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INFLUENCE OF LOW LEVEL LASER THERAPY ON ROOT RESORPTION DURING ORTHODONTIC TOOTH MOVEMENT USING APICALLY DIRECTED FORCES – A SEM STUDY.

Dental Science

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ABSTRACT

INTRODUCTION: Studies have been reported that with the application of low level laser therapy, inflammation around root was decreased, bone regeneration and tooth movement was accelerated, which may have great benefit in reducing root resorption. The aim of this study was to test the hypothesis, that the low level laser therapy decreases root resorption secondary to the application of orthodontic forces in an apical direction.
MATERIALS AND METHODS: This study was designed to test the efficacy of GaAlAs laser irradiation on 10 patients. Apically directed force of 25 grams was delivered by using cantilever springs. Laser irradiation was applied on the mucosa at 6 points around the first premolar on the experimental side. Laser irradiation was started on the day '0' after inserting intrusion spring and was repeated on 7th, 14th and 21st day and teeth were extracted on 28th day after taking photographs and impressions. Root resorption craters on the buccal and palatal surfaces were recorded using a scanning electron microscope.
RESULTS: Compared with the control side, the mean resorbed root surface area of the experimental side was less and it was statistically significant ($p = 0.040$).
CONCLUSION: Under the limitations of the present study, it can be concluded that GaAlAs irradiation together with apically directed forces led to reduction in the amount of root resorption on experimental side compared to control side and can be used as an adjunct to reduce the root resorption.

KEYWORDS

Low level laser therapy, SEM, root resorption

INTRODUCTION:

Root resorption was first described by Bates [1] in 1856 and was intercorrelated to orthodontics by Ottolengui(1914).[2] Albert Ketcham was the first to bring the message that apical root resorption is a common and occasionally severe iatrogenic consequence of orthodontic treatment. [3,4] Accordingly, based on the actual process, Brezniak N and Wasserstein A suggested a new term: Orthodontically Induced Inflammatory Root Resorption (OIIRR). [5]

Orthodontically Induced Inflammatory Root Resorption is a sterile inflammatory process that is extremely complex and composed of various disparate components including forces, tooth roots, bone, cells, surrounding matrix and certain known biologic messengers. [6] It is unavoidable and unpredictable side effect of orthodontic treatment influenced by many biologic and mechanical factors. [7,8,9] Approximately 90 percent of patients undergoing orthodontic treatment have some extent of root resorption, [10] 32 percent being moderate (>3 mm resorption) while 5 percent of the cases manifest as severe resorption (>5 mm resorption). [11] Treatment duration has been associated with increased risk and severity of OIIRR; [12,13] hence, various methods have been reported in an effort to decrease treatment time. Mechanical vibration,[14] corticotomy, [15]piezocision, [16]as well as several pharmacological agents such as local application of prostaglandins and vitamin D [17] have been proposed as possible methods for accelerating orthodontic tooth movement. Although most were effective, their use may not be clinically feasible due to their invasive nature or side effects. [18,19]

In contrast, low-level laser therapy (LLLT) is a non-invasive method with its effects limited to the target tissue. [20] Cellular absorption of laser light by the target tissue leads to the activation of intracellular signalling cascades, which increases cellular metabolism, and anti-inflammatory changes. [21] Photobiomodulation involving LLLT or light-emitting diodes (LED) therapy has been tested in animal and human studies and it has been proven to stimulate epithelization, vascularization, and collagen synthesis. [22] Low level laser therapy enhances tissue regeneration by improving cellular differentiation and proliferation, accelerating the clearance of tissue debris, and inducing angiogenesis. [23,24,25] Thereby, LLLT may be beneficial for treating inflammatory processes such as orthodontic root resorption.

Therefore, this clinical study was taken up to evaluate the effect of LLLT on root resorption in patients who received apically directed forces.

MATERIALS AND METHODS

The sample consisted of 20 maxillary first premolars from 10 patients who required first premolar extractions as part of their fixed appliance orthodontic treatment. Their age ranged from 15 years to 22 years. Patients were recruited according to strict selection criteria: (1) Patients who required upper first premolar extractions for orthodontic treatment; (2) no previous dental treatment to the teeth to be extracted, (3) no previous trauma to the teeth to be extracted, (4) no previous orthodontic treatment involving the teeth to be extracted, (5) no past or present signs or symptoms of periodontal disease, bruxism, (6) no significant medical history, (7) no physical abnormality concerning the anatomy of the craniofacial or dentoalveolar complex, and (8) completed apexification. Ethics approval was granted by the Institutional Ethics Committee. All subjects and their guardians consented to participate in this study after receiving verbal and written explanations.

McLaughlin, Bennett, Trevisi preadjusted edgewise (MBT) brackets 0.022”x 0.028" and molar tubes were bonded on the first premolars and first molars, respectively. A split-mouth design [26,27] was used to compare effectiveness of LLLT on amount of root resorption and rate of tooth movement. Apically directed force of 25 grams was applied to premolars via a 0.017 x 0.025-inch beta-titanium cantilever from the first molar to the first premolar, bypassing the second premolar. The force produced was verified with a dontrix gauge. The right maxillary first premolar constituted the experimental tooth, received low level laser therapy. The left maxillary first premolar served as the control did not receive laser treatment.

Transpalatal arch made of 0.036” SS wire was inserted into the lingual sheaths of first molars on both sides for stabilization. (Fig.1). Intrusion springs made with 0.017” x 0.025” TMA wire were inserted into the first molar tubes and ligated to first premolar brackets on both sides. Twenty five grams of force was applied on both premolars and magnitude of force was measured with a dontrix gauge and checked on 7th, 14th and 21st day and adjusted to 25 grams.

Fig 1. Buccal cantilever spring, 0.017” x 0.025” TMA wire. This was the experimental setup for the application of 25 g of force to the first premolar. The amount of activation was verified with a dontrix gauge before insertion into the bracket.

A gallium-aluminium-arsenide (Ga-Al-As) diode laser with a wave length of 810 nm was applied on the experimental tooth. Three points on buccal surface and 3 points on palatal surface of the root corresponding to the cervical third, middle third and apical third were selected for application of laser and probe was held perpendicular on each point for 20 seconds. Laser parameters used were - Output power of 100 mW and power density 0.043 W/cm^2. This dose was set based on Arndt Schultz Law.[28] The total dose delivered for session was 12 joules (6 points x 20sec x 100 mW) as premolar root surface area is 234 mm^2 i.e. 2.34 cm^2. Dose at each point was 2 J and 5 J/cm^2, in total 12 J per session (Fig 2 a, b). Low level laser irradiation was started on the day '0' after inserting intrusion spring and was repeated on 7th, 14th and 21st day.

Fig 2a Fig 2b

Fig 2: Laser application on buccal surface (a) and palatal surface (b) of experimental maxillary first premolar

After 4 weeks i.e., on 28th day, photographs and impressions were taken and then teeth were extracted carefully to prevent surgical trauma to the root cementum. After removal, each tooth was immediately stored in an individual container of sterilized deionised water that had been previously tested as an appropriate storage medium. [29] Each tooth was then placed in an ultrasonic bath for 10 minutes to remove all traces of residual PDL and soft-tissue fragments. The tooth was then disinfected in 70% alcohol for 30 minutes, bench dried at ambient room temperature.

After sputtering with a 25 - nm layer of gold, the root surfaces were examined and quantification was carried out by scanning electron microscope operated at 20 kV. Six teeth were scanned at a time. All teeth were scanned from the cementoenamel junction to the root apex on buccal and palatal surfaces with resolution between 30 µm and 300 µm. (Fig 3 a,b. 4 a,b)

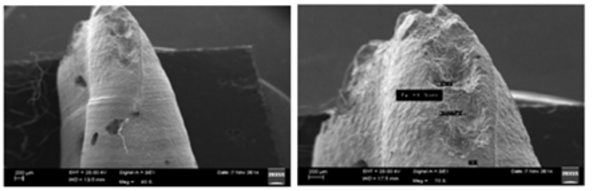


Fig: 3a Fig: 3b

Fig 3: Scanning electron micrographs of experimental side (a) palatal apical third root surface (b) higher magnification view

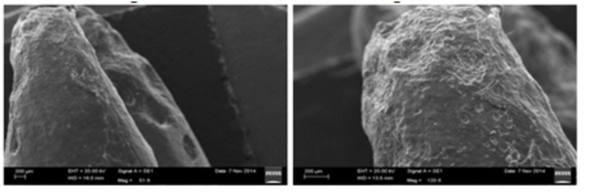


Fig: 4a Fig: 4b

Fig 4: Scanning electron micrographs of control side (a) palatal apical third root surface (b) higher magnification view

Statistical analyses

Kolmogorov-Smirnov test revealed that the data regarding root resorption were normally distributed. The difference in number of craters between the buccal and palatal surface of each tooth in experimental and control sides were also tested by paired t- test. The data were analyzed by SPSS (Statistical Package for Social Sciences) and the significance level was predetermined at $p < 0.05$.

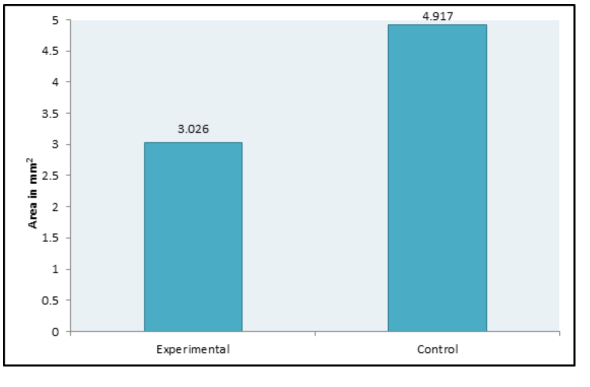
RESULTS

The mean root resorption areas were 3.026 ± 2.322 mm^2 and 4.917 ± 3.002mm^2 in the experimental side and control side respectively with statistically significant difference between them (p = 0.040). Compared with the control side, the mean resorbed root area of the experimental side was lesser. Therefore, results suggested that GaAlAs laser irradiation reduced the severity of orthodontically induced root resorption in the first premolars and it was statistically significant (Table 1 and graph1).

Table 1: Comparison of root resorption surface area on experimental and control sides

Paired Samples Statistics								
		Mean	N	Std. Deviation	Std. Error Mean	t-value	p value	sig
Pair 1	Experimental side surface area of root resorption in mm2	3.026	10	2.322	0.734	2.403	0.040	s
	Control side surface area of root resorption in mm2	4.917	10	3.002	0.949			

Graph: 1 Root resorption surface area of maxillary first premolar on experimental and control sides

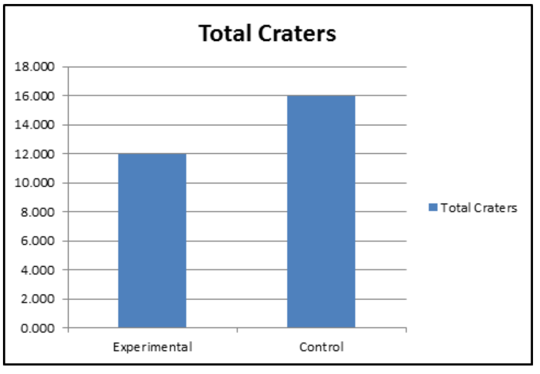


Comparison of number of craters in the experimental side and control side was done with paired t- test and it showed less number of craters in experimental side (12.000 ± 6.182) compared to the control side (16.000 ± 8.781) with statistically significant difference between them (p = 0.022) (Table 2 and graph 2).

Table 2: Number of craters on experimental and control sides

number of craters	Mean	S.D	p-value	sig
Experimental side	12.00	6.182	0.022	S
Control side	16.00	8.781		

Graph: 2 Number of craters on experimental and control sides



The results obtained in this study during orthodontic force application suggested that the use of LLLT during orthodontic treatment decreases root resorption (p = 0.040).

DISCUSSION

Orthodontically induced inflammatory root resorption is a form of pathologic root resorption related to the removal of hyalinized areas of the periodontal ligament following the application of orthodontic forces and is considered an undesirable but unavoidable iatrogenic consequence of orthodontic treatment. Schwarz [30] advocated the optimal force level for tooth movement between 7gm- 26 gm / cm2. He also stated that when force exceeded this threshold, root resorption occurs.

The use of various pharmacologic agents and hormones has been proposed for clinicians to prevent orthodontic root resorption. In the recent literature, much interest has been focused on pharmacologic methods that could control the severity of root resorption. [31,32,33] However, a specific drug that can prevent root resorption without interfering with tooth movement has not been discovered yet.

It has been suggested that the etiology of orthodontically induced inflammatory root resorption is multifactorial. [34] Although several studies have investigated it, the exact etiology has not been established yet. The magnitude of force [35,36,37] and the duration of treatment [38,39] were shown to be important factors related to root resorption. The magnitude of force has received significant attention in orthodontics without considering that it is important only because it is related to other characteristics of the force system and surface area of the periodontal ligament over which it is dissipated. Twenty five grams of force was selected as the light force and a 9-fold increase was selected as the heavy force at 225 g. These force magnitudes were based on previous the studies by Schwarz,[40] Ogura et al, [41] Owman-Moll et al, [42] and Proffit reported that forces well below the optimal level cause no reaction in the periodontal ligament. Forces exceeding the optimal level would lead to areas of tissue necrosis, preventing frontal bone resorption.

After 10 days of force application, Kvam [43] recorded small, round root resorption cavities using scanning electron miscroscopy; after 25 days, the resorption had reached the dentin and showed a characteristic honeycomb appearance. In our study, 28 days was selected as the experimental duration, because this allowed for noticeable resorption. [44] The extent of the experimental period also allowed for the springs to be tolerated by the patients, avoiding breakages and minimizing force decay.

This clinical study was under taken to test the hypothesis that mechanical forces combined with low-level laser therapy (LLLT) decreases root resorption.

This is one of the few human studies to report a statistically significant decrease in root resorption between irradiated and control side with the use of LLLT. The specific laser protocol was derived from literature [28] with the aim of instigating the biostimulatory and/or bioinhibitory benefits of LLLT to minimize root resorption. The energy density used in this study fall into the range of 2.0 to 5.0 J/cm2, which is considered to be the most effective in triggering tissue biological response.

It is unclear whether the reduction in root resorption on the laser side is the result of the preventative effect of LLLT or whether it is due to its reparative potential.

In this study, we analyzed in detail all root surfaces: buccal, lingual, mesial, and distal; the root was divided into thirds (cervical, middle, apical). In this study, root resorption, found on both tooth surfaces, was greater toward the cervical and apical third of buccal surface, and apical third of palatal surfaces in both LLLT treated premolars and control premolars. In this study apically directed force was used, which was buccal to the centre of resistance of premolar. Hence along with intrusion, buccal crown tipping and lingual root tipping was expected. This may have created pressure zones on buccal cervical and palate apical region, tension zones on palatal cervical and buccal apical region, so more root resorption craters were observed in cervical third of buccal surface and apical third of palatal surfaces in both LLLT treated group and control group. The middle thirds did not exhibit significant areas of resorption.

Our results agree with those of Ekizer A et al. (2013) [45] in an animal study evaluated the effects of light emitting diode mediated photobiomodulation therapy (LPT), on orthodontically induced root resorption, concluded that LPT method had inhibitory effects on orthodontically induced resorptive activity. However, Nimeri G et al. (2014) [46] results showed that the photo-biomodulation did not cause root resorption greater than the normal range that is commonly detected in orthodontic treatments.

Limitations:

Limitations of this study were small sample size, ethical and practical constraints in human clinical research led us to a sample of 10 patients and 10 premolars in each group and the surface of the premolar teeth was curved and an absolute straight-on view was very difficult which can induce measurement errors. [47] As root resorption craters were usually 3-dimensional, further investigation is needed to determine the effect of LLLT on crater depth, as well as its influence on the various phases of tooth movement.

CONCLUSION:

The duration of the study was 4 weeks; hence, results and conclusion should be interpreted with caution. LLLT seems promising in preventing or reducing orthodontic root resorption during the initial stages of orthodontic force application. There was significantly less root resorption crater volume on the experimental side compared to the control side, indicating either possible prevention or induction of root repair in patients susceptible to root resorption. However, further research is required with patients undergoing a full course of orthodontic treatment and LLLT application.

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