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Efficiency of the diode laser in preventing orthodontic induced pain in Sulaimani city: *In vivo*, comparative study.

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Abstract

Objective: This clinical study was conducted to assess the efficiency of diode lasers (940 nm) in preventing orthodontic induced pain. Orthodontic induced pain acts as a barrier for orthodontic therapy, Painless procedures ensure patient satisfaction toward orthodontics which subsequently, improves the quality of oral health.

Materials and methods: One hundred twenty orthodontic patients were included and randomly allocated into 4 equal groups (Study, Laser-Placebo, Analgesic, and control groups). A laser beam was applied in contact mode for 1 min duration on the study group. Pain experience was evaluated using a standardized self-administered questionnaire following the Universal Pain Assessment Tool guidelines. Data were analyzed using the statistical package for the social sciences (V. 22).

Results: The highest level of pain was experienced at the second day after arch-wire insertion. At the third day a radical decline in pain sensation was observed in the study group, with maximum pain relief at the fourth day, the difference being considered statistically significant at P value ≤ 0.05.

Conclusion: The application of Laser therapy was found to be more effective in subsiding orthodontic induced pain than analgesics, taking into consideration the pharmaceutical side effects of analgesics.

Keywords: Diode Laser, Orthodontic pain, Placebo, Analgesics.

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Introduction

Despite the advantageous aspect of orthodontic therapy, the treatment has concurrent complications and numerous pathological and iatrogenic risks such as caries development, root resorption, gingival problems, allergic reactions, systemic effects, and tooth structure damage during brackets and adhesive removal [1-3], with pain and discomfort being the most prevalent disturbing features [4-6].

Pain sensation is subjective and varies among individuals; it depends on age, gender, the magnitude of the applied force, pain threshold of the individual, psychological state and stress, cultural differences, and other factors [6-9]. The severity of orthodontic pain sensation varies from a tolerable sensation of pressure to an extensive unbearable painful sensation, which could be felt soon after force application [10] or within the next couple of days after insertion of the arch-wires [11,12], peaking at 24 h and decreasing to the minimum level by the third day [5]. Others proposed that it could persist for up to a week, with noticeable differences in severity each day [12,13].

The severity and duration of the pain are most crucial aspects of orthodontic pain [14]. Researchers and clinicians have emphasized the importance of alleviating dental pain in general, and biomechanical orthodontic pain without medicaments in particular [15-18]. Painless procedures ensure patient satisfaction toward orthodontics and improve the quality of oral health [19,20].

Laser therapy as a novel technology has been introduced to the field of dentistry; different Laser modalities can be used in different aspects of dentistry. Orthodontic tooth movement is facilitated by a bone remodeling process that involves osteoclastic bone resorption at the pressure site and osteoblastic bone deposition at the tension site of the targeted tooth. Prostaglandins E (PGE), especially PGE1 and PGE2, act as mediators for bone resorption; this biological process is usually associated with an unpleasant sensation of pain [21]. Giannopoulou et al. stated that occurrence of pain at the second post-insertion day of orthodontic force is related to increased level of Interleukin-1 [22].

Pulpal tissue can be irritated by orthodontic tooth movement that induces pain [14,23-25]. However, the direct application of orthodontic force Low level Laser irradiation inhibits the nerve conduction of C-Fibers of the pulp, stimulates the release of Endorphins and Serotonin, increases oxygenation and lymphatic drainage, and causes a decrease of prostaglandin E2 and cyclooxygenase-2 levels which in turn leads to analgesia [26,27].

The aim of this clinical study is to assess the efficiency of diode lasers (940 nm) in preventing orthodontic induced pain.

Materials and Methods

The sample

The sample of this clinical comparative, *in vivo* study consisted of 120 orthodontic patients who attended the orthodontic unit at one of the following hospitals: The dental department of Faruk Medical City (FMC), the specialized dental center of B and R in Sulaimani city, Piramerd center for dental specialties, and Shorsh dental center. The data collection period lasted almost two years, among patients suffering from malocclusion which needed to be treated with fixed orthodontic therapy.

Patients of both genders and in the age range 17-25 yr who had just received the first arch-wire (a round super elastic square shaped nitinol arch-wire, gauge 0.014 inch in diameter, 3M Company, USA) were included in the research.

All the cases were treated by a specialized orthodontist using straight wire technique (Roth technique) and Unitek Gemini 0.22 inch slot metal brackets. No tooth extraction was performed (Non-Extraction cases) and all brackets were engaged with the arch-wire using an elastic ligature.

Ethical considerations

This research was done in accordance with World Medical Association Declaration of Helsinki for medical research involving human subjects. In addition to an approval from the ethical committee of the medical colleges at the University of Sulaimani (registration No. 183). Moreover, every patient or care givers of underage patients (less than 18 yr) was informed about the clinical procedures and the purpose of the study before he/she signed on a consent form (written in his/her language).

The procedure

After thorough examination and diagnosis of the cases, the degree of anterior segment teeth crowding was measured with a sensitive digital Vernier caliper using a study cast for each patient. Patients with less than 6 mm crowding in the anterior segment were selected, which resulted in a total of 126 patients being nominated for the procedure, of whom six were excluded for not satisfying the inclusion criteria. The rest of the patients (120 Patients) were randomly allocated into one of the following four groups:

I. Group One (G1): Laser group, which was the study group, comprising 30 patients receiving fixed orthodontic appliance and Laser therapy. As a matter of standardization, to avoid bias, the laser beam was applied on a separate group of patients in the present study to exclude any effect of the laser on non-irradiated oral tissues of the targeted patients.

II. Group Two (G2): Laser-Placebo group, comprising 30 patients who received fixed orthodontic appliance and a pseudo-laser application with similar settings but without laser emission.

III. Group Three (G3): Analgesic group, in which 30 orthodontic patients were advised to take analgesic tablets (Ibuprofen tablets, 500 mg or Mefenamic acid tablets, 500 mg) as prescribed by the researcher (Orthodontist) for relieving the induced pain.

IV. Group Four (G4): Control group of 30 patients who received fixed orthodontic appliance without any Laser, Pseudo-laser application or analgesics unless the pain was intolerable.

Pain scores

Pain intensity was evaluated in all four groups using The Universal Pain Assessment Tool which is a 100 mm, horizontal visual analogue scale (VAS) with scores ranging from zero to ten in degree of severity, Zero for no pain sensation

The scores and emotions regarding the scale were clarified for the patients in their own language (Kurdish and Arabic), then each patient was asked to mark the most suitable score to express his/her feeling on the particular day. This process started on the day of the arch-wire insertion and continued on the three subsequent post-insertion days; since this tool is available for free use, no permission was needed for re-use.

Laser application

Laser application with a portable Diode laser device (Class IV; Wavelength 940 nm; Maximum power output 10 Watt; Power mode CW, Pulsed; Tip diameter 200, 300, 400 µm; pulse duration 0.01 to 20 ms) was started immediately after insertion of the first arch wire for the study 7 group (G1) by one operator, following the various precautions and safety measures mentioned in the Academy of Laser Dentistry guidelines (Laser Safety in the Dental Office by ALD, 2016).

The laser beam was applied on the labial surface of mucosa overlying the root of each tooth with the arch wire. Each selected area was exposed to laser irradiation with impulse power of 10 W and frequency of 60 Hz for 1 min (set by a digital timer) using a 5 mm nozzle in contact mode of irradiation. For the Laser-placebo group (G2) a simulated procedure was followed in the patient's mouth but without any laser application. Patients of these two groups were advised not to take any pain relieving drugs during the course of the study unless the pain became intolerable. Orthodontic treatment continued with the third group (Analgesic group) and the patients were advised to take analgesic tablets (Ibuprofen, 500 mg or Mefenamic acid tablets, 500 mg) according to each patient`s medical status for controlling the orthodontic induced pain in a systematic way. Patients in the last group (Control group) did not receive any laser irradiation, laser simulated procedure, or any analgesic drugs.

Statistical analysis

All recorded data were processed with a statistical analyzer, using the statistical package for the social sciences (SPSS, V. 22), with P values equal to or less than 0.05 considered

statistically significant. Analysis of Variance (ANOVA) was utilized to identify any significant differences in pain scores among the groups in addition to the Least Significant Difference test (LSD) to find out the difference between any two particular groups among the studied groups, while Student's t-test was used to compare the difference between the genders.

Results

Descriptive analysis

Descriptive analysis is shown in Table 1.

Inferential analysis

Table 2 shows the distribution of pain scores throughout the course of the study. In general, it is evident that in the third day the pain scores of G1 and G3 decreased (positive sign of the mean difference) compared to the first day, while the G2 and G4 readings were still higher than those for day one. The differences between G2 and G1, G2 and G3 were significant ($p<0.001$). Significant differences were also detected between G4 and G1, and G4 and G3 ($P<0.001$).

Table 1. *Distribution of the sample according to gender and type of therapy.*

Study groups	Males	Females	Total
Laser group	14	16	30
	46.70%	53.30%	100%
Laser-placebo group	13	17	30
	43.30%	56.70%	100%
Analgesic group	11	19	30
	36.70%	63.30%	100%
Control group	14	16	30
	46.70%	53.30%	100%
Total	52	68	120
	43.30%	56.70%	100%

Table 2. *Mean differences in pain scores (comparing first day scores with second, third, and fourth days) across the four study groups.*

	Study Groups	N	Mean VAS	SD	P (ANOVA)	LSD (Groups)	P (LSD)
Difference in pain scores between 1st and 2nd day	Laser. G1	30	-0.2	1.243		G 1 × G2	<0.001
	Laser-Placebo. G2	30	-3.3	1.803		G1 × G3	0.075
	Analgesic. G3	30	-1.1	2.412	<0.001	G1 × G4	<0.001
	Control. G4	30	-3.533	2.113		G2 × G3	<0.001
	Total	120	-2.033	2.39		G2 × G4	0.642
						G3 × G4	<0.001
Difference in pain scores between 1st and 3rd day	Laser. G1	30	1.267	1.363		G 1 × G2	<0.001
	Laser-Placebo. G2	30	-2.1	2.426		G1 × G3	0.107
	Analgesic. G3	30	0.467	1.961	<0.001	G1 × G4	<0.001
	Control. G4	30	-1.3	1.725		G2 × G3	<0.001
	Total	120	-0.417	2.318		G2 × G4	0.107
						G3 × G4	<0.001
Difference in pain scores between 1st and 4th day	Laser. G1	30	1.9	1.373		G 1 × G2	0.09
	Laser-Placebo. G2	30	1.133	1.795		G1 × G3	0.065
	Analgesic. G3	30	1.067	1.999	0.033	G1 × G4	0.004
	Control. G4	30	0.567	1.716		G2 × G3	0.882
	Total	120	1.167	1.779		G2 × G4	0.209
						G3 × G4	0.267

G: Group; LSD: Least Significant Difference; N: Number; P: Calculated Probability

In day 4, when compared to day one, the highest decrease in the mean pain score was in G1 (1.90), while the lowest was in G4 (0.567), and the difference between G1 and G4 was significant ($p=0.004$). All inter-group differences for the whole study period (day one through today four) are clarified in Table 2. Males and females were exposed similarly to laser

irradiation in regards to: power, duration, and exposure mode. No significant gender differences were found during the study period (Table 3).

Table 3. Gender differences among the laser group.

Difference in pain scores/ days	Gender	N	Mean	Std. Deviation	P t-test
1st-2nd	Male	14	-0.5	1.16024	0.222
	Female	16	0.0625	1.28938	
1st-3rd	Male	14	1	1.1767	0.325
	Female	16	1.5	1.50555	
1st-4th	Male	14	1.4286	1.15787	0.078
	Female	16	2.3125	1.4477	

N Number of patients

Discussion

This comparative study was conducted to assess the efficiency of the Diode laser (940 nm) in prevention of orthodontic induced pain, in relation to which numerous previous attempts have been made to overcome or reduce concurrent orthodontic pain in regards to its severity and/or duration using medicaments, various laser modalities, and wafer bites [28-32]. Within the four studied groups, 88.34% patients developed varying degrees of pain at the first day, and the ratio spontaneously rose to more than 99% twenty four h later in accordance with the results observed by [32,33]. A slight elevation in intensity of the pain sensation (Mild degree, 2.26) was observed immediately after wire insertion. These results confirmed that this limited elevation in pain sensation soon after wire insertion, recording a 2.26 score (Mild pain), without doubt is related to the mechanical force applied on the teeth by the arch-wire, which is in agreement with other findings [5,10,34,35]. Twenty four h later, the pain reached the peak value of intensity, especially at masticatory time, a similar finding was recorded by Polat et al. [36]. No patient recorded the uppermost score on the scale, which might be due to the subjective nature of the pain, or the type of arch-wire, or the degree of the crowding not inducing pain up to this level.

Nonsteroidal anti-inflammatory drugs (NSAID) are the painkiller of choice for inflammatory orthodontic pain [37]. In this study, patients in the analgesic group reported low pain scores compared to those in the laser-placebo and control groups. NSAID emulated the action of the laser from the analgesia point of view (0.8, 0.7, and 0.73 difference in mean scores across the whole sample at the 2nd, 3rd, and 4th day of the study respectively), whereas the laser was found to be the most effective treatment, taking into consideration the relatively powerful analgesic effect and minimal adverse biological effects on oral and extra-oral tissues; a finding which is agreement with the study done by Bayani et al. [32]. However, Farzanegan et al. [35] recommended both chewing gum and viscoelastic bite wafers as suitable substitutes for Ibuprofen. The pain gradually subsided with time until it reached the minimum level on the last day, in line with the findings of several other researchers [5,10,34,35]. Laser application was found to be the most effective therapeutic regimen in terms of statistically significant difference, as concluded by He et al. [38] in a systematic review and meta-analysis conducted in 2013, while in contrast with the results of Lim et al. [39,40].

Conclusion

No significant gender differences were found in the laser group regarding pain alleviation per time, from which it can be interpreted that laser therapy affects both genders equally.

In conclusion, Laser application with Diode laser (940 nm) is a preferable means of controlling orthodontic induced pain over Non-Steroidal Anti-inflammatory Drugs (NSAID), taking into consideration the pharmaceutical side effects of drugs, and the relative power and ease of application of the laser.

These authors contributed equally to this work.

Conflict of Interest

None

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