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LASER-AIDED CERAMIC ORTHODONTIC BRACKETS DEBONDING EFFECTS ON SHEAR BOND STRENGTH AND ENAMEL SURFACE

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ABSTRACT:

The objective of the present study is to assess the effects of (Er:YAG) laser debond ing of ceramic brackets on the shear bond strength h and the amount of adhesive resin remnant and ceramic cracks caused by removing the adhesive remnant .

Materials and Methods: Sample of the study consisted of 50 upper first premolars extracted for orthodontic reasons to which ceramic brackets were attached using (Light Bond resilience orthodontic products Inc, USA) . The sample randomly divided into two equal groups . The ER:YAG was applied for 6 seconds using the scanning method on one of these groups using the (KaVoKEY LASER HI 1243) device . later all the specimens were debounded and tested on a testing machine (Tecnotest) in Tishreen University . The amount of adhesive remnant was evaluated with adhesive remnant index (AR1) . After de-bounding of the brackets tungsten carbide bur was used to remove adhesive remnant in all specimens , examination of the buccal surface of all specimens to evaluate enamel cracks caused by removing the adhesive remnant post debonding of ceramic brackets statistical calculations were conducted for search using a program (SPSS Version 13,0)

Results : Application of (ER: YAG) laser thermally softened adhesive resin structure , lowered the bonding resistance of ceramic brackets and enabled their debonding ,decrease of shear bond strength values ($P<0.05$) . Laser debonding caused a significant decrease in the frequency of enamel cracks compared to conventional debonding . There are no statistically significant differences in ARI scores between laser group and the control group .

Conclusion : W power Er:YAG laser application with the scanning method to polycrystalline ceramic brackets demonstrated lower bond strengths and decrease of enamel cracks during the debonding procedure .

Key words : Ceramic brackets - Er:YAG Laser – Shear strength –Brackets debonding

INTRODUCTION:

Using the ceramic brackets in mid- 1980th was considered a massive notable step towards realizing aesthetics element of orthodontic devices ,these brackets were well admitted by the adult patients who are interested in dental aesthetics.

Al though the ceramic brackets is strong and colour changes resistant ,they encountered several problems in its orthodontic clinical performance like enamel cracking and fractures in ceramic brackets particularly when de-bonding using traditional methods which is caused by higher bonding strength along with the lower fracture strength of ceramic brackets .

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Enamel cracks are separation lines in the lower enamel, and when tooth is exposed to thermal stimulants this may cause cracks in the solid dental tissue due to different thermo/mechanical properties in enamel and dentine. Enamel cracks may negatively effect the teeth aesthetics which may need a costly restorative therapy in a latter date . Breaking the brackets will prevent reusing the same bracket in order to correct its position.

Several techniques were proposed to de-bound theceramic brackets like special knives for mechanical debonding or using rapid burs but this solution has its problems in tooth enamel , or using ultra-sonic , laser or electro-thermal tools. Ultra sonic method will decrease chance of harming the enamel and the bracket and remove the adhesive material remained on same ultrasonic head.

The two negative points of this method are the need for cooling following to debonding beside time consumption . the electro-thermal equipment depend on softening the resin adhesive material in 150-200 degree which permits debonding at lower strength limit but this will cause harm to pulpal tissue.

All this served to decrease in popularity of using the electro-thermal methods and turning towards employing laser technique . Laser depends on thermo-optical reaction which causes softening the composite , then brackets are removed.

Using laser to debond the mono and multi crystals ceramic brackets served to clearly decrease the debonding strength and enamel break and failure of the brackets , using laser Nd : YAG to debond ceramic brackets did not case any harm to enamel and brackets.

Hayakawa Pointed to that using laser Nd: YAG serves to decrease debonding strength and insures realizing optimum rate of adhesive remnant index. Freedmand in his study to investigate the efficiency of using Laser Diod for debonding ceramic brackets discovered that using this laser has reduced

The required debonding strength of the mono-crystalline breakers without increasing the pulp temperature , while this is not true with poly-crystalline breakers . Using laser (Er:YAG) by scanning technique for debonding ceramic brackets has produced positive results without endangering enamel or pulpal tissues . In the study of (Mehmet Oguz Ozroprak) he proved that applying the laser (Er: YAG) is effective in debonding ceramic brackets by effecting the adhesive material through thermal softening , Using this technique with the multi-crystalline brackets caused a reduced bonding strength beside increasing the value of adhesion remnant index . This study aims to investigate laser ability to reduce the adhesive material bonding force and its effect on shear bond strength which will facilitate debonding of ceramic brackets without harming the bracket of enamel .

Importance of the Study :

The main problem when using the ceramic brackets is breaking and cracking due to its fragile nature compared to metal brackets that will cause enamel cracking when debonding due to its higher bonding strength .

- The great challenge in the previous studies was to produce adhesive material between enamel surface and brackets with adhesive force sufficient to finis h the orthodontic treatment and in the same time to be with easier brackets debonding features which will not cause harm to enamel .

-Previous studies attempted to discover a method for decreasing adhesion strength during debonding the brackets .

-The duty of all types of laser is to soften the adhesive material, then to lower the high bonding strength thus protecting enamel surface from cracks produced during ceramic brackets debonding .

- Objectives of the study :

The objectives here are to assess the shear strength and the changes in the microstructure of enamel surface when debonding ceramic brackets using laser (Er:AG)

MATERIALS AND METHODS:

The sample of this study comprises 50 human premolars , and the sample selection criteria comprises the following :

1- The premolar should be newly extracted for orthodontic purposes.

The premolar should not be chemically treated previously .

The premolar enamel should be safe – particularly the vestibular surface (free of any developmental defects , caries , fillers , cracks or enamel fractures.

Directly following to extraction , following to Premolars washing with running water and preserving in physiologic serum , the (X10) photo-microscope was used to detect enamel cracks in vestibular surfaces of teeth , all teeth that do not meet this condition were rejected . Premolars were immersed in acrylic resin in a way that each premolar is positioned inside a separately numbered acrylic die .

Following to cleaning the surfaces of extracted teeth , the vestibular surfaces were polished for 10 seconds using soft ,fluor-free ,water-mixed pumice powder by polishing brush on micro motor hand piece in slow speed , then extracted teeth were washed for 10 seconds with running water and dried .

Teeth surfaces were harshened using 37 % for 30 seconds followed by washing in water for 20 seconds phosphoric acid then dried by air current.The bonding agent was applied using smooth brush followed by exposing to a light air current , then was photo-solidified , then a thin layer of adhesion composite was applied on the ceramic brackets system then placed at the center of the tooth , this was

followed by placing the bracket and removing the extra composite and solidifying for 20 seconds at both the misial and distal sides . Ceramic brackets were stuck using adhesive composite (Light Bond Resiliance Orthodontic Products , Inc, USA prepared for using with all plastic, ceramic, and metallic brackets.

The sample was randomly divided into two groups:

-first group contains 25 premolars and debonding will be affected by mechanical method without using laser.

-second group contains 25 premolars where debonding will be affected by using mechanical method following to using the laser.

Laser ray was applied to half of the studying sample – using hand piece 2060 according to the following parameters:

The applied force 300 milly joul with a frequency of 15 Hz at a distance of 1 cm

For 8 seconds at the peripheral of each bracket , the premolars were kept in distilled water until debonding of brackets using the mechanical device.

Shear force test was performed to simulate the effect of the occlusion force for the opposite teeth which is an important factor in failure of brackets bonding .

- Index of (ARI) :

Using device (Tecnotest) in the faculty of civil engineering – Tishreen University. Samples were separately tested for all groups and the cast was fixed inside the mandible of the device then shear forces were applied by the maxilla of the device with a speed of 1 mm/ minute . The goal of affecting the mechanical test is to know that the debonding force was decreased due to the effect of laser ray compared to that which surface was not exposed to the laser.

Microscopic test:

Samples were tested and pictures were shot by optical microscopy (Sterio microscope) to detect existence of cracks or fractures in enamel and to know the quantity of the remained adhesive material on tooth surface (ARI) to detect site of the failure . The taken picture was compute r processed, beside inspection of the taken electronic pictures , then calculating the total area of the area already defined and the area of the remained adhesive material using the computer program (AutoCAD Classic) then calculating the ratio of adhesive material remained to the total area of each sample in this study as seen in the following :

Ratio of remained adhesive / total area x 100 , the residual adhesive index was classed using the index (ARI) to describe the quantity of residual adhesive on the enamel after failure of adhesion .

Grade	Class
5	No remaining adhesive
4	Less than 10 % on enamel
3	Remained on enamel 90 % and less than 10 %
2	More than 90 %
1	All adhesive remained on enamel

Following to this , the remaining adhesive was removed using a Carbide Tungstun bur (a new bur for each tooth) fixed on turbine hand piece with cooling to remove the remained adhesive on the vestibular surfaces of teeth till removing all remained adhesive then smoothing the surface using white rubber at law speed

- Figure (4) finding area of remained adhesive on tooth surface

- Figure (5) removing the remained adhesive using tungsten carbide bur After finishing removal of the remnant adhesive the vestibular surfaces of teeth were examined searching for the enamel cracks and the cracks index was ied . According to the study of (Bishara) et al , c racks are divided into two types :

1 – Weak cracks which are seen in 25.4X magnification

2- visible cracks under ordinary light .

RESULTS:

A – Study of removing the remnant adhesive :

Result of supervising the degree of removal of remnant adhesive in the study sample according to the method of ceramic bracket debonding :

Remnant adhesive removal rate	Premolars numbers		Percentage	
	Mechanical bracket debonding using ER:YAG	Without using laser	With using laser	Without using laser
All the adhesive material is on surface of tooth	11	14	44.0	56.0
More than 90 % of the adhesive material on the tooth surface	6	2	24	8
More than 10 % and less than 90 % of the adhesive material on the enamel .	4	5	16.0	20.0

Less than 10 % of the adhesive material remained on tooth surface	2	0	8	0
No adhesive material remnant on tooth surface	2	4	8	16.0
Total	25	25	100	100

Figure (1) : Ratio of the result of testing the rate of removal of remnant adhesive

In the study sample according to the method of ceramic bracket debonding .

-Studying the effect of ceramic bracket debonding method in the rate of removing the remnant adhesive in the study sample according to the debonding method applied :

-We selected the test method of (Mann-Whitney U)to study the indices of the differences in recurrence of remnant adhesive removal rate between the group of bracket removal by mechanical method using laser (Er:YAG) and the group of brackets removal by mechanical method without using laser (Er: YAG) in the study sample as follows :

- Result of (Mann-Whitney U) test :

Table no. 2 displays grades statistics and the results of applying this test to study the importance of the difference in recurrence of removal of the remnant adhesive between the group of bracket removal by mechanical method with using the laser and without using the laser in the study sample :

The variable studied : Rate of removing the remnant adhesive					
Method of ceramic bracket removal	Number of premolars	Average ranks	U value	Value of index level	Difference index
Bracket debonding by Mechanical method with laser Er: YAG	25	26.16	296.0	0.730	Nill
Bracket debonding by mechanical method without using laser	25	24.84			Differences exist

We notice in the above table that the value of index level is far greater than value 0.05 , this means that it is at confidence level 95 % and there are no statistically significant differences in the recurrence of the removal rate of the remnant adhesive between the groups of bracket debonding by mechanical method following to using laser and the another group without using the laser .

Drawing no. 2 – Average grades for the remnant adhesive debonding in the study sample according to the method of ceramic bracket debonding .

B – Studying the cracks index grade :

Grade of cracks index	Number of premolars		Percentage	
	Mechanical method for Bracket debonding with use of laser Er: YAG	Debonding without use of laser	Debonding with use of laser Er:YAG	Debonding without use of laser Er: YAG
No any cracks	18	4	72.0	16.0
Little cracks exist	7	7	28.0	28.0
Cracks are clearly visible	0	14	0	56.0
Total	25	25	100	100

Drawing no. 3 – the percentage for results of monitoring results of cracks index grade in study sample according to the method of ceramic brackets debonding .

-Studying the influence of ceramic bracket debonding method in the cracks index degree in the study sample according to the debonding method :

- We selected the method of (Mann Whitney U) to study the differences in the recurrence of cracks index grade between the group of bracket mechanical debonding with and without using laser (Er:YAG)in the study sample as follows :

- Results of (Mann Whitney U) test :

- Table no. 4 displays results of this experiment to study differences in degrees of cracks index using mechanical method with and without use of laser (Er: YAG)

In the research process :

Method of debonding the ceramic bracket	Number of that the lepremolar	Average of grades	U value	Index level value	Difference index
Mechanical method of Bracket debonding with use of laser Er:YAG	25	16.54	88.5	0.000	There exist index differences
Mechanical method of debonding without use of laser Er: YAG	25	34.46	88.5	0.000	-----

We notice in the above table that the value of significance level is far smaller than the value 0.05 = at confidence level 95 %, there exist differences of statistical significance in the recurrence of cracks index grade between the two groups of crack debonding, using mechanical method with laser and without use of laser in the study sample, when studying the average grades we conclude that the cracks index grade in the group of bracket debonding by mechanical means and using the laser Er: YAG is less than the grade when debonding using mechanical means but without using the laser Er: YAG in the study sample .

- Drawing no. 4 = average grades of cracks index grades in the research sample according to the method of ceramic bracket debonding .

- Studying the Shear Force : SBS :

-Studying the effect of using the method of ceramic bracket debonding on the shear force (SBS) n the study sample :

-The (T . Student) test was applied for the independent samples to study the significance of difference in average shear force (SBS) between the group of bracket debonding by mechanical method after using the laser (Er: YAG) and the group of bracket debonding by the mechanical method without using the laser in the study laser as follows :

-Result of (T – Student) test for independent samples :

- Table no. (5) denotes the descriptive statistics and the results of applying the test of (T – Student) in isolated samples to study the significance of differences in the everage shear force (SBS) between the group of bracket debonding using mechanical method after using laser (Er: YAG) and the group of bracket debonding

without using the laser (Er: YAG) in the study sample :

The studied variable (Shear force) N.									
Method of ceramic bracket debonding	Premolars	Average	Standard deviation	minimum	maximum	Difference between averages	T value	significance	Significance of dfferences
Mechanical debonding with laser	2.5	44.64	11.75	30	76	15.40	4.447	0.000	Significant difference
Bracket debonding without laser	62	60.04	12.72	38	92				

We notice in the above table that significance level value is much smaller than 0.05 = at confidence level 95 % there exist differences of statistical significance at the in shear force value average SBS (Newton) between the group of bracket debonding by mechanical method after using laser Er: YAG and the group of bracket debonding by mechanical method without using laser in the study sample , since the algebraic signal of the difference between the two averages is negative , we conclude that the value of shear force SSB in the group of bracket debonding using mechanical method and use of laser was less than it in the group of bracket debonding using mechanical method without laser in the study sample

Drawing no. 5 = average of shear force SSB in the study sample according to the method of ceramic brackets debonding .

DISCUSSION:

Debonding force in orthodontics should range between 6 – 8 Mega Pascal as a precaution from causing damage to the teeth , the use of cosmetic ceramic brackets will increase this force to 20 mega pascal which will increase the probability of causing enamel cracks and fractures in ceramic brackets . Recently laser ray was used in debonding the ceramic brackets a substitute of the mechanical method with the aim of limiting the volume of debonding forces applied and to protect the ceramic brackets from fracture and to minimize the expected enamel cracks , for using laser technique will cause thermal softening of the resin adhesive which in turn will facilitate the debonding operation . This effect is caused by using lower laser energy (heat is absorbed first by the brackets which will indirectly effect the adhesive material). Studies revealed that mono and multi crystals ceramic brackets display different responses

towards the emitted laser light depending on how long is the wave of the applied laser light . The results of our study revealed that the value of the force applied to debound the ceramic brackets when using laser was less than that when not using the laser , this means that laser assists in the process of brackets debonding beside minimizing the force applied for debonding which is caused by heat generated due to applying laser (Er: YAG) which serves to minimize the force required to debond the ceramic brackets .

The outcomes of our study correspond to those of other workers (Ahmed year 2014) and (Oztoprak) and others in year 2010 regarding the effect of laser in debonding ceramic brackets by the heat effect of the adhesive to facilitate the process of debonding the bracket from tooth surface , this beside less shear bond strength , and was active in brackets debonding without causing any breaks or cracks in enamel surface , thus we conclude that ceramic brackets debonding is possible at lower energy levels, this proves conformity between the results of our study and those of (Tocchio) 1993 , where the laser (ER: YAG) light is absorbed by the adhesive resin which contains water or remnant monomer which in turn will serve to debonding the resin due to the moistioning and evaporation that take place ,which has a positive effect in reducing the debonding strength and is more safe on the tooth surface , where in clinical practice the proper strength for brackets debonding ranges between 6 – 8 Mpa .

Our study revealed no statistically significant differences in the recurrences of the remained adhesive index (ARI) between the group of bracket debonding with use of mechanical method after using laser (Er: YAG) and the group of bracket debonding by mechanical method without use of laser (Er: YAG) .

These results defer with those results which proved that using laser decreases the value of (ARI) index like the studies of ; (Bishara Et al- 2000) (38) and the study of (Shamsi et al – 2006) and the study of (Hbibi et al - 2007) (40) which indicate that the spot of adhesion failure took place at the site of adhesive enamel.

This study disagree also with the studies (Bishara) which confirmed that remaining of the most adhesive material will serve to protect the tooth but this will effect adhesive mechanical removal process following to the debonding process , thus the adhesion failure took place in the bracket site during the debonding process , we also disagree with the study of (SABUNCUOGLU) year 2015 – where these studies revealed an increase in the value of (A R I) when using laser , this may be due to using different method of brackets debonding , and the use of different type of resin composite adhesive material . Difference may be also in the structure of the study sample where (SABUNCUGLU) year 2015 the molars while in our study we used premolars which will effect thickness of the adhesive materials , absence of this

buckling in the molars may assist in unifying thickness, we did not reach definite method to unify thickness of the adhesive material . The difference may be in the time interval between brackets debonding and laser application , where most studies attempt to minimize this time interval within few hours ,while in our study we failed to consider this factor

-We disagreed with the results of (Farzaneh Ahmad) year 2011 and this disagreement may be due to using different laser type or the difference in applying the mechanical debonding methods , for he used traditional knives for ceramic brackets debonding , while we used (Tecnotest) device , and he used laser (CO2) while in our study we used laser (Er: YAG) . In our study the results of (ARI) index have no statistically significant values , the quantity of adhesive remained on the tooth surface depends on the adhesion failure between adhesive / bracket or adhesive / enamel .

When large quantity of adhesive remains on tooth surface this means the failure is between bracket and adhesive , and it may leave the enamel surface relatively safe , even though it takes longer time to rebond the remained adhesive , with the probability of causing injury to enamel surface during the brackets debonding process , but if failure was between adhesive and enamel this means a little quantity of adhesive to be removed from enamel surface after brackets debonding but when failure takes place it may cause injury and cracking to the enamel surface .

The degree of cracks index in the bracket debonding group using the mechanical method with using laser (Er: YAG) was less than degree in the group of bracket debonding using mechanical method without using laser in the study sample .

In this study we agreed with the study of (Farzaneh Ahrari) year 2011 regarding no enamel cracks exist when using laser which will soften the adhesive material and reduces the volume of power needed for brackets debonding , consequently this will serve to reduce the enamel cracks .

We agreed with (SABUNCUOCLU) year 2015 regarding the cracks index , for when increasing the index of (ARI) most residuals of the adhesive will be on the enamel and this will reduce probabilities of enamel cracks but will lengthen the time for burs use which in turn will raise the temperature of the pulp, therefore we should investigate the pulp temperature when using laser (Er: YAG) .

t is not possible to compare the results of our study with those of Zidan, Abdalsalam study year 2016 , where we studied the effect of laser on the index of enamel cracks using laser to remove the remains of the adhesive following to debondin of ceramic brackets in spite of conformity in the results that ratio of enamel cracks in the group of removing the remained adhesive using laser (Er: Yag) is less than in the group of removing the remaining adhesive using a Carbide Tungeston bur in the group of Resin composite .

The worker concluded that no relation exists between the method applied in removing the remnant adhesive and the formed enamel cracks , but there exists a relation with the type of the adhesive used (chemical or optical solidifying property) , and he noted that when a little amount of the adhesive material remains on the tooth surface following to removal of the orthodontic device , the time required to remove these residuals will not be sufficient to cause difference in temperature of the enamel surface during the operation of adhesive removal , and he noted that the temperature resulted from using Laser (Er: YAG) and Carbide Tungestin bur is affected by several factors like (application time on the surface of the tooth .

CONCLUSION:

Using laser in brackets debonding served to minimize shear force and decrease cracks formed on tooth surface without the need of reusing laser for remains removal , its use for primary softening caused decreasing the quantity of the remained adhesive material on the tooth surface and, consequently served to shorten the contact time between the tungsten – carbide bur with tooth surface this besides limiting the rise of tooth temperature which in turn will prevent formation of cracks.

Recommendations: It is required to remove adhesive material remnant directly 3 seconds following to exposing to laser as a precaution from increasing debond forces which serve to formation of enamel cracks.

To compare cracks formed on the enamel following to debonding the ceramic brackets fixed using a chemically solidifying adhesive material .

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