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Efficacy of Er: YAG versus ErCr: YSGG In Metal Brackets Debonding.

Abstract
Introduction*: The principle of safe bracket debonding is to degrade the adhesive resin strength connecting the tooth and the bracket by softening or ablation.of adhesive resin from tooth surface without damaging the enamel. Aim: The aim of this study were to Compare the efficacy of erbium yttrium aluminum garnet (Er:YAG) laser and ErCr;YSGG in debonding on the metal brackets and determination if there are any adhesive remnants on the enamel surface by the stereomicroscope. Methods: Sixty metal brackets were bonded to sixty upper first premolars and they were divided into three groups, Group 1(control) debonded by conventional plier, group 2 debonded by Er:YAG laser and group 3 debonded by Er Cr:YSGG. The Enamel surface were evaluated by stereo microscope for any enamel cracks and damage.Results: Er:YAG 7W laser debond the metal brackets in a shorter time than Er Cr; YSGGandErbium Chromium Yttrium Scandium Gallium Garnet (Er Cr:YSGG) laser (6W and 7W) decreased the enamel damage compared to the Er:YAG laser and the conventional method for Debonding.*
Conclusion: *The Er Cr;YSGG 7 W laser are clinically safer than other groups as it has acceptable chair side time in debonding and less damage on the enamel.*

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I. Introduction

After active orthodontic treatment, brackets are mechanically debonded and residual adhesive must be mechanically removed, since resin remnants accumulate dental plaque which might discolor the enamel surface. Efforts are made to minimize the loss of the enamel external layer, because it is hardest and richest in fluoride.Thus, The principle of safe bracket debonding is to degrade the adhesive resin strength connecting the tooth and the bracket by softening or ablation [(1)].of adhesive resin from tooth surface without damaging the enamel is generally the main problem of this method. Selecting the appropriate laser, resin, and bracket combination can minimize risks and make debonding more efficient [(2-4)].

Laser Radiation in orthodontics is relatively new technique. Lasers help in solving several problems related to orthodontic therapy ranging from mucogingival surgery to enamel surface etching or ceramic and metal bracket debonding. Hard tissue laser application in orthodontics comprises enamel etching, bracket bonding, and debonding. The bonding of brackets on the tooth surface requires penetration of the bonding material into the etched enamel. Etching by laser radiation, mainly Nd: YAG, Er:YAG can produce retentive surface known as micro-irregularities suitable for resin penetration. The last method frequently used is laser debonding after active orthodontic treatment [(5-7)].

In the present study, the efficiency of Eribium doped Yttrium Aluminum Garnet versus Erbium Chromium Yttrium Scandium Gallium Garnet lasers was investigated by assessing the adhesive remnants and the enamel damage[(6-8)].

II. Material And Methods

In this studysixty upper first premolars with intact buccal surface were extracted for orthodontic reason were collected to bond sixty metal brackets on them.

Inclusion criteria

The teeth fulfilled the following criteria**:**

- Freshly extracted first premolars.
- Absence of any enamel facets.
- Free from any visual chipping of enamel.
- Free of caries or white spots as visually inspected and detected with a sharp explorer.
- Free from any visual enamel crack when inspected by trans-illumination.

The samples were divided into three main groups: Group 1 (Control group) contained 12 premolars, group 2 (Er:YAG group) 24 premolars and group 3 (Er Cr;YSGG group) 24 premolars. The laser groups were divided equally each one 12 premolarsto be tested with two different watts (6W and 7W).

Bonding of the brackets

At the time of bonding, the buccal enamel surfaces of the teeth were rinsed and polished by pumice for 10 seconds, washed for 30 seconds and dried for 10 seconds with moisture-free air spray.

The enamel was etched with application of 37% phosphoric acid in the middle third of the buccal surface for 20 seconds then rinsed with water for 30 seconds and air dried for 10 seconds with moisture-free air spray until the enamel showed frosty chalky appearance. The buccal surface was coated with a layer of the adhesive primer and light cured for 10 seconds.Then a sufficient amount of adhesive was applied on the base of the bracket and the bracket was placed onto the middle of the buccal surface along the axis of the crown, and then pressed from its middle to allow for the escape of excess adhesive according to the standard method.The flush material was removed carefully with a sharp explorer and the adhesive was cured for a total of 20 seconds (5 seconds from occlusal, gingival, mesial and the distal) side with a light-emitting diode curing device (LED).
The teeth were mounted in an acrylic base to facilitate the use during laser irradiation. The acrylic bases are differentiated by color coding into pink, blue, yellow and white

Debonding

Debonding of the brackets: Group 1**:** The plier's blades were placed at the bracket base/ enamel interface (inciso-gingival plane) to allow debonding of the brackets**.**Group 2A, 2B: the samples were debonded with Er:YAG (wavelength 2940 nm, rounded end tip 400um) at power output of 6 and 7 W with the repetition rate 20 Hz, 350 M J, water 65% and air 75%. Group 3A, 3B: the samples were debonded with Er Cr;YSGG (wavelength 2780nm, rounded end tip 400um) at a power output of 6 W with the repetition rate 20Hz 300M , water 65% and air 75%.For all the four laser groups, the laser beam was directed on the adhesive parallel to the bracket and guided by the long axis of the tooth and it was applied between the base of the bracket and enamel surface at 1-2 mm distance in a non-contact mode using back and forth motion at the mesial, incisal and distal sides to debond the bracket[(9)].

Evaluation:

1) Microscopic evaluation of the enamel surface was done after debonding.

Adhesive remnant index(ARI)

The enamel was examined under stereomicroscope 30x to quantify the remaining adhesive on enamel surface by the adhesive remnants index (ARI)[9]:Score 0 = no adhesive remaining, Score 1 = less than half of the adhesive remnants on the tooth surface, Score 2 = more than half of the adhesive remnants on the tooth surface and Score 3 = all the adhesive remains on the tooth surface.

Statistical analysis

The collected data were obtained through microscopic observation performed using scanning electron microscope.Data were statistically analyzed by Microsoft Excel ®* 2016 Statistical Package for Social Science (SPSS) ®** Ver. 24[1]. And Minitab[2]*** ® statistical software Ver. 16. A descriptive study was performed to reveal different adhesive remnant index scores and different enamel damage score among different groups including control group using percentage calculation. Then, Chi square and One-way ANOVA followed by Tukey`s post hoc test for multiple comparisons were performed to detect the significance between different groups for each score at level of significance $P \leq 0.05$

III. Results

1) Assessment of ARI between all the five groups

As presented in table (1), comparison was performed between all five groups after debonding using ARI scores. Regarding score (0), with no adhesive remnant observed (fig.1-A) revealed that Erbium lasers at 7W were significantly the highest percentages than the other groups with (66.7%) and (58.4%). Regarding score (1) (fig 1-B); with less than half the adhesive remnants observed,Er:YAG 6W and 7W together with Er Cr;YSGG 6W and 7W were the same (33.3%) and higher than control group (16.7%). Regarding score (2) (Fig.1-C); with more than half the adhesive remnant observed, control group revealed the highest percentage (33.3%) than all other groups. Also score (3) (Fig.1-D) ; with all the adhesive remnants observed, control group revealed the highest percentage (41.7%) than all other groups.

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Table (1) Descriptive and comparative study of enamel surface after debonding (ARI) between all five groups

	Control group		Er: YAG (G2A) 6 W		Er: YAG (G2B) 7 W		Er,Cr; YSGG (G3A) 6W		Er,Cr;YSGG (G3B) 7W		P value
	N	%	N	%	N	%	N	%	N	%	
score 0	1	$8.3^{a\,A}$	5	$41.7^{a\,A}$	8	$66.7^{b\,A}$	4	$33.3^{a\,A}$	7	$58.4^{b\,A}$	0.003*
Score 1	2	$16.7^{a\,A}$	4	$33.3^{a\,A}$	4	$33.3^{a\,A}$	4	33.3^{aA}	4	$33.3^{a\,A}$	0.31 ns
Score 2	4	$33.3^{a\,A}$	2	$16.7^{ab\,A}$	0	$0^{b\,B}$	2	$16.7^{ab\,A}$	1	$8.3^{b\,B}$	0.03*
Score 3	5	$41.7^{a\,A}$	1	$8.3^{ab\,A}$	0	$0^{b\,B}$	2	$16.7^{ab\,A}$	0	$0^{b\,B}$	0.01 *
P- value	0.06 ns		0.06 ns		0.007*		0.33 ns		0.002*		

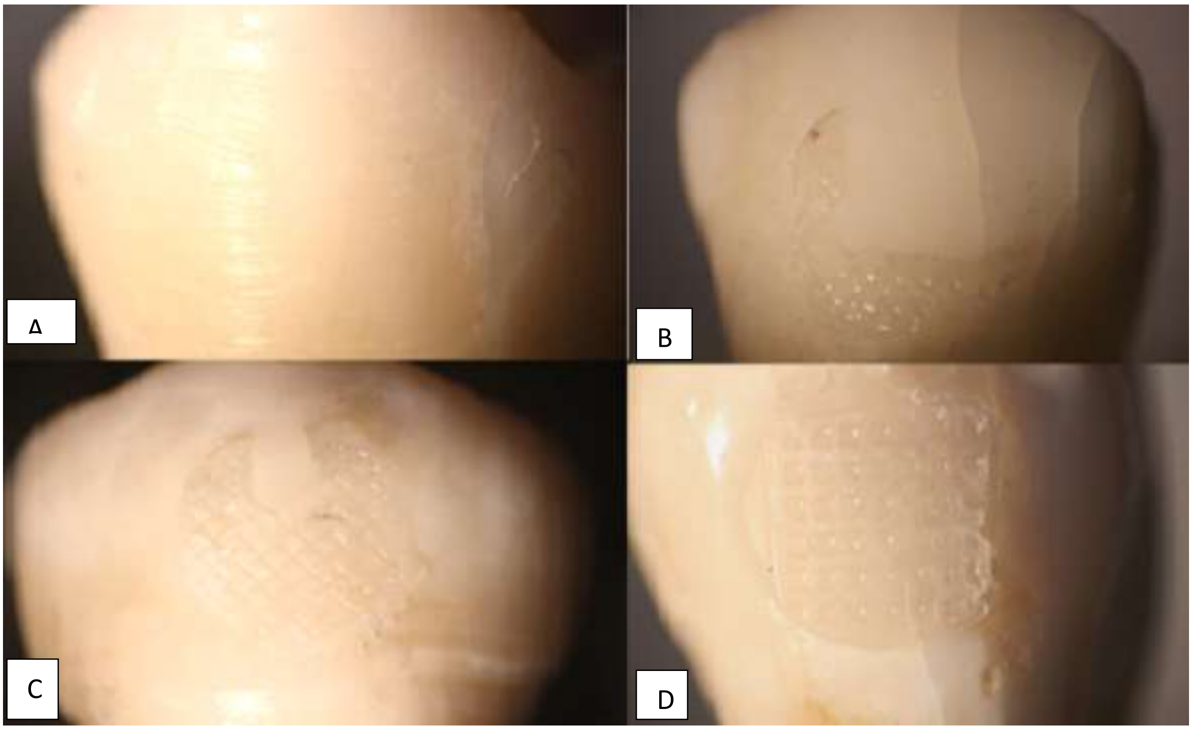

Figure (1): Stereo microscopic image revealing adhesive enamel index on enamel surface after debonding; (A) score 0, (B) score1, (C) score 2, (D) score 3.

IV. Discussion

In this study, laser has been chosen for metal brackets debonding as a promising method to avoid enamel damage. Laser energy has been suggested to decreases shear bond strength by degrading the adhesive resin used to bond the brackets. According to Tocchio et al [10]the mechanism of laser debonding includes thermal softening, thermal ablation or photo ablation. Thermal softening occurs when the laser with low power density irradiate the bracket until the resin softens and the bracket slides off the tooth. However, thermal ablation and photo ablation vaporize the resin when its temperature is raised quickly therefore bracket can be blown off the tooth[11,12].

The present study was designed to compare the efficacy of two types of lasers in debonding the metal brackets; through checking the enamel for any adhesive remnant or any enamel damage after debonding. The scale used for measuring Adhesive remnant index (ARI) was taken from the study of Yapel and quick [9]and. Inthe current study, upper first premolars have been chosen to be the experiment tooth as it is the most frequently extracted teeth in orthodontics with the higher frequency for being sound and free of caries or any cracks, the premolars were kept in distilled water with 1%thymol crystals for disinfection, inhibiting any bacterial growth and preventing enamel dehydration. After bonding they were kept in distilled water for 14 days till debonding to ensure complete polymerization and being hydrated, as dehydration of tooth structure can change the physical properties of enamel. The parameters used in this study followed those used by, Lesniak[4],Sedky and Gutknecht [7]and Habibi and Nik[13]in their studies.

In this study, debonding was done by using thermal ablation which agreed with the work of Tocchio et al and Mandethu et al[11-14]with two types of laser with different energy powers (Er: YAG and Er Cr:YSGG). They have the advantage of direct application of the laser to the resin to enhance the effect of thermal ablation by increasing the laser energy to the resin leading to stronger debonding and less thermal effect on the pulp. Both lasers used in this study were able to debond the brackets without any additional force to remove the bracket. As a result of thermal ablation, the brackets jumped off the teeth which was contradicting with Oztopark [15].Based on the recommendation of Basarana and Ozer[16] regarding a power output of 2.5-6 W for adhesive ablation, the 6 W was selected to be used in the study with two different groups one with the Er:YAG laser and one group with the Er Cr:YSGG. Two different groups with 7 W were added to test a more powerful energy for bracket debonding and to examine the effect of its application on enamel surface.

The results of the study showed that there were significant differences in ARI scores between the control group (G1) and the laser groups (G2, G3). The highest ARI scores were observed in all laser groups with ARI scores 0 and 1 which showed the least adhesive remnant in comparison to the control group that had the highest ARI scores 2 and 3. These findings were consistent with other studies by Sedky andGutknecht[7]and Mundethu et al [14]Both Er: YAG groups (G2A, G2B) had their highest value in score 0 but the percentage in Er: YAG 7W group (66.7%) was significantly higher than Er: YAG 6W (41.7%). Also regarding the ARI score 0 for the two Er Cr: YSGG groups (G3A, G3B), there was a significant difference between the Er Cr; YSGG 6W (33.3%) and Er Cr;YSGG 7W (58.4%).Regarding the ARI scores 2 and 3, the Er Cr;YSGG groups had higher scores than the Er:YAG groups which might be the result of high energy level of the Er:YAG lasers that helped in softening the adhesive on the enamel surface.

V. Conclusion

From the current study, the following was concluded:

- Both Er: YAG and Er Cr: YSGG can effectively debond metal brackets without any additional forces with the used parameters.

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