact of two LLLT application protocols on the amount of anchorage loss (mesial molar movement), accompanying the canine retraction phase of orthodontic treatment. One of the studied protocols involved a high laser application frequency (on days 0, 3, 7, 14, and every 2 weeks thereafter), while the second protocol required less frequent laser irradiations (every 3 weeks).

The employed study design was a clinical randomized controlled trial (RCT). RCTs are regarded as the gold standard for the evaluation of intervention efficiency(17). The split-mouth technique has also been implemented, providing the advantage of eliminating inter-subject variability, as the patient acted as his/her own control, thus reducing the number of participants required.

The experimental site was restricted to the maxillary arch because of the feasibility and reliability of measuring mesial molar movement from the dental models, where the medial ends of the third palatal rugae were taken as reference points. The palatal rugae are considered stable anatomic points for the construction of reference planes for cast analysis, especially at their medial ends(18). Additionally, the palatal rugae were recommended for the evaluation of tooth movement in the transverse and antero-posterior directions, in both extraction and non-extraction cases(19). The rugae area has been the chosen reference point for measurement of molar anchorage loss by several investigators, such as Aboul-Ela et al(20).

The effect of LLLT on molar anchorage loss:

Insignificant differences have been documented between the laser and control sides in both groups A and B, in the amount of mesial molar movement. Also, the pattern of tooth movement in both study groups, on the laser and control sides was relatively similar, where the highest recorded movement was at the 3rd week, the least was at the 6th week, followed by an incremental increase thereafter. A possible explanation to this pattern might be that during the first 3 weeks, the effect of the initial displacement of the tooth in response to the applied forces is expressed, which includes root movement in the PDL, and bone bending(21), together with an advancement of the biological processes(22). The decreased tooth movement recorded at the 6th week, can be attributed to the lag phase that takes places after the initial tooth displacement, in which the processes of bone resorption and deposition occur, which in turn allow the progression of tooth movement afterwards(23).

Over the 12-week study period, the total amount of molar anchorage loss in Group A was 0.971 ± 0.07 mm on the laser side, and 0.985 ± 0.06 mm on the control side, which was slightly higher, but this difference was not statistically significant. As for Group B, on the laser side, the total mesial molar movement was 0.981 ± 0.07 mm, and on the control side it was measured to be 0.982 ± 0.08 mm, and the difference was also insignificant statistically. Despite the slightly greater amount of molar anchorage loss observed on the control sides in both groups compared to the laser sides, the difference between them being statistically insignificant rejects the claim that the acceleration of OTM may aid in preserving posterior anchorage.

Moreover, the difference in the mesial molar movement between both laser sides in the two study groups was statistically insignificant. Accordingly, it’s been deduced that both the tested LLLT protocols, with the parameters employed in the current study, did not affect the amount of mesial molar movement. Some studies have reported less anchorage loss on the laser sides in comparison with the control sides, such as the investigation by Abd El-Ghafour et al(11), but the differences between them were not statistically significant, which is a similar outcome to that reported in the current study. However, the lack of statistical significance regarding molar anchorage loss between all the compared groups, might be attributed to the minimal amount of movement yielded, whether incrementally at each of the measured time points, which was a small fraction of a millimeter, or in the overall amount of movement after 12 weeks, which was less than 1 mm in all groups, making statistical comparisons rather difficult.

CONCLUSION

Molar anchorage has not been augmented by either of the studied LLLT protocols, where equivalent amounts of mesial molar movements have been displayed with and without laser application.

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