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EFFECT OF DIODE LASER ON DEBONDING OF ORTHODONTIC CERAMIC BRACKET (IN VITRO STUDY)

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KEYWORDS

Adhesive remnant index, ceramic brackets, diode laser, Intra pulpal temperature, Shear Bond Strength.

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ABSTRACT

Introduction: Ceramic brackets are tough to be removed. Consequently, their removal becomes more difficult and time-consuming to run an orthodontic office, and risky, since enamel may be damaged. The adoption of novel debonding processes for ceramic brackets is intended to limit the danger of damaging the enamel structure. Ceramic bracket's and enamel's bonding compound may be weakened by laser, allowing brackets to be removed without injuring the enamel. However, the temperature of the tooth surface may be raised by using laser, in particular. To weaken the link between the bracket and the enamel without permanently damaging it harming the pulp, the appropriate laser's output power and time of application must be determined. **Aim:** To see how effective a 940-nm diode laser was at debonding ceramic brackets. **Materials and Methods**: Sixty-six premolar teeth were fitted with ceramic brackets come in two styles (monocrystalline and polycrystalline). Brackets in the experimental groups were treated with a diode laser. Shear bond strength and heat effects on the pulp chamber were tested at two laser energy levels: 2W and 5W. ANOVA analysis was used. **Results:** Polycrystalline brackets rendered the diode laser ineffectual radiated by 2W and effective with polycrystalline brackets radiated at 5W in considerably (P≤0.05) decreasing shear bond strength; and efficient in decreasing shear bond strength in monocrystalline brackets (P≤ 0.05). There were no significant differences in the adhesive remnant index comparing the adhesive remnants of the groups studied. There was significant increase in intrapulpal t temperature but beyond the critical temperature elevation 5.5 C. **Conclusion:** Diode laser reduced both the critical pulp temperature and the debonding force required for monocrystalline brackets and polycrystalline brackets radiated by the 5W laser.

INTRODUCTION

Among orthodontic equipment, ceramic brackets provide the greatest cosmetic outcome. Due to the high adhesion between the base and the fixing composite[(1)]. It is tough to remove ceramic brackets. Unfortunately, ceramic brackets are brittle and can break due to the poor ductility and high modulus of the alumina crystals that make them up [(2)]. As a result, removing them in an orthodontic clinic becomes more difficult, time-consuming, and risky, with the possibility of damaging the enamel structure [(3)]. The adoption of novel debonding processes for ceramic brackets is intended to limit the danger of damaging the enamel structure. The bonding compound between the ceramic bracket and the enamel may be weakened by laser, allowing brackets to be removed without injuring the enamel. However, the temperature of the tooth surface may be raised by using this laser. Professionals have employed a variety of regimens with laser potencies ranging from 3 to 20W and application times ranging from 2 to 6 seconds. To lessen the bonding strength between the bracket and the enamel without permanently harming the pulp, the appropriate output power and application time of this laser must be determined [4].

RESEARCH METHOD AND MATERIALS

This research was carried out in Faculty of Dentistry, Suez Canal University after approval of the ethical committee. Sixty-six freshly extracted human premolar teeth which were extracted for orthodontics reasons. In this study, two types of Orthodontic Ceramic premolar brackets were used:

- Thirty-three clear polycrystalline ceramic brackets (DIAMONDLINK TM; MATT Orthodontics, LLC Chicago, IL USA) were used. These samples were divided equally into three different subgroups as follow:

Group I: The first group was a control group consisted of eleven teeth that were not receiving laser irradiation

Group II: it was a test group consisted of eleven teeth that were irradiated by 2W diode laser for 3 sec.

Group III: it was a test group consisted of eleven teeth that were irradiated by 5W diode laser for 3 sec.

- Thirty-three mono crystalline Orthodontic Ceramic Brackets (PERFECT Clear II; HUBIT Orthodontics, Uiwang-si, Korea) were utilized These samples were divided equally into three different subgroups as follows:

Group IV: it was a control group of eleven teeth not receiving laser irradiation.

Group V: it was a test group consisted of eleven teeth that were irradiated by 2W diode laser for 3sec.

Group VI: it was a test group consisted of eleven teeth that were irradiated by 5W diode laser for 3 sec.

All samples were subjected to the following:

1. ***Disinfection and storing:***

   All the teeth were washed and disinfected for a week in a 0.1 percent thymol aqueous solution. After that, they were kept in distilled water in a refrigerator at 4°C.

2. ***Samples divided in six groups.*** Every group contained eleven teeth.

3. ***Mounting in blocks*** of auto-polymerized polymethylmethacrylate (Self cure acryl, Acrostone, Egypt) (2*1.5*1.5 cm) blocks using a standard-sized stamp.

4. ***Cavity preparation on occlusal surface by*** using a water-cooled diamond cutting disc (ceramic; worldwide Diamond instrument, New York, USA) vertically from the occlusal surface to make a hole like access makes in endodontic treatment to be able to insert the K- type thermocouple tip [5].

5. ***Bonding procedure of ceramic brackets:*** For 30 seconds, teeth were engraved with a 37% ortho-phosphoric acid solution, washed for 20 seconds, and dried fully with a mist of air. A light-cured orthodontic composite resin was used on all the teeth, employed to attach the

brackets to the enamel surface. An orthodontic bracket-positioning equipment was used to place all brackets 4 mm from the cusp tip of the teeth. A halogen curing lamp was used to light cure the bracket (Woodpecker RTA Curing Light: 1000 to 1200 W, China) for twenty a second (10 seconds from each proximal side).

6. ***Storing after Bonding:*** To guarantee full polymerization, for more than 24 hours, the teeth were submerged in room temperature water.

7. ***Measuring temperature of buccal intrapulpal wall:***

It was recorded before and during the debonding procedure to calculate the temperature elevation. The thermocouple device was used to record temperature values at tooth surface. It was placed at the wall of the buccal cavity intrapulpal cavity from the time of debonding until the time of bracket debonding. The beginning temperature and the most elevated temperature during the debonding procedure were recorded and the difference between them showed the temperature elevation during the procedure to compare it with the critical temperature increase which is 5.5 c [6].

8. ***Measuring the shear bond strength (SBS) for all specimens:***

Specimens were each inserted separately in a retaining ring in the lower jaw of the TIRA machine (MG89075, Power, MADEN, Turkey) so that the bracket bases were parallel. A shearing force was used perpendicular to the bracket interface. We employed a TIRA machine with a blade operating at a constant speed of 1mm/min to describe the peak of SBS in all groups. As soon as the laser beam was turned off, the blade reached the tooth bracket contact. In the lased groups, it was discovered what the peak shearing bond strength was.

9. ***Recording the quantity of adhesive left behind for all specimens:***

The quantity of remaining adhesive after debonding ceramic brackets was categorized as the Modified Adhesive Remnant Index used according to Mona et al.[7].

On a scale of 1 to 5, the following modified Adhesive Remnant Index was utilized to measure the quantity of leftover adhesive:

Scale: 1 _ The adhesive was completely removed from the tooth.

Scale: 2 _ More than 90% of the adhesive was left on the tooth.

Scale: 3 _ Anything from 10% to 90% of the adhesive remained on the tooth.

Scale: 4 _ Only around 10% of the adhesive remained on the tooth.

Scale: 5 _ There was no adhesive left on the tooth.

Statistical Examination:

Microsoft Excel software was used to code, input, and analyze data obtained during the history, basic clinical examination, laboratory investigations, and outcome measures. The information was then entered into the SPSS is a statistical package for the social sciences (SPSS version 20.0) SPSS (Statistics Software for the Social Sciences) is a social science statistical package. Analytical software the following tests were used to test differences for significance: differences between quantitative independent ANOVA or Kruskal-Wallis tests are used to multiply the results. Followed by LSD or Tamhan's, paired by paired t. P value was set at 0.05 for significant results & 0.001 for highly significant results, according to the type of data.

RESULTS

Table (1) *Shows the distribution of shear bond strength among the groups tested.*

		N	Mean	Std. Deviation	Minimum	Maximum	F	P
SBS	Group I	11	159.9064	52.38621	80.80	300.64	5.428	0.05*
	Group II	11	172.2180	51.02081	111.15	258.03		
	Group III	11	128.4673	42.53007	33.84	237.54		
	Group IV	11	134.6800	43.38325	82.31	228.99		
	Group V	11	134.9650	39.59272	85.54	228.39		
	Group VI	11	60.4578	20.52823	21.16	108.68		

**: Statistically significant at P≤0.05*

SBS was substantially greater in groups I and II than in the other groups. While there was no significant difference between groups I and II, there was a significant difference between groups III and IV.

There was no significant difference between groups III (5 W laser polycrystalline group), IV (the non-lased monocrystalline group) and V (the 2 W laser monocrystalline group). While group VI (the 5 W laser monocrystalline group) was significantly lower than all for significant results, the P value was set at 0.05.

Group II had higher SBS than Group I although it was subjected to 2W laser as the results showed that the 2W laser has no effect on SBS in group II and the difference in statistical numbers given has no significant effect, it may be due to bias. Laser produces thermal energy transmitted to ceramic bracket then reaches the adhesive and softens the adhesive material that facilitates debonding. However, the structure of polycrystalline bracket made it difficult to transmit heat to the adhesive.

Table (2) *Temperature changes (difference between before and after temperature) at each group*

		N	Mean	SD	Minimum	Maximum	Kruskal Wallis	P
Difference in temperature	Group I	11	0.9455	0.43420	0.00	3.00	15.24	0.007*
	Group II	11	0.8855	0.38755	0.00	2.00		
	Group III	11	0.9091	0.50065	0.00	2.00		
	Group IV	11	0.8364	0.40452	0.00	1.00		
	Group V	11	1.1818	0.78165	0.00	4.00		
	Group VI	11	2.0000	1.11421	0.00	5.00		

**: Statistically significant at P≤0.05*

Regarding the temperature changes, the temperature of groups II (2W laser polycrystalline ceramic brackets group), III (5W laser polycrystalline ceramic brackets group), V (2W laser brackets made of monocrystalline ceramic) and VI (5W laser monocrystalline ceramic brackets group) significantly increased while temperature of groups I (non lased polycrystalline ceramic brackets group) and group IV (non lased monocrystalline ceramic brackets group) didn't significantly change Significant results were given a P value of 0.007**.**

Table (3) *Adhesive Remnant Index distribution among groups that were investigated*

		N	Mean	SD	Minimum	Maximum	F	P
ARI	Group I	11	3.6364	0.80904	3.00	5.00	2.074	0.081*
	Group II	11	3.5455	0.82020	2.00	5.00		
	Group III	11	3.7273	0.64667	3.00	5.00		
	Group IV	11	2.5455	0.81356	1.00	5.00		
	Group V	11	2.7273	0.93729	1.00	5.00		
	Group VI	11	3.2727	1.07208	1.00	5.00		

**: Statistically significant at P≤0.05*

Regarding the ARI, there was no significant difference among all groups [group I (non-lased polycrystalline), group II (2W laser polycrystalline), group III (5W laser polycrystalline), group IV (non-lased monocrystalline), group V (2 W laser monocrystalline) and group VI (5W laser monocrystalline). For significant results, the P- value was set at 0.05.

DISCUSSION

In this study, the cavity preparation of teeth was on the occlusal surface not on lingual surface. It was consistent with the study of Sinaee et al.[8], and this was to ensure and facilitate the complete removal of pulp structure which made it difficult to measure the temperature of the buccal intrapulpal wall, so all the pulpal tissue was removed completely.

Regarding the Strength of the Shear Bond:

The results of the present study revealed that the employment of a 5W diode laser for debonding was effective significantly in decreasing the polycrystalline brackets needed debonding force which disagreed with Feldon et el [9]. This may be due to different sample type which was bovine teeth.

The results revealed because of its uniform crystalline structure results in great transmissibility of the bracket and reduces energy loss, a diode laser with 2W or 5W power considerably decreased the binding strength of monocrystalline ceramic brackets (not polycrystalline). This agreed with Azzeh et al.[10], Feldon et al.[9], Almohaimeed and El Halim [11], and Yassaei et al.[12].

Regard the pulp temperature elevation

Results of this study revealed that the pulp temperature was dramatically enhanced 5.5°C after

3 s of laser radiation with either 2W or 5W power, using either polycrystalline or monocrystalline ceramic brackets, which was consistent with the investigations of Feldon et al.[9], and Yassaei et al.[12].

According to the results of Zach and Cohen's[5] investigation, the mean of pulp temperature elevation in this study was bearable. According to their findings, if the pulp temperature rises beyond 5.5°C, 15 percent of the sample teeth would display necrosis. Elevating the pulp temperature to 5.5°C is bearable, according to Serebro et al.[13]. and Goodis et al.[14].

The low absorption coefficient of diode laser in enamel accounts for these observations; hence, the surface energy accumulates and declines rapidly during and after laser exposure, respectively, with no negative effect on the pulp according to Yussif[15]. These results also disagreed with Iijim[16] who looked at the impact on the mechanical characteristics of enamel after CO2 laser debonding of a ceramic bracket This disagreement may be due to using different laser type (CO2 laser).

The diode laser debonding protocol used 2W and 5 W laser outputs for 3 seconds. It appears that the diode laser's mode of action was to give thermal softening of the adhesive. These results agreed with Steffen et al.[17].

Regarding Adhesive Remnant Index

The most common score in each group was score 3 resulted in no statistically significant difference between the groups in terms of ARI Score. After debonding, the adhesive was left on the tooth in all the samples, including an impression of the bracket pad even in the group VI which show low SBS, the ARI was scored 3. Romano et al. [18], Feldon et al.[9], and Yassaei et al. [12] all came to the same conclusion.

These findings contradicted those of Almohaimeed and El Halim [11], who found that the laser diode enhanced ARI Scores. This might be due to differences in the construction of the base of brackets utilized in the two investigations and different laser parameter: 3W power in pulsed mode.

CONCLUSION

1. The use of Diode laser with 5W power, the binding strength of polycrystalline ceramic brackets can be reduced by applying heat for 3 seconds.
2. Debonding of the monocrystalline ceramic bracket appears to be possible using a diode laser with 2W power and 5 W power for 3 seconds.
3. The heat generated by the diode laser, whether it is powered at 2W or 5W for 3 seconds, has no effect significant effect of raising temperature to a temperature difference of 5.5 degrees Celsius
4. Diode laser has no significant on ARI as there are no significant differences between lased or non lased groups.

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