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Research Article

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Impact of Laser and Ultrasound on Pain Intensity and Enamel Surface During Orthodontic Debonding (A Randomized Clinical Trial)

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Abstract

Introduction

Orthodontic debonding procedures usually involve pain and discomfort. The purpose of this in vivo study was to evaluate the effectiveness of laser and ultrasound on pain management during orthodontic debonding along with its effect on the enamel surface.

Materials and Methods

42 patients referred for orthodontic treatment at the Department of Orthodontics, University of Hama, were recruited. After finishing treatment, a randomized debonding was accomplished with one of three methods: group 1 (control group): bracket removing plier (KP-013-135-PMK ,CHIFA ,Germany); group 2: Er:YAG laser (Pluser, Doctor Smile, Italy); group 3: ultrasonic scalar (Woodpecker, UDS-J ,China) (n=14). The pain intensity was evaluated using numeric rating scale (NRS), and the amount of adhesive remnant was determined by The Adhesive Remnant Index (ARI). Data were subjected to analysis of variance (ANOVA) and Bonferroni test.

Results

The highest NRS values was observed with group 1 (3.86 ± 1.46), whereas the lowest values were recorded with group 2 (1.64 ± 1.15). Debonding brackets using Er:YAG laser produced significant lower pain intensity compared to plier and ultrasonic scalar (P < 0.05). The ARI values recorded for group 1 were significantly higher than those of two other groups (p<0.05), while there were no statistically significant differences between group 2 and group 3.

Conclusion

Debonding orthodontic bracket with Er: YAG laser reduce the pain intensity and discomfort. Additionally, Er: YAG laser appears as an alternative method to reduce the adhesive remnants were left on the tooth surface.

Keywords: Er: YAG - Ultrasonic Scalar - Orthodontic Debonding - Adhesive Remnant - Pain Intensity

1. Introduction

Orthodontic debonding procedures usually involve pain and discomfort and up to 95% of patients experienced pain during orthodontic debonding [1]. Debonding procedure should be harmless, painless and quick [2]. Various methods applied to minimize pain during orthodontic debonding like the use of different orthodontic instruments, laser application, analgesics, ultrasound, adjunctive procedures, or thermal heating the orthodontic adhesives [3-5].

On the other hand, after orthodontic brackets debonding, the residual adhesive must be mechanically removed, since resin remnants accumulate dental plaque and might discolor [6]. This process may be led to cracks and fractures in the enamel surface, and it increases the risk of caries and pulp inflammation [7].

According to previous study; mechanical methods, ultrasonic scalars, and laser are used to remove brackets [8,9]. However, the mechanical removal methods are most widely used in clinical practice [10]. Literature reported the safety and cost-effectiveness of debonding brackets using ultrasonic technique [11]. However, the significant increase in debonding time remained one of the shortcomings [12]. Laser irradiation of brackets have been evaluated in several studies [11]. Erbium-doped yttrium aluminum garnet (Er:YAG) showed success over others lasers such as carbon dioxide (CO_2); because of the ability to be directly absorbed by the adhesive resin without detrimental consequences on the pulpal tissues [13,14].

Previous studies fail to compare the effect of different debonding methods on pain management using randomization [5]. In 2019 a systematic review revealed that there is weak evidence on different pain management methods like use of laser and ultrasound on pain perception during orthodontic debonding [15].

During orthodontic debonding, it is important to select the correct method that will not cause a harmful effect to the enamel and provide painless debonding to the patients as much as possible. In view of this concern, the purpose of this in vivo study was to evaluate the effectiveness of laser and ultrasound on pain management during orthodontic debonding along with its effect on the enamel surface.

The null hypotheses of this study: There were no significant differences in (1) pain intensity and (2) enamel surface among different debonding methods.

2. Methods

This study was approved by the Research Ethics Committee of the Faculty of Dentistry – University of Hama, Hama, Syrian Arab Republic. Written consent was obtained from the patients prior to participation.

3. Sample Size and Patient Selection

Sample size estimation was calculated using power and sample size calculation computer software (G*Power 3.1.9.7 software, USA). At $\alpha=0.05$ and with a power of 0.95, a minimum of 14 patients per group was required.

Consecutive patients referred for orthodontic treatment at the Department of Orthodontics, University of Hama, were recruited. All experimental phases took place in this center. Information was collected by administering specific surveys to each patient, who subsequently underwent a clinical and radiographical dental examination performed by the same operator to determine eligibility (figure 1 and 2).

Figure 1: Clinical dental examination for patient

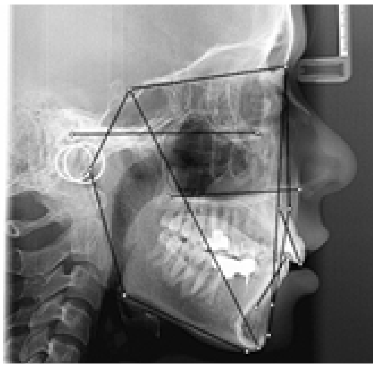

Figure 2: Radiographical dental examination for patient

Inclusion criteria for the experimental groups were: Patients aged 18-35 years, appears of sound upper anterior teeth, good oral health, no craniofacial deformities that would affect dentoalveolar bone quality.

4. Interventions

Victory MBT brackets (3M Unitek, Monrovia, CA, USA) were bonded in each patient at the beginning of orthodontic treatment with Transbond XT primer and resin (3M Unitek). After finishing treatment with present a 0.017×0.025-inch stainless steel finishing arch wires, a randomized debonding was accomplished with one of three methods: group 1 (control group): bracket removing plier (KP-013-135-PMK ,CHIFA ,Germany); group 2: Er:YAG laser (Pluser, Doctor Smile, Italy); group 3: ultrasonic scalar (Woodpecker, UDS-J ,China).

5. Debonding Techniques

- Group 1 (control group): the blades of pliers were placed between the wings and base of the bracket (wings model) (figure 3).
- Group 2 (Er: YAG): Er: YAG laser with a 2940 nm wavelength, power of 4 W, energy of 200 mJ, frequency of 20 Hz, pulse duration of 300 µs, tip diameter of 0.8 mm, air/fluid cooling of 3.5 mL/s, and illumination time of 6s (figure 4).
- Group 3 (ultrasonic scalar): the ultrasonic scalar was used by Cavitron 2002 (Dentsply Equipment Division, Long Island, N. Y.) at maximum power under water spray. The scalar tip was placed between the bracket and adhesive to avoid damage to the enamel (figure 5).

Figure 3: Debonding brackets with pliers

Figure 4: Er: YAG laser devise

Figure 5: Debonding brackets with ultrasonic scalar

Just after debonding the brackets, the buccal enamel surface of anterior upper teeth was evaluated visually (figure 6), and photos were taken by digital camera and transferred to computer software photoshop, to determine the amount of adhesive remnant using The Adhesive Remnant Index (ARI) as follow:

- Score one: Indicated absence of composite remnants on the enamel surface.
- Score two: Less than 50% of composite remaining on the enamel surface.
- Score three: More than 50% of composite remaining on the enamel surface.
- Score four: The entire composite remained on the enamel surface with a clear impression of the bracket base on the remaining composite.

Figure 6: the amount of adhesive remnant (ARI) after debonding the brackets

With regard of pain intensity, A numeric rating scale (NRS) was used to assess pain intensity just after debonding (figure 7). This scale was composed of a centimeter ruler; the number 0 indicates no pain whereas number 10 indicates severe intolerable pain. Before debonding, each patient was instructed about the study objectives and explained that at the end of debonding, it would be necessary to assess the pain intensity of the procedure using an NRS.

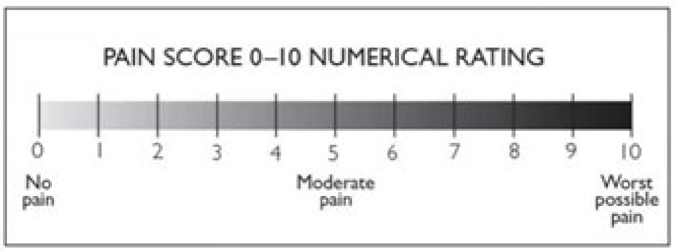

Figure 7: numeric rating scale.

6. Statistical Analysis

Data obtained were coded and transferred to MS-excel sheet. The data were verified and analyzed statistically using software IBM SPSS version 25 (SPSS, Inc., Chicago, IL, USA) with confidence level set at 95% ($p<0.05$) to test for significance. Data were descriptively analyzed. Normality of the data was tested using Kolmogorov–Smirnov and showed normally distributed. The one-way analysis of variance (ANOVA) was used for studying significance among groups. Statistically significant interactions were followed up with post hoc analyzes (Bonferroni test).

7. Results

7.1 Evaluation of Pain Intensity among Three Techniques

Table 1 and (figure 8) show the means and standard deviations of NRS values. The ANOVA comparing the pain intensity of debonding in the three groups indicated that significant differences were present between the three debonding techniques ($F = 9.33$, $p = 0.000$). The highest values of NRS were recorded with control group, while group 3 exhibited the lowest mean values. The results of Bonferroni test showed that no statistically significant differences between group 1 and group 2. A statistically significant difference was found between group 3 and two other groups.

Groups	n	means	standard deviations
Group 1	14	3.86	1.46
Group 2	14	1.64	1.15
Group 3	14	3.00	1.47

Table 1: Means and standard deviations of NRS values for each group

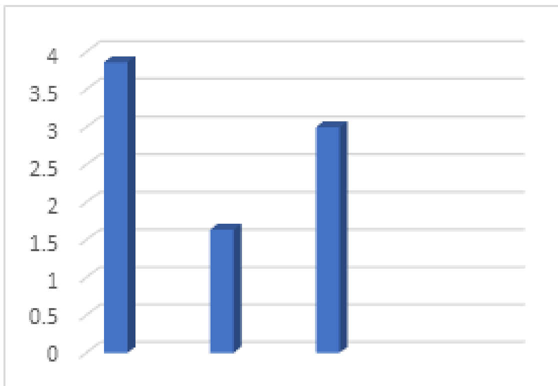

Figure 8: Results of NRS Index for the experimental groups

8. Evaluation of Enamel Surface with Three Techniques

The means and standard deviations of ARI values of the adhesive remnant were listed in Table 1 (figure 9). The analysis of variance (ANOVA) indicated a significant difference in the total amount of adhesive remnant among the three groups compared ($F = 12.90$, $p < 0.05$). The teeth in group 1 had the greatest amount of adhesive remnant after debonding with pliers, whereas debonding with Er:YAG laser exhibited the lowest mean values in adhesive remnant.

Groups	n	means	standard deviations
Group 1	14	2.71	0.83
Group 2	14	1.43	0.51
Group 3	14	1.79	0.70

Table 2: Means and standard deviations of ARI values for each group

According to the results of Bonferroni test, the ARI values recorded for group 1 were significantly higher than those of two other groups ($p<0.05$), while there were no statistically significant differences between group 2 and group 3.

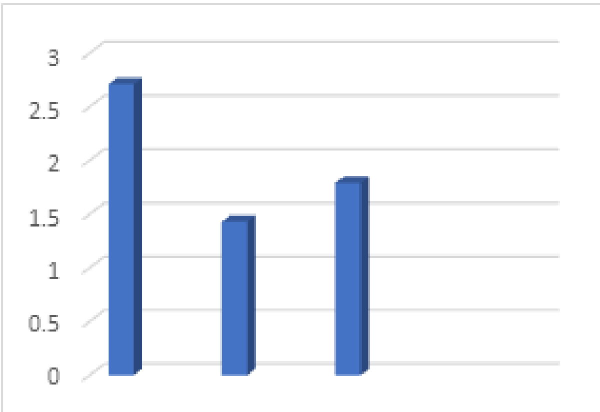

Figure 9: Results of ARI Index for the experimental groups

9. Discussion

This study was designed to evaluate the efficacy of different pain control methods which can be used for debonding of orthodontic brackets with minimal discomfort. Results of intergroup evaluation showed that the patients in laser group perceived significantly lesser pain during debonding than the patients in control and ultrasound group. So, it can be said that laser method was a better method of pain control when compared to the control and ultrasound method. The first null hypothesis has been partially rejected that there were no significant differences in pain intensity among different debonding methods.

Taking into consideration the adhesive remnants, the results of our study showed that maximum ARI scores were recorded in the control group followed by ultrasound group, whereas least ARI scores were recorded in laser group. In this respect, the second null hypothesis has been rejected.

In present times, orthodontic treatment is highly sought by patients of all ages. The most common orthodontic treatment consists in bonding brackets or other attachments to dental structures to move teeth [16]. When the active orthodontic treatment is finished, the brackets used are de-bonded and all adhesive remnants should also be removed [17]. Studies demonstrated that the mechanical debonding procedures can cause pain and discomfort for the patients [18]. Also, no mechanical technique available to the practitioners allows debonding without any damage whatsoever to the enamel surface [19]. With the development of technology, alternative techniques for orthodontic bracket removal have been tested.

Laser energy helps remove the adhesive resin from the tooth surface in three ways: thermal softening, thermal ablation and photoablation. thermal ablation was used in current study which means that the temperature of the adhesive resin rapidly increases, and the substrate is blown off the surface of the enamel prior to the occurrence of thermal softening [20]. Despite the effectiveness of this method, it also presents some inconveniences such as the occasional diffusion of the heat to the tooth structure, which can lead to pulpal damage [21]. To avoid this potential damage air/fluid cooling of 3.5 mL/s was used in current study, in accordance with Olek et al who suggested that the use of Er: YAG lasers together with water cooling seems to represent a safer option for reducing the chance of intrapulpal temperature increases [22].

Debonding procedures of orthodontic attachments using laser-technology are especially, but not exclusively, used by Er: YAG lasers in scanning mode which decreases the shear bond strength [23]. Er: YAG laser was used to debonding in current study because of its some advantages such as water/air concentration, power, used energy, frequency, time, and irradiation method is essential in protecting the integrity of the enamel surface and preventing the increase of temperature in the intrapulpal chamber beyond the acceptable thresholds [24]. Additionally, the ultrasonic debonding technique, which was originally developed for removing cast metal, bridge retainers, has also been found to be useful in removing metal and ceramic orthodontic brackets. No brackets broke when using the ultrasonic instrument to remove them, whereas 10% to 35% broke when using a pliers [25].

The location of the tooth has an impact on the degree of pain, being the debonding of incisors more painful than that of posterior teeth [5,26].This phenomenon may be related with the tactile sensory threshold, since this threshold is about 1 gram in the anterior portion of the dentition in normal subjects and gradually increases toward the posterior segment, ranging from 5 to 10 gram [27]. So that, this study was designed to evaluate the pain intensity of anterior teeth directly. Various scales are used to quantify the pain intensity of the patient like visual analog scale (VAS), numeric rating scale (NRS) and verbal rating scale (VRS). Comparative studies regarding these scales showed no statistically significant difference among them [28]. In this study, NRS was used because of its ease of application.

In the current study, the mean value of the pain intensity was affected by various debonding techniques. Our results indicate the NRS values recorded with the Er: YAG laser were significantly lower than that observed with the control group or ultrasonic scalar. NRS values of ultrasonic group were no significantly lower than control group, may be due to the force required to remove brackets with the ultrasonic scalar in the present study was reduced compared with the application of plier. These results disagreed with the work of Khan et al [29]. who compared the ultrasonic/sonic instruments with the debonding plier and concluded that although sonic/ultrasonic based debonding technique is less painful approach.

The results of current study agreed with some previous works which showed that the use of laser technology in orthodontics can improve pain management during orthodontic debonding [30-32]. However, the patients still feel discomfort during debonding with Er: YAG laser may be due to the increase in temperature within the pulp chamber.

On the other hand, the main purpose of debonding orthodontic brackets by lasers is to protect the enamel topography and to reduce the enamel damage compared to conventional manual debonding [24]. Control group showed a high score (2.71) of ARI, some of which were extended apical and incisal to the bracket area, as described also by Dumbryte [33]. The results of the present study showed that the ultrasound reduced the shear strength of brackets, the results agree with other studies where the use of ultrasound to remove brackets was reported as satisfactory and considered a very feasible option [34]. In the current study, the ultrasonic scalar is applied parallel to the enamel surface and the base of the bracket, resulting a higher incidence of failures in the enamel–adhesive interface and allowing a significantly smaller amount of adhesive to remain on the enamel surface than control group.

In the Er: YAG laser of the present study, most of the brackets were de-bonded at the adhesive-enamel interface. therefore, lower adhesive remnants were left on the tooth surface. In contrast, Yassaei et al performed a study on ceramic bracket debonding using a diode laser and reported no significant difference between the lased samples and the samples de-bonded conventionally with regard to the ARI [35].

This study has some limitations. Molars were not evaluated because attachments thereon may vary according to patients' treatment needs and orthodontists' preference. Patients' attitudes toward pain can also depend on varied conditions such as cultural background, gender and personal traits.

Further studies should be performed to provide clear indication that only one type of laser would be significantly a better or safer choice for the procedure of orthodontic bracket removal.

10. Conclusion

Under the limitations of the present study, it may be concluded that:

1. Debonding orthodontic bracket with Er: YAG laser reduce the pain intensity and discomfort.
2. Er: YAG laser appears as an alternative method to reduce the adhesive remnants were left on the tooth surface.

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