Al-Azhar Journal of Dentistry

Volume 7 | Issue 2 Article 3

Pediatric dentistry and orthodontics Issue (Pediatric Dentistry, Orthodontics)

4-1-2020

The Effect of Using Full Thickness Mucoperiosteal Flap versus Low Level Laser Application on Orthodontic Tooth Movement Acceleration

Mohsena Abdarazik
Assistant Lecturer at Orthodontics Department, Faculty of Dental Medicine for Girls, Al-Azhar University, Cairo, Egypt., mohsena.ahmad23@gmail.com

Samir Ibrahim
Professor of Orthodontics, Faculty of Dental Medicine for Girls, Al-Azhar University, Cairo, Egypt., samirabdoh@hotmail.com

James Hartsfield
E. Preston Hicks Endowed, Professor of Orthodontics and Oral Health Research, University of Kentucky-USA., jkha2@g.uky.edu

Hatem AlAhmady
Professor and Head of Oral and Maxillofacial Surgery Department, Faculty of Dental Medicine for Girls, Al-Azhar University, Cairo, Egypt., dralahmady@gmail.com

How to Cite This Article

Abdarazik, Mohsena; Ibrahim, Samir; Hartsfield, James; and AlAhmady, Hatem (2020) "The Effect of Using Full Thickness Mucoperiosteal Flap versus Low Level Laser Application on Orthodontic Tooth Movement Acceleration," *Al-Azhar Journal of Dentistry*: Vol. 7: Iss. 2, Article 3.
DOI: https://doi.org/10.21608/adjg.2020.13312.1157

AL-AZHAR
Dental Journal
For Girls

The Official Publication
of The Faculty of Dental
Medicine For Girls,
Al-Azhar University
Cairo, Egypt.

Print ISSN 2537-0308 • Online ISSN 2537-0316

ADJ-for Girls, Vol. 7, No. 2, April (2020) — PP. 285:293

The Effect of Using Full Thickness Mucoperiosteal Flap versus Low Level Laser Application on Orthodontic Tooth Movement Acceleration

Mohsena A. Abdarazik[1*], Samir A. Ibrahim[2], James K. Hartsfield[3], Hatem H. AlAhmady[4]

Codex : 36/2004

azhardentj@azhar.edu.eg

http://adjg.journals.ekb.eg

DOI: 10.21608/adjg.2020.13312.1157

Pediatric Dentistry & Orthodontics
(Pediatric Dentistry, Orthodontics)

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 1divided 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 the 3,7,14,28.56 days of retraction. During retraction study model for all patients were taken at 2nd, 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 distance moved by maxillary canine and weekly rate of retraction between the FTMPF and its control in I1, I2 and I5 and in I2, I3 and I5 LLLT and its control. The total retraction time was significantly decreased in both FTMPF and LLLT in comparison to control. **Conclusions:** FTMPF could accelerate orthodontic tooth movement with 25%, while LLLT could achieve 20% decrease with no significant difference between both techniques.

KEYWORDS

Acceleration,
Mucoperiostreal 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"

1. Assistant Lecturer at Orthodontics Department, Faculty of Dental Medicine for Girls, Al-Azhar University, Cairo, Egypt.
2. Professor of Orthodontics, Faculty of Dental Medicine for Girls, Al-Azhar University, Cairo, Egypt.
3. E. Preston Hicks Endowed, Professor of Orthodontics and Oral Health Research, University of Kentucky- USA.
4. Professor and Head of Oral and Maxillofacial Surgery Department, Faculty of Dental Medicine for Girls, Al-Azhar University, Cairo, Egypt.

* Corresponding author email: mohsena.ahmad23@gmail.com

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 [17,18] showed 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:**

o Free of any syndromes affecting the head region or any craniofacial injuries.

o No history of previous orthodontic treatment

o All of the permanent dentition present excluding third molars.

o Good oral hygiene before starting treatment.

o Cases indicated for extraction of the maxillary first premolars and canine retraction into the extraction space with maximum anchorage.

o Malocclusion cases that allow initial stage of leveling and alignment without extraction.

- **Exclusion Criteria:**

o Patients with systemic diseases especially bleeding disorders and osteoporosis.

o History of administration of corticosteroids, exogenous hormones and non-steroidal anti-inflammatory drugs (all drugs interfere with OTM).

o 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 mucopreiosteal 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 mucoperiostal 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 Prolyline. (Fig. 1, 2)

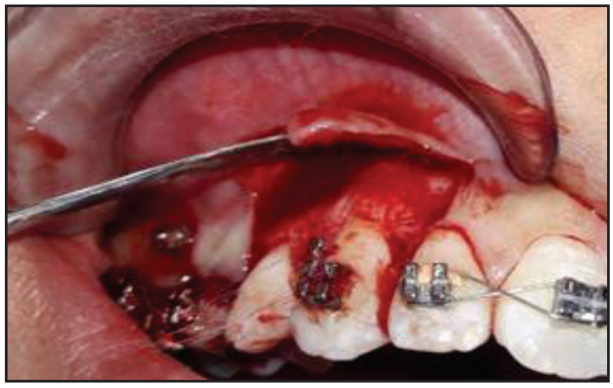
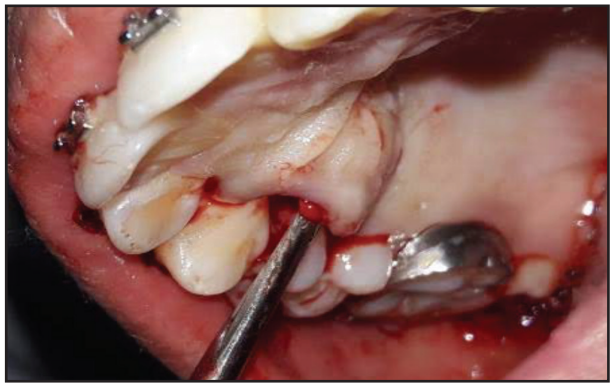


Figure (1) Flap design



Figure(2) Palatal flap

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). The work was done at Al-Azhar Dental Laser Center, Faculty of Dental Medicine for Girls, Al-Azhar University. It is a semiconductor diode soft laser. Active medium is In-Ga-As with 940nm wave length. LLLT protocol was using active laser tip (Whitening/Contour Handpiece) output power 0.2 W with total energy12 J and energy density (4.2 J/cm^2) in continuous radiation mode for 60 second. 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 and 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 with P value of significance less than 2%. While the difference between each technique and its control was assessed using Wilcoxon Signed Ranks test. All tests were bilateral and a P value less than 1% was the limit of statistical significance. Analysis was performed by statistical package software IBM-SPSS version 21.

RESULTS

In the current study, the overall distance moved by maxillary canine by the end of retraction in FTMPF and its control side were {6.77mm, 6.70mm} respectively. While in LLLT and its control were {6.88 mm, 6.55mm} respectively. There were a statistical significant differences in this distance in I1and I2. Moreover, there was a statistically significant difference between the 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)

Regarding each interval, there was statistically significant increase in I1 and I2. The median total weeks were needed to achieve full canine retraction {17.14 weeks} in FTMPF and {22.42 weeks} in control. While in LLLT and its control were {0.38mm/week } and {0.28mm/week } respectively. The mean total weeks were {17.87 weeks} and its control {22.75 weeks}. There was a statistically significant difference in the weekly rate of canine retraction in I2 and I3 between FTMPF and LLLT groups. (Table 1,) (Table 2, Fig4)

Table (1) *Statistical comparison of the 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	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 <0.01 b. Grouping Variable: Group c. Not corrected for ties*

Table 2: *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 <0.01 b. Grouping Variable: Group c. Not corrected for ties.*

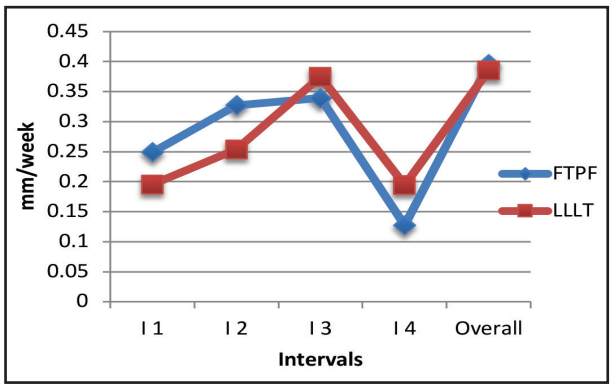


Figure (3) Line chart weekly rate of maxillary canine retraction between Group 1a FTMPF and Group 2a LLLT

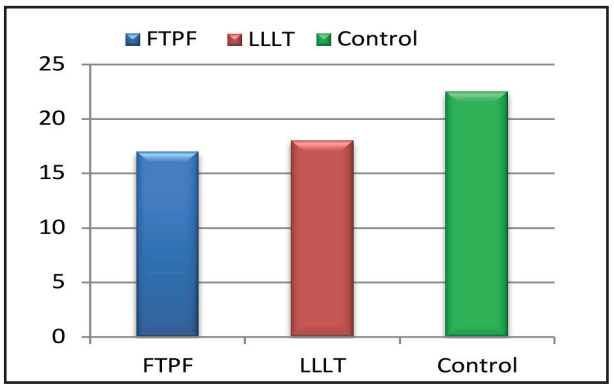


Figure (4) Bar chart showing total weeks for fullcanine retraction in FTMPF,LLLT and there control

The median amount of mesial movement of 1st maxillary molar in FTMPF group and its control and LLLT and its control was {0.21mm , 0.26mm, 0.38mm, 0.36mm} 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 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 probing depth average was assessed. In FTMPF group and its control was {0.13mm, -0.21mm} respectively, with a statistically significant difference between FTMPF and its control. However, in LLLT ant its control group, t is {0.08mm, 0.06mm} respectively with no statistical significant difference in both groups. Also there were no statistical significant difference in the average of periodontal probing 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 verity of different energy parameters (wave length, exposure time and mode radiation) were used 0.7j/cm^2 [24], 5j/cm^2 [27], 8j/cm^2[28] and 29j/cm^2 [29]. In the current study the total tissue energy was calculated according to manufacture recommendations 4.2j/cm^2 in continues mode for 60sec. The LLLT frequency of applications had also a great variability in the literatures. A previous study used LLLT at 0,3,7and 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 (I2and 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 probing depth average for the maxillary canine were assessed in FTMPF group and its control. A statistically significant increase in the average periodontal probing depth in FTMPF comparing to its control. This was agreed former study [28], while disagreed with other studies [29-32].

CONCLUSIONS

Within the limitation of this study and on the bases of the obtained results, a full thickness muco-periosteal 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 (LLLT) 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.

REFERENCES

1. Yina Li, Laura A. Jacox R, Shannyn H. Ching-Chang Ko. Review Article Orthodontic tooth movement: The biology and clinical implications J. Med. Sci. Res. 2018; 34:207-14.
2. Mohammed M, Jawad A, Adam H, Mohammad K., Rozita H, Rumaizi S,. Effect of low level laser and low intensity by pulsed ultrasound therapy on bone remodeling during orthodontic tooth movement in rats. Prog Orthod. 2018;12:10-9.
3. Gurbax S, Raahat V S, Roopsirat K, Devinder P S. Accelerated Orthodontic Tooth Movement: A Review. Mod Res Dent. 2017;1:5-8.
4. American Dental Association. The Future of Dentistry, pg. 81. Retreived 7/12/2005 at http:// www.ada.org/prof/ resources/topics/futuredent/ future 2001.
5. Skidmore KJ, Brook KJ, Thomson WM, Harding WJ. Factors influencing treatment time in orthodontic patients. Am J Orthod Dentofacial Orthop 2006;129:230-8.
6. Fink DF, Smith RJ. The duration of orthodontic treatment. Am J Orthod Dentofacial Orthop. 1992;102:45-51.
7. Alger DW. Appointment frequency versus treatment time. Am J Orthod Dentofacial Orthop. 1988;94:436-9.
8. Popowich K, Nebbe B, Heo G, Glover KE, Major PW. Predictors for Class II treatment duration. Am J Orthod Dentofacial Orthop. 2005;127:293-300.
9. Boester CH, Johnston LE. A clinical investigation of the concepts of differential and optimal force in canine retraction. Angle Orthod 1974;44:113-9.
10. Samuels RH, Rudge SJ, Mair LH. A comparison of the rate of space closure using a nickel-titanium spring and an elastic module: a clinical study. Am J Orthod Dentofacial Orthop 1993;103:464-7.
11. Gkantidis N. Effectiveness of non-conventional methods for accelerated orthodontic tooth movement: A systematic review and meta-analysis. J.Dent. 2014:5:1-20.
12. Cano J, Campo J, Bonilla E, Colmenero C. Corticotomy-assisted orthodontics. J Clin Exp Dent 2012;4:54-9.
13. Mayur S., Rajkumar M., Harsh M, Harpreet S., Kunal A. Accelerated Orthodontics: A paradigm shift, J Indian Orthod Soc. 2017;3:64-8.
14. Melsen B. Biological reaction of alveolar bone to orthodontic tooth movement. Angle Orthod 1999;69:151-8.
15. Safavi SM, Heidarpour M, Izadi SS, Heidarpour M. Effects of flapless bur decortications on movement velocity of dogs' teeth. Dent Res J. 2012;9:783-9.
16. Swapp A, Campbell PM, Spears R, Buschang PH. Flapless cortical bone damage has no effect on medullary bone mesial to teeth being moved. Am J Orthod Dentofacial Orthop 2015;147:547-58.
17. Yaffe A, Fine N, Binderman I. Regional accelerated phenomenon in the mandible following mucoperiosteal flap surgery. J Periodontol 1994;65:79-83.
18. Owen KM, Campbell PM, Feng QJ, Dechow PC, Buschang PH. Elevation of a full-thickness mucoperiosteal flap alone accelerates orthodontic tooth movement. Am J Orthod Dentofacial Orthop 2017;152:49-57.

19. Lee W, Karapetyan G, Moats R, Yamashita DD, Moon HB, Ferguson DJ, et al. Corticotomy-/osteotomy-assisted tooth movement micro CTs differ. J Dent Res 2008;87:861-7.

20. Araújo MG, Lindhe J. Ridge alterations following tooth extraction with and without flap elevation: an experimental study in the dog. Clin Oral Implan Res 2009;20:545-9.

21. Alissa V, Ameet V. Revankar, Anand K. Patil. Low-level laser therapy increases interleukin-1b in gingival crevicular fluid and enhances the rate of orthodontic tooth movement. Am J Orthod Dentofacial Orthop. 2018: 154:1-12.

22. Yoshida T, Yamaguchi M, Utsunomiya T, Kato M, Arai Y. Low-energy laser irradiation accelerates the velocity of tooth movement via stimulation of the alveolar bone remodeling. Orthod Cranio fac Res. 2009;12: 289-98.

23. Kawasaki K, Shimizu N. Effects of low-energy laser irradiation on bone remodeling during experimental tooth movement in rats. Lasers Surg Med. 2000;26: 282-91.

24. Karu TI, Afanas'eva NI. Cytochrome c oxidase as the primary photoacceptor upon laser exposure of cultured cells to visible and near IR-range light. Dokl Akad Nauk 1995; 342: 693-5.

25. Saito S, Shimizu N. Stimulatory effects of low-power laser irradiation on bone regeneration in midpalatal suture during expansion in the rat. Am J Orthod Dentofacial Orthop 1997;111:525-32.

26. Angeletti P, Pereira MD, Gomes HC, Hino CT, Ferreira LM. Effect of low-level laser therapy (GaAlAs) on bone regeneration in midpalatal anterior suture after surgically assisted rapid maxillary expansion. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2010;109:38-46.

27. Cruz DR, Kohara EK, Ribeiro MS, Wetter NU. Effects of low intensity laser therapy on the orthodontic movement velocity of human teeth: a preliminary study. Lasers Surg Med 2004;35: 117-20.

28. Youssef M, Ashkar S, Hamade E, Gutknecht N, Lampert F, Mir M. The effect of low-level laser therapy during orthodontic movement: a preliminary study. Lasers Med Sci 2008;23:27-33.

29. El-Ashmawi NM, Abd El-Ghafour M, Nasr S, Fayed MS, El-Beialy AR, Nasef E. Effect of surgical corticotomy versus low level laser therapy (LLLT) on the rate of canine retraction in orthodontic patients. Orthodontic Practice US.2018;9:1-11.

30. Doshi-Mehta G, Bhad-Patil WA. Efficacy of low intensity laser therapy in reducing treatment time and orthodontic pain: A clinical investigation. Am J Orthod Dento facial Orthop 2012;141:289-97.

31. Eid FY, El-Kenany WA, El- Kalza AR. Effect of micro-osteoperforations on the rate of canine retraction; a split-mouth randomized controlled clinical trial Orthod J. 2017;52:57-64.

32. Aboul SM, El-Beialy AR, El-Sayed KMF, Selim EMN, EL-Mangoury NH, Mostafa YA. Miniscrew implant-supported maxillary canine retraction with and without corticotomy- facilitated orthodontics. Am J Orhod Dentofacial Orhop. 2011;139:252-9.

33. Alikhani M, Raptis M, Zoldan B. Effect of micro-osteoperforations on the rate of tooth movement. Am J Orthod Dentofacial Orthop. 2013;144:639-48.

34. Marquezan M, Bolognese AM, Araujo MT. Effects of two low-intensity laser therapy protocols on experimental tooth movement. Photomed Laser Surg. 2010;28: 757-62.

35. Arumughan S, Somaiah S., Muddaiah S., Shetty B., Reddy G. Roopa S. A Comparison of the Rate of Retraction with Low-level Laser Therapy and Conventional Retraction Technique. Contemp Clin Dent. 2018; 9: 260–6.