*ISSN: 1110.435X*

*Egyptian Orthodontic Journal*

# EVALUATION OF DIFFERENT TECHNIQUES FOR DEBONDING OF CERAMIC BRACKETS (AN IN VITRO STUDY)

Ahmed S. Khalil[1] ; Nazla M. Tamish[2]; Ahmed R. Elkalza[3]

***Abstract***

***Objective:*** *To compare different techniques for debonding of ceramic brackets in terms of adhesive remnant index (ARI).*

***Material and methods:*** *A sample of 100 extracted human premolars were randomly and equally allocated into 5 groups of 20. Thereafter, monocrystalline ceramic brackets were bonded to teeth using light cure composite resin. Among the 5 groups; group I: served as control, group II: chemical assisted debonding using peppermint oil, group III: ultrasonic assisted debonding, group IV: diode laser assisted debonding, and group V: Er: YAG laser assisted debonding. Brackets were then debonded using a universal testing machine, followed by ARI assessment.*

***Results:*** *A statistically significant higher ARI scores was found solely in Er:YAG laser assisted debonding. Yet, no significant difference was found with chemical, ultrasonic, and diode laser assisted debonding.*

***Conclusion:*** *Er:YAG laser could be effective for debonding of ceramic brackets. Hence, this method might be recommended to alleviate enamel damage.*

***Keywords:*** *Ceramic brackets, Er:YAG, Diode, Ultrasonic, Chemical.*

## INTRODUCTION

Ceramic brackets were introduced to orthodontics in the mid-1980s as a result of the increased demand of esthetics along with the increased number of adult patients. Compared to metallic brackets, ceramic brackets have lower fracture toughness and higher bond strength.(1) High bond strength has been a clinical challenge, increasing difficulties encountered during debonding including enamel cracks, fractures and tear outs. (2,3)

Various methods have been proposed in attempt to minimize patient discomfort and shift the site of bond failure into bracket-adhesive interface.(4,5) The use of specially designed debonding pliers to apply squeezing force at the bracket base have been developed.(6) However, those pliers often resulted in potential damage to enamel surface and patient discomfort remained an unavoidable side effect.(7,8) Electrothermal debonding technique has been suggested for bracket debonding through controlled application of heat.(9) In turn, this led to thermal softening of the adhesive along with the deformation of bracket-adhesive interface.(10) However, careful attention should be taken as the associated rise of pulp temperature increased the risk of pulpal injury.(11)

Reduction of the risk of tooth fracture, enamel damage and pain sensation that often accompany ceramic brackets debonding is of great concern. There is a lack of studies that compare the effects of chemical, ultrasonic, and laser assisted debonding of ceramic brackets. Finding an optimal method for debonding of ceramic brackets without adverse

[1] Resident, Department of Orthodontics, Faculty of Dentistry, Alexandria University, Alexandria, Egypt.

[2] Professor, Department of Orthodontics, Faculty of Dentistry, Alexandria University, Alexandria, Egypt.

[3] Assistant Professor, Department of Orthodontics, Faculty of Dentistry, Alexandria University, Alexandria,

effects on the enamel surface is crucial.

Hence, the objective of this study was to compare different techniques for debonding ceramic brackets in terms of adhesive remnant index.

## MATERIAL AND METHODS

### Study sample:

The sample size estimate was calculated to be 75 premolars. At a power of 90% and $\alpha$ =0.05, a minimum of 15 teeth per group were required.(12) In order to cater for any damage during the study, 100 sound premolars extracted for orthodontic reasons were collected. randomly allocated into 5 equal groups of 20 each. Teeth were excluded in case of the presence of carious lesion, hypoplastic lesions, restoration, or fracture.

### Sample Allocation:

Each premolar was cleaned with tap water and then stored in 0.9% isotonic saline solution. Specimens were then assigned a number and randomly allocated into one of the 5 groups using Random Allocation Software (Version 1.0) computer software. (13)

### Samples preparation and intervention

### Group I (Control group)

The buccal surface of the teeth was polished using rubber cup with non-fluoridated oil-free pumice and water, then rinsed and dried with oil/moisture-free air spray. Thereafter, etching of the buccal surface of the teeth was done using 37% phosphoric acid (Denfil, Vericom, South Korea) for 30 seconds, rinsed thoroughly with water spray for 20 seconds, and then dried with oil/moisture-free air spray until the enamel had chalky white appearance.

Monocrystalline ceramic brackets (Perfect Clear, Hubit, South Korea) were bonded to the center of the buccal surface using the one step GC Ortho Connect adhesive (GC Ortho Connect, GC Orthodontics, Germany) that incorporates the primer into the paste, then firmly pressed, subjected to a 300g compressive force using a force gauge (Morelli, SP, Brazil) and excess adhesive was removed with a sharp explorer. The adhesive was then light cured with a LED curing light (True dent, Guangzhou, China) for 20 seconds. After the bonding procedure, teeth were stored in distilled water for 24 hours. The roots of the teeth were then embedded in self cure acrylic resin blocks leaving the crown exposed.

### Group II (Chemical assisted debonding)

Teeth were bonded and then mounted using the same technique employed for group I. Peppermint oil (Peppermint Essential Oil, Areej, Egypt) was applied on the mesial, distal, occlusal, and gingival surface of the brackets for 10 minutes.(Fig.1A)

### Group III (Ultrasonic assisted debonding)

Teeth were bonded and then mounted using the same technique employed for group I and II. Ultrasonic tip with full power (Woodpecker, Guilin, China) was applied at the bracket-tooth interface for 12 seconds: 3 seconds on each of the mesial, distal, occlusal, and gingival aspects, with sweeping motion in each direction. (Fig.1B)

### Group IV (Diode laser assisted debonding)

Teeth were bonded and then mounted using the same technique employed for group I, II, and III. Diode laser (Simpler, Doctor Smile, Italy) with continuous mode at a power of 4 W with a wavelength of 980 nm and 300 µm tip diameter, was applied at the bracket-tooth interface for 12 seconds: 3 seconds on each of the mesial, distal, occlusal, and gingival aspects, with sweeping motion in each direction.(Fig.1C)

**Group V (Er:YAG laser assisted debonding)**

Teeth were bonded and then mounted using the same technique employed for group I, II, III, and IV. Er:YAG laser (Pluser, Doctor Smile, Italy) at a power of 4 W with a wavelength of 2940 nm, 1 mm tip diameter, 400 mJ energy, 100 µs pulse duration,10 Hz frequency, 60% water, and 60% air, was applied at the bracket-tooth interface for 12 seconds: 3 seconds on each of the mesial, distal, occlusal, and gingival aspects, with sweeping motion in each direction. (Fig.1D)

**Outcome assessment**

Brackets were debonded using a universal testing machine (LIoyd Instruments Ltd, United Kingdom) at a crosshead speed of 1 mm/min and Adhesive remnant index was assessed using stereomicroscope (Olympus, Tokyo, Japan) at x20 magnification. (Fig.2) ARI scores ranged from 0 to 3 as follows:

Score 0 - no adhesive remaining on the tooth surface.

Score 1 - less than half of the adhesive remaining on the tooth surface.

Score 2 - more than half of the adhesive remaining on the tooth surface.

Score 3 - all the adhesive remaining on the tooth surface.

**Statistical analysis**

Data was fed to the computer and analyzed using IBM SPSS software package version 20.0 **(**Armonk, NY: IBM Corp). Data was described using number and percent. Significance of the obtained results was judged at the 5% level ($P \leq 0.05$).

**The used tests were**

**1 - Chi-square test**

To compare between different groups

**2 - Monte Carlo correction**

Correction for chi-square when more than 20% of the cells have expected count less than 5.


**Fig.1: Techniques used in the study A. Peppermint oil, B. Ultrasonic device, C. Diode laser, D. Er:YAG laser**

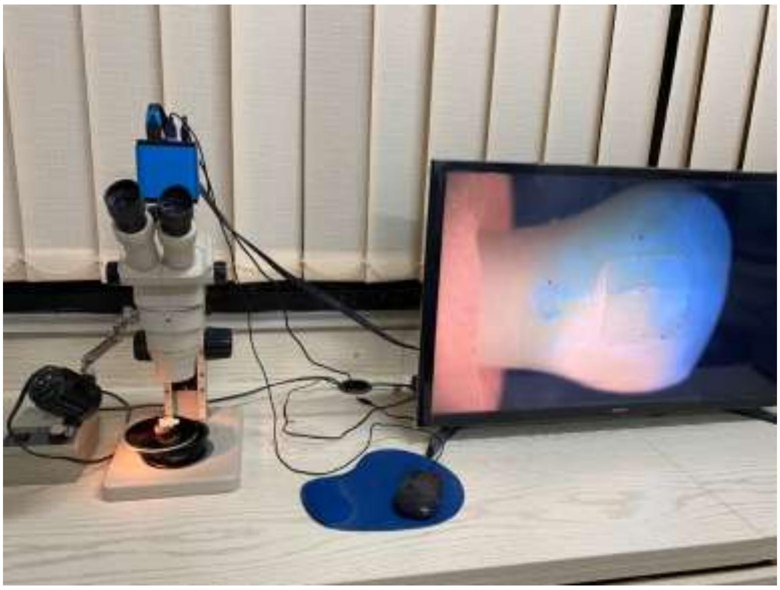

**Fig.2: Assessment of ARI using stereomicroscope**

## RESULTS

The ARI of the five groups is presented in Table 1. Comparison between all groups is depicted in Fig. 3.

Comparison between group I (control group) and other groups showed a statistically significant higher ARI solely in group V (Er:YAG laser aided debonding) (P=0.0002). No statistically significant difference was found in group II (chemical aided debonding)(P=0.736), group III (ultrasonic aided debonding)(P=0.335), and group IV (diode laser aided debonding)(P=0.184) compared to group I (control group).

By comparing between group II (chemical aided debonding) and other groups, a statistically significant higher ARI was found solely in group V (Er:YAG laser aided debonding)(P=0.0002). No statistically significant difference was found in group III (ultrasonic aided debonding)(P=0.533), and group IV (diode laser aided debonding)(P=0.241) compared to group II (chemical aided debonding)

A statistically significant higher ARI was found between group V (Er:YAG laser aided debonding) and group IV (diode laser aided debonding)(P=0.033) and between group V (Er:YAG laser aided debonding) and group III (ultrasonic aided debonding)(P= 0.006). Yet, no statistically significant difference was found when comparing between group III (ultrasonic aided debonding) and group IV (diode laser aided debonding)(P= 0.606).

**Table 1:** Comparison between the different studied groups according to adhesive remnant index

| **Adhesive remnant index** | **Group I (Control) (n = 20)** | | **Group II (Chemical assisted debonding) (n = 20)** | | **Group III (Ultrasonic assisted debonding) (n = 20)** | | **Group IV (Diode laser assisted debonding) (n = 20)** | | **Group V (Er:YAG laser aided debonding) (n =20)** | | **$\chi^2$ ($^{MC}p$)** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | **No.** | **%** | **No.** | **%** | **No.** | **%** | **No.** | **%** | **No.** | **%** | |
| 0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | 0 | 0.0 | |
| 1 | 14 | 70.0 | 13 | 65.0 | 10 | 50.0 | 10 | 50.0 | 3 | 15.0 | $25.609^*$ ($0.001^*$) |
| 2 | 6 | 30.0 | 7 | 35.0 | 9 | 45.0 | 7 | 35.0 | 8 | 40.0 | |
| 3 | 0 | 0.0 | 0 | 0.0 | 1 | 5.0 | 3 | 15.0 | 9 | 45.0 | |
| **$p_0$** | | | 0.736 | | $^{MC}p=0.335$ | | $^{MC}p=0.184$ | | $^{MC}p=0.0002^*$ | | |
| **$^{MC}p_1$** | | | | | 0.533 | | 0.241 | | $0.0002^*$ | | |
| **Sig. bet. grps.** | | | | | $^{MC}p_2=0.606, p_3=0.006^*, p_4=0.033^*$ | | | | | | |

$\chi^2$: **Chi square test** MC: **Monte Carlo**
p: p value for comparing between the studied groups
$p_0$: p value for comparing between **Control** and each other group
$p_1$: p value for comparing between **Peppermint oil** and each other group
$p_2$: p value for comparing between **Ultrasonic** and **Diode Laser**
$p_3$: p value for comparing between **Ultrasonic** and **Er: YAG Laser**
$p_4$: p value for comparing between **Diode Laser** and **Er: YAG Laser**
*Statistically significant at $p \leq 0.05$

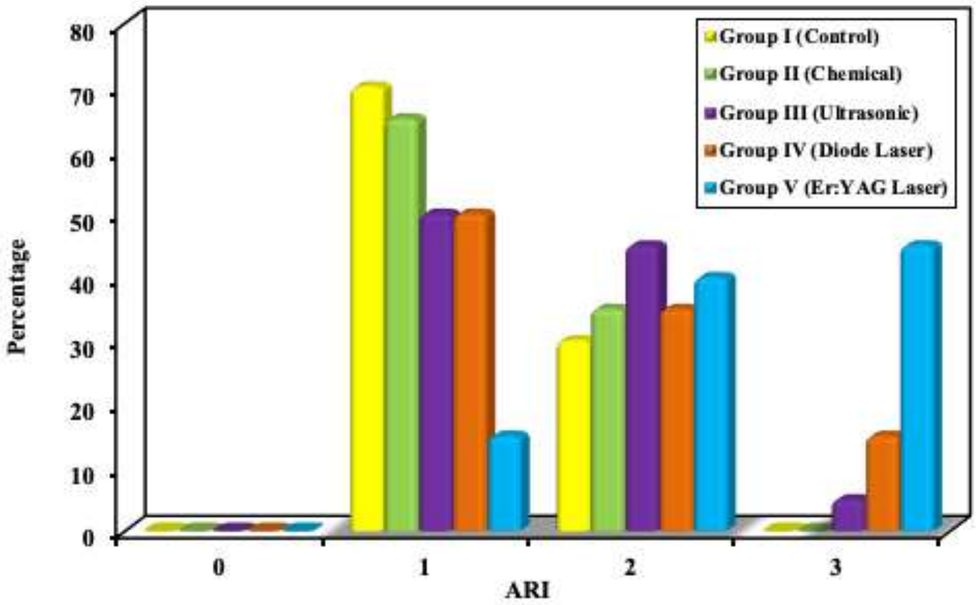


**Fig.3:** Graphical comparison between the five studied groups according to adhesive remnant index score percentages

## DISCUSSION

Ceramic brackets have been favored by many clinicians due to its esthetic superiority.(14) Given the relatively low tensile strength of enamel and high bonding strength of ceramic brackets, damage to enamel remained inevitable.(2) This study aimed to compare different methods for debonding ceramic brackets in terms of adhesive remnant index.

Attempts have been made to dissolve the orthodontic adhesive via chemical agents to aid in debonding of ceramic brackets. The present study found no statistically significant difference with regard to adhesive remnant index when peppermint oil was used. This was in line with some previous results.(15,16) Longer application time yielded promising results.(17) Yet, it did not reach statistical significance when compared to control.

Ultrasonic devices have been utilized for brackets assisted debonding and consequently removal of remaining adhesive.(4) The results of this study showed no statistically significant difference with regard to adhesive remnant index, likewise previously reported results by Bonetti et al. (18) who assessed ultrasonic instrumentation of ceramic brackets with full power via 45 and 0 degree scaler tip angulation.

There is scarcity of guidelines for the use of diode laser in debonding ceramic brackets. Diode laser assisted debonding of ceramic brackets yielded contradictory results. To the best of our knowledge, no study used the same laser settings employed in ours. Laser irradiation to the bracket-tooth interface via sweeping motion has been chosen due to positive results found in previous studies.(19,20) In the present study, adhesive remnant index analysis showed no statistically significant difference when diode laser was employed. This was in accordance with previous work done by others.(20–22) Yet, Almohaimeed and Abdelhalim (23) and Anand et al. (24) found a statistically significant higher adhesive remnant index when diode laser assisted debonding was used with ceramic brackets. Nevertheless, Stein et al. (25) yielded a statistically significant reduction. This might be due to different laser parameters utilized.

Favorable results were noted when Er:YAG laser was used for debonding laminate veneers. (26,27) In essence, Er:YAG laser has the advantage of exhibiting less thermal effect on pulpal tissues in comparison to $CO_2$ and Nd:YAG laser.(28) The present study showed a significant increase of adhesive remnant index when Er:YAG was used. This was in line with results reported by others.(29–31) This is explained by the fact that free monomer as a component of adhesive absorbs energy and expands, causing explosions in the micro-level. This theory also elucidated the reason behind using the single step orthodontic adhesive in the present study. Conversely, Dostalova et al. (32) and Sedky and Gutknecht (33) contradicted this finding. This might be explained by the different types of lasers used.

All the tested groups had a relatively higher adhesive remnant index compared to control. Yet, the only group that reached statistical significance was Er:YAG laser assisted debonding. The more increase in adhesive remnant index, the less enamel damage is likely to occur. Therefore, Er:YAG laser assisted debonding might be the technique of choice.

## CONCLUSION

Based on the results of the current study, Er:YAG laser might be effective for debonding ceramic brackets. Therefore, this method could be recommended to reduce enamel damage.

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