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The Effect of Using FTMPF versus Low Level Laser Application on Orthodontic Tooth Movement Acceleration

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ABSTRACT

PURPOSE: This study aimed to evaluate the effect of using full thickness mucoperiosteal flap (FTMPF) elevation only versus low level laser therapy (LLLT) on acceleration of orthodontic tooth movement. **MATERIAL and METHODS:** This study was a split mouth design study included 32 side according to sample size calculation. Those sides were divided into 2 groups. Group 1 divided into (group 1a: 8 sides with FTMPF, group 1b:8 sides control). Group 2(group 2 a: 8 sides with LLLT, group 2b: 8 sides control). Extraction of the first maxillary premolars followed by canine retraction in the extraction space with maximum anchorage were indicated. FTMPF was elevated from the mesial interdental papilla of maxillary canine to the mesial interdental papilla of second maxillary premolar. LLLT was applied at 3,7,14,28.56 days of retraction. During retraction study model for all patients were taken at 2^{ed}, 6th, 14th,16th weeks and at the end of retraction (I1,I2,I3,I4,I5 or overall interval). 3D laser scanning and digital superimposition was done to measure the rate of canine retraction and anchorage loss. **RESULTS:** Statistical analysis showed a significant difference in the mean distance moved by maxillary canine and weekly rate of retraction between the FTMPF and its control in I1, I2 and I5,and in I2,I3and I5 LLLT and its control. The total retraction time was significantly decreased in both FTMPF and LLLT in comparison to control. **COCLUSIONS:** FTMPF could accelerate orthodontic tooth movement with 25%, while LLLT could achieve 20% decrease with no significant difference between both techniques.

Key words: Acceleration, Full thickness mucoperiosteal flap, low level laser therapy.

Paper extracted from Doctor thesis titled " The Effect of Using Full Thickness Mucoperiosteal Flap versus Low Level Laser Application on Orthodontic Tooth Movement Acceleration"

INTRODUCTION

Today, a great increase of the population undergoes orthodontics treatment in order to bring about better occlusion, improved oral function as well as harmonized facial appearance ⁽¹⁾. Owing to the fact that the metabolism in adults is much slower than those in younger patients the time taken for treatment in adults is significantly greater than that taken in adolescents ⁽²⁻⁴⁾. Studies on treatment time have found durations ranging from 21-27 months for non-extraction treatment and 25-35 months for extraction treatment ⁽⁵⁻⁸⁾. Much research has been done to quantify the rate of tooth movement possible, with most studies showing approximately 1 mm/month ^(9,10).

In the surgical approaches to accelerate orthodontic treatment, Regional Acceleratory Phenomenon (RAP) is a way to increase bone remodeling rates and decrease bone density. The RAP is a sequence of tissue reactions during healing of injured bone ⁽¹¹⁻¹⁴⁾. Noxious stimuli include crushing injuries, fractures, and bone operations. It occurs regionally in the anatomical sense, involves both hard and soft tissues ⁽¹⁴⁾. In corticotomies, the bone injury occurs in two ways. First by elevating a full-thickness mucoperiosteal flap. Second, by cutting or perforating cortical bone. However, with the depth of damage in cortical bone ranging from 2 to 3 mm without flap elevation tooth movements were not accelerate orthodontic tooth movement because the RAP effects were limited to the cortical bone only ^(15,16). Former studies showed ^(17,18) that RAP is produced by elevation of a FTMPF so the rate of OTM increased approximately 24% to 31% because it decreases the amount and relatively the density of the medullary bone by about 9% ⁽¹⁸⁾. The decrease in bone volume fraction and density were small, less than previously shown to be associated with the RAP ^(19,20).

Laser is the acronym for "Light Amplification by Stimulated Emission of Radiation". Bone remodeling biomarkers assessment during laser irradiation could allow understanding of the mechanism of accelerated OTM with this novel approach ⁽²¹⁾. The effect of LLLT is photochemical not thermal which can be divided into primary and secondary responses. **Primary Response** include absorption of photons of LLL by photoacceptor molecule (Cytochrome C oxidase) ⁽²²⁻²⁴⁾. It is an integral membrane protein of mitochondria; the excitation of this molecule with light energy increases the capacity of mitochondria to generate ATP ⁽²⁴⁾. Increased ATP results in increased energy available for that cell's metabolic processes. Moreover, the increase of Nitric Oxide (NO) alters the cell activity by increasing cell membrane permeability to calcium and other ions. **Secondary responses** include RNA and DNA synthesis, cell proliferation, release of the growth factors, increase in collagen synthesis, change in nerve conduction and neurotransmitter. A number of studies in the literature have shown cellular LLLT increases fibroblast proliferation and the quantity of osteoid tissue ^(25,26). Most of the clinical studies ^(27,28) used Ga-Al-As diode laser, showed a stimulating effect on OTM and inducing an increase of up to 30%.

MATERIAL and METHODS:

This study included volunteer female patients (15-20 years old) from the clinic of orthodontics, Faculty of Dental Medicine for Girls, Al-Azhar University. All the patients who participated in this study were informed in simple language about the goals of the research and informed consent was

obtained from the patients and from one of the parents of those younger than 18 years before the study. The faculty Research Ethics Committee (REC) approval was obtained.

A split mouth study design was used (within each group a test side and control side). Sample size calculation using G Power software suggested a total size 32 sides with 10% drop out rate form 16 patients to be assigned randomly in allocation fashion 1: 1:1:1 as the following:

Group 1: Group 1.a. Full thickness mucoperiosteal flap (8 sides) and group 1.b. Control (8 sides)

Group 2: Group 2.a. Low level laser application. (8 sides) and Group 2.b. Control.(8 sides).

Eligibility Criteria:

• **Inclusion Criteria:**

- Free of any syndromes affecting the head region or any craniofacial injuries.
- No history of previous orthodontic treatment
- All of the permanent dentition present excluding third molars.
- Good oral hygiene before starting treatment.
- Cases indicated for extraction of the maxillary first premolars and canine retraction into the extraction space with maximum anchorage.
- Malocclusion cases that allow initial stage of leveling and alignment without extraction.

• **Exclusion Criteria:**

- Patients with systemic diseases especially bleeding disorders and osteoporosis.
- History of administration of corticosteroids, exogenous hormones and non-steroidal anti-inflammatory drugs (all drugs interfere with OTM).
- Presence of previous history of oral surgeries in maxillary arch.

All the patients were examined clinically and following diagnostic case records were taken for every patient including a clinical examination chart, standardized photographs (extraoral & intraoral photographs), lateral cephalometric radiograph, panoramic radiograph and orthodontic study model.

Study Design: This study included three phases:

Phase I: Initial Orthodontic Treatment Phase

Bonding and Banding: For all 16 patients the orthodontic treatment was started with installment of fixed orthodontic appliances to close the space that will be created after first premolar extraction and to restore an ideal occlusion and facial aesthetics.

Anchorage preparations: 1.4x8mm miniscrews were used to achieve maximum anchorage in all cases.

At this point, the patients were ready for maxillary first premolar extraction.

Phase II: Intervention Phase:

-Preoperative records included study model and periodontal pocket depth assessment.

-Randomization: Randomized selection was done for patients that were treated with FTMPF (Full thickness mucopreosteal flap) and other with LLLT (Low level laser thereby).

- Extraction of first maxillary premolars: Extraction on the control side was done one week earlier than test side. The post extraction instructions were firm and clear not to use NSAIDs for analgesia, Paracetamol drugs were prescribed.

Surgical Procedure (FTM PF Group):

A full thickness mucoperiosteal flap (FTMPF) was reflected on FTMPF side at the maxillary canine/premolar region by the same surgeon for all patients following the same procedures.

Disinfection for this area was done with Betadine. Subsequently, infiltration local anesthesia was injected on the canine-premolar region (buccal and palatal).

- Flap design:

The canine root length was approximately detected digitally from the preoperative lateral cephalometric radiograph. Scalpel blade (number 15) was used to make the incision. A free gingival sulcular incision was done from the distal surface of maxillary second premolar to the mesial side of the maxillary canine. A releasing oblique incision was done including the interdental papilla between maxillary canine and lateral incisor extending to the mucogingival junction just beyond the attached mucosa. The flap reflection extended beyond the canine root apex. A FTMPF reflection was done with mucoperiosteal elevator. Free sulcus incision was done to allow elevation of palatal mucosa by tunneling technique on the palatal gingiva of maxillary canine.

Extraction of first maxillary premolar on this side was done using premolar extraction forceps. Irrigation and lavage with saline was done then tissue was reapproximated with simple interrupted sutures by 4-0 Prollyline. (Fig 1)

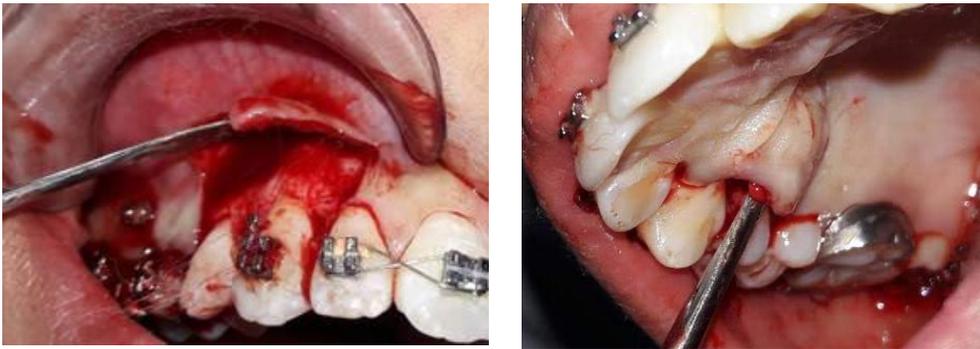


Figure 1 : Flap design and elevation

- Canine retraction:

The same 0.016x0.022 Stainless Steel rectangular arch wire was inserted in the same day and canine retraction was immediately started. A NiTi closed coil spring (12mm) was used from the power arm mesial to upper canine to the miniscrews in both sides. A force gauge was used to ensure that the retraction force is within the physiological limits (150 g).

- Low Level Laser Therapy Procedure (Group 2a):

LLLT was done using a diode soft laser (Epic X, BioLase, USA). It is a semiconductor diode soft laser. Active medium is In-Ga-As with 940nm wave length. LLLT protocol was using active laser tip (bleaching tip) 5w/cm² output power with continuous radiation mode. All protective measures were taken. LLLT was done by the principal operator throughout the study with the following sequence 3days after extraction, after 7 days, after 14 days, after 28 days, after 42 days, after 56 days

Measurements:

For all patients the rate of canine retraction was measured by measuring the distance moved by the maxillary canine through a series of 3D scanned study models and 3D superimposition. The distance

was measured from the cusp tip of the maxillary canine to reference plane which was drawn just mesial to the 1st maxillary molar. In order to monitor the rate, study models were taken at T0 (just immediately before starting of retraction), T1 (At the 2nd week of retraction)(Interval 1),T2 (at the 6th week of retraction)(Interval2),T3 (at the 14th week of retraction)(Interval3).T4 (at the 16th week of retraction)(Interval4),T5 (at the end of retraction)(Overall Interval)

Statistical analysis:

Values were presented as median (minimum – maximum), mean and standard deviation. As the data was nonparametric, the difference between the two techniques was evaluated by Mann-Whitney U test. While the difference between each technique and its control was assessed using Wilcoxon Signed Ranks test. All tests were bilateral and a P value of 5% was the limit of statistical significance. Analysis was performed by statistical package software IBM- SPSS version 21.

RESULTS:

In the current study, the mean overall distance moved by maxillary canine by the end of retraction in FTMPF and its control side were {6.77mm (0.32), 6.70mm (0.35)} respectively. While in LLLT and its control were {6.88mm (0.24), 6.55mm (0.24)} respectively. There were a statistical significant differences in this distance in I1 and I2. Moreover, there was a statistically significant difference between the mean distance moved by maxillary canine between I2 and I3 with a statistically significant difference in the overall distance in LLLT and its control. Subsequently, there were a statistically significant difference in this distance between FTMPF and LLLT in I 2 and I 3. (Table 1)

Table1: Statistical comparison of the mean distance moved and difference in weekly rate maxillary of canine retraction between group 1a FTMPF and group 2a LLLT at different intervals by Mann-Whitney U test

| Intervals | Mean distance moved by maxillary canine FTMPF vs LLLT | | | | |
|--------------|--|------------|--------|------------------------|--------------------------------|
| | Mann-Whitney U | Wilcoxon W | Z | Asymp. Sig. (2-tailed) | Exact Sig. [2*(1-tailed Sig.)] |
| I1 | 12.000 | 48.000 | -1.862 | 0.063 | 0.072 ^b |
| I2 | 2.500 | 38.500 | -2.954 | 0.003 | 0.001 ^{b*} |
| I3 | 5.500 | 33.500 | -2.606 | 0.009 | 0.006 ^{b*} |
| I4 | 27.000 | 63.000 | -.116 | 0.908 | 0.955 ^b |
| I5 (Overall) | 25.000 | 53.000 | -.347 | 0.728 | 0.779 ^b |
| | Weekly rate of maxillary canine retraction FTMPF vs LLLT | | | | |
| I1 | 12.000 | 48.000 | -1.862 | 0.063 | 0.072 ^b |
| I2 | 2.500 | 38.500 | -2.954 | 0.003 | 0.001 ^{b*} |
| I3 | 5.500 | 33.500 | -2.606 | 0.009 | 0.006 ^{b*} |
| I4 | 27.000 | 63.000 | -0.116 | 0.908 | 0.955 ^b |
| I5 (Overall) | 19.000 | 55.000 | -1.042 | 0.298 | 0.336 ^b |

a. Values with * are statistically significant with P value <0.05 b. Grouping Variable: Group c. Not corrected for ties

Regarding each interval, there were statistically significant increase in I1 and I2. The mean total weeks were needed to achieve full canine retraction {17.14 weeks (0.89)} in FTMPF and {22.42

weeks (0.97)} in control. While in LLLT and its control were {0.38mm/week (0.013)} and {0.28mm/week (0.01)} respectively. The mean total weeks were {17.87 weeks (0.83)} and its control {22.75 weeks (0.98)}. There was a statistically significant difference in the weekly rate of canine retraction in I2 and I3 between FTMPF and LLLT groups. (Table 1, Fig 2) (Table 2, Fig3)

Table2: Statistical comparison of the difference in total number of weeks needed to complete maxillary canine retraction between group 1a FTMPF and group 2a LLLT at different intervals by Mann-Whitney U test.

| Total Number of Weeks of Maxillary Canine Retraction FTMPF vs LLLT | Mann-Whitney U | Wilcoxon W | Z | Asymp. Sig. (2-tailed) | Exact Sig. [2*(1-tailed Sig.)] |
|--|----------------|------------|--------|------------------------|--------------------------------|
| | 16.500 | 44.500 | -1.404 | 0.160 | 0.189 ^b |

a. Values with * are statistically significant with P value <0.05 b. Grouping Variable: Group c. Not corrected for ties.

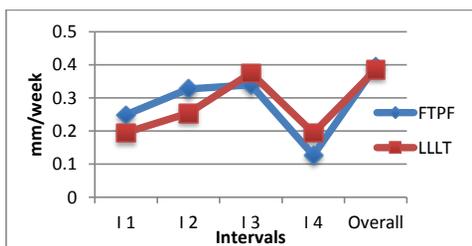


Figure 2: Line chart weekly rate of maxillary canine retraction between Group 1a FTMPF and Group 2a LLLT

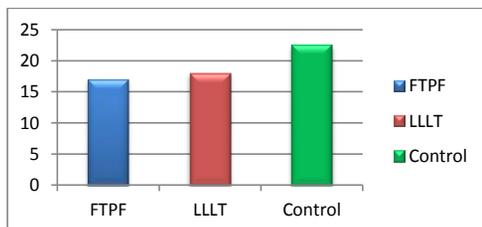


Figure 3: Bar chart showing mean total weeks for full canine retraction in FTMPF, LLLT and their control

The mean amount of mesial movement of 1st maxillary molar in FTMPF group and its control and LLLT and its control was {0.21mm (0.073), 0.26mm (0.13), 0.38mm (0.100), 0.36mm (0.076)} respectively. There was no statistical significant difference between those both groups. There was no statistical significant difference between those both groups. On the other hand, there was a statistically significant difference between the mean amount of mesial movement of 1st maxillary molar between FTMPF group and LLLT group; it was higher in the LLLT. In the current study, the amount of change in periodontal pocket depth average was assessed. In FTMPF group and its control was {0.13mm (0.20), -0.21mm (0.35)} respectively, with a statistically significant difference between FTMPF and its control. However, in LLLT and its control group, it is {0.08mm (0.27), 0.06mm (0.28)} respectively with no statistical significant difference in both groups. Also there were

no statistical significant difference in the mean average of periodontal pocket depth between FTMPF group and LLLT group.

DISCUSSION:

The aim of the current study was to compare the acceleratory effect of a minimally invasive surgical technique in which only elevation of FTMPF with non-invasive technique as LLLT by evaluating the rate of canine retraction after using both techniques. According to literature there were no golden parameters for LLLT, a variety of different energy parameters (wave length, exposure time and mode radiation) were used $0.7\text{j}/\text{cm}^2$ ⁽²⁴⁾, $5\text{j}/\text{cm}^2$ ⁽²⁷⁾, $8\text{j}/\text{cm}^2$ ⁽²⁸⁾ and $29\text{j}/\text{cm}^2$ ⁽²⁹⁾. In the current study the total tissue energy was calculated according to manufacture recommendations $35\text{j}/\text{cm}^2$ in a continues mode for 100sec. The LLLT frequency of applications had also a great variability in the literatures. A previous study used LLLT at 0,3,7 and 14 days then repeated it after every 21 days ⁽²⁸⁾ and after 30 days ⁽²⁷⁾. Another study ⁽³⁰⁾ used 4 applications in the 1st month, then 2 applications per month for the end of canine retraction. Later study ⁽²⁹⁾ apply LLLT at 0,7,14,21 days, then every 2weeks until the end of retraction. In the current study LLLT was applied at 0,7,14,24,48,56 days after starting retraction.

However, within every group, there were a statistical significant differences in the mean distance travelled by maxillary canine in I1 and I2 between the FTMPF and its control group. This finding is agreed with other studies which use any other minimal invasive surgical techniques. In those studies, it was clear that the acceleratory effect can be seen obviously in the first 4 weeks after procedure, then it effect begin to decrease or even disappear at 14 weeks duration ^(31,32). In previous studies, which compare flap corticotomy to LLLT, the rate of canine retraction achieved on the corticotomy side was highest during the first 5 weeks and lowest at the 15th week which was corresponded to the current study results ^(29, 32, 33).

The highest rate in LLLT group of OTM was observed on the intervals (I2 and I3) not earlier and not later. The peak of acceleration was seen at the first 10th week of retraction then it showed a sharp decrease after the 13th week of retraction. This is could be explained due to presence normal lag phase during OTM in order to remove the hyalinized bone to continue the canine retraction. Moreover, it could be due stoppage of LLLT application depending on the fact that the cellular response to laser therapy is dose dependent. Effectiveness of LLLT is believed that LLL is dose-dependent and the force applied it can speed up or slow down biological processes depending on the fluency applied and the irradiation protocol, so there was a great difference in each study outcome ^(23,27,34).

Over the current study, there was a significant difference between FTMPF and LLLT groups in the weekly rate of canine retraction in I2 and I3. At I2 the FTMPF group has shown a higher weekly rate of canine retraction rather than the LLLT group, while in the I3 the LLLT group shown the higher weekly rate of canine retraction. These results were corresponded to former studies ^(27,29,30,35) findings. This could be explained as the RAP after FTMPF tend to start earlier than cellular stimulatory effect of LLLT.

In view of the current study, regarding the mean total weeks were needed to achieve full canine retraction, in FTMPF it showed a statistically significant decrease in the total retraction weeks which

were about 17.14 weeks versus 22.42 weeks in its control. Therefore, flap elevation increased the rate of tooth movement by approximately 25%. These results were in accordance with a former study that had showed the elevation of a full-thickness mucoperiosteal flap alone increases the rate of mesio-distal orthodontic tooth movement ⁽¹⁸⁾.

In LLLT, there was statistically significant decrease in the average total weeks for full canine. These results were in accordance with other previous studies regarding the concept only that LLLT accelerate the OTM but not in the amount of acceleration which may be due to different protocols were used for LLLT in every study ⁽²⁷⁾.

However, comparing the FTMPF group with LLLT group, both interventions achieved a total decrease in treatment duration but with no statistically significant difference between both. Reviewing the literatures there was no similar study that evaluate the acceleratory effect of elevation of FTMPF alone on OTM in humans. Moreover, there was no similar study that compare the FTMPF with LLLT using the same parameters. Clinically, FTMPF group showed about 25% decrease in the total time needed to achieve full canine retraction. While in LLLT group it showed about 20% decrease. These findings are in agreed with few of the former studies regarding acceleration but with different rates ^(18, 27, 28, 30).

There was a statistically significant difference between the mean amount of mesial movement of 1st maxillary molar between FTMPF group and LLLT group, it was higher in the LLLT. This could be due to the extension of laser radiation effect to the 1st molar investing tissue as the LLLT was an area application rather than point application. This wasn't coordinate with a former study that had shown no statistically significant difference between Laser and surgical groups ⁽²⁹⁾.

In the current study, the amount of change in periodontal pockets depth average for the maxillary canine were assessed in FTMPF group and its control. A statistically significant increase in the average periodontal pocket depth in FTMPF comparing to its control. This was agreed former study ⁽²⁸⁾, while disagreed with other studies ⁽²⁹⁻³²⁾.

CONCOLUSIONS

Within the limitation of this study and on the bases of the obtained results, a full thickness mucoperiosteal flap elevation (FTMPF) only could accelerate the rate of canine retraction clinically by 25% of total conventional canine retraction time. A low level laser therapy (LLL) application (within the parameters that was used in this study) could accelerate the rate of canine retraction clinically by 20 % of the total conventional canine retraction time. Within Both techniques, there were no statistically significant difference on their effect on the rate of canine retraction. LLLT has showed more amount of molar anchorage loss (5%) than the FTMPF elevation (3%). Both techniques were safe regarding the periodontal health around the maxillary canine.

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