RESEARCH

23(99), September - October, 2019

ISSN 2321–7359 EISSN 2321–7367

Medical Science

Shear bond strength of ceramic brackets bonded on the composite surfaces prepared with CO_2 Laser, Chromium Erbium, and Etching Acid

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Article History
Received: 05 June 2019
Reviewed: 08/June/2019 *to* 18/July/2019
Accepted: 20 July 2019
Prepared: 25 July 2019
Published: September - October 2019

Citation
Meysam Noori, Mashallah Khanemasjedi, Nasim Ghorani. Shear bond strength of ceramic brackets bonded on the composite surfaces prepared with CO_2 Laser, Chromium Erbium, and Etching Acid. *Medical Science*, 2019, 23(99), 745-756

ABSTRACT

Background & Aim: Recently, the use of ceramic brackets in the orthodontic treatments has been increased due to its inherent esthetic results. In adult orthodontic patients, the ceramic brackets should be bonded to composite restorations on the patients' teeth sometimes. The routine surface preparation method for composite restorations is etching by acid phosphoric; however, laser irradiations have been used in this regard recently. This *in vitro* study compared the shear bond strength of the ceramic brackets bonded to the composite restorations following preparations by CO_2 and Er;Cr:YSGG lasers and conventional phosphoric acid etching. *Materials & Methods:* In this *in vitro* trial, class V cavities were prepared on the buccal surfaces of 60 acrylic central teeth by the dimensions of 7×6×2mm and restored using Z100 composite after etching by 37% phosphoric acid gel. The specimens' surfaces were randomly prepared by 37% phosphoric acid gel or Er;Cr:YSGG (power: 3W, wavelength: 2780nm and frequency: 20Hz) or CO_2 lasers (power: 3W, wavelength: 10600nm and frequency: 20Hz). The ceramic brackets were bonded to the composite restoration surfaces. The specimens were stored in the distilled water for 24 hours at 37C° and received thermal cycles for 500 times. Shear bond strength of the brackets to composite surfaces were measured on the universal testing machine by the crosshead speed of 0.5 mm/min. After brackets' debonding, the scores of the remaining adhesive on the surfaces were calculated by ARI index in 5 scales. The shear bond strength values were subjected to one-sided analysis of variance and Tukey tests while the ARI scores were analyzed by Chi-square test. *Results:* The shear bond strength of the ceramic brackets to the surfaces of composite restorations were found to be 12.34±4.34 MPa, 17.62±5.08 MPa and 13.72±4.10 MPa using routine acid phosphoric etching and irradiation of Er;Cr:YSGG and CO_2 etching respectively ($p<0.001$). The mean shear bond strength of the ceramic brackets to the surfaces of composite restorations following Er;Cr:YSGG laser irradiation was significantly higher than CO_2 laser irradiation ($p<0.02$) and acid etching ($p<0.001$). However, no significant differences were found between acid etching and CO_2 laser in this regard. Er;Cr:YSGG laser irradiation showed the best results in terms of ARI scores and significant differences existed among the studied surface preparation techniques in terms of adhesive remnant scores ($p<0.001$). *Conclusion:* Then; all surfaces preparation methods showed adequate bond strength between the ceramic orthodontic brackets and composite restorations. Although, CO_2 and Er;Cr:YSGG lasers are suggested for the clinical applications due to adequate bond strength created between the brackets and composite surfaces as well as advantages such as lower chair time and no damage to the gingival tissues.

Keywords: Surface preparation methods, Composite restorations, Phosphoric acid, Lasers of CO2 and Er;Cr:YSGG

1. INTRODUCTION

Orthodontic operations demand a solid clinical bond between the orthodontic brackets and the tooth (enamel) surface. In 1955, the application of a micro-mechanical bond between dental materials and tooth surfaces was introduced (Feilzer et al., 1987; Staxrud & Dahl, 2011). Orthodontic operations without the necessity for performing full bondage (bondless operations) were noted among patients for not requiring post-treatment space closure, less gum irritation, ease of removal for the plaque layer and improved esthetics. In the late 1970s, the introduction of a bonding technique with the possibility of presenting convenient tolerance against force gradually changed into an accepted clinical method in orthodontics (Maneenut et al., 2011).

Corresponding with the progress in various fields of science, the advances made in dentistry sciences and dental materials lead to the emergence and application of synthetic materials that presented easier procedures, more precise and economically advantageous results in orthodontics (Sobouti et al., 2016). In general, the main basis of all these improvements can be sought in the endeavor to achieve optimal bonding (Usumez & Aykent, 2003). Strictly speaking, in orthodontics, the appropriate amount of bond strength is the measure that prevents the occurrence of unwanted bracket removals during treatment process besides not damaging the enamel during the bonding procedure. If the bracket's bond strength is too high, the chance of damage to the enamel increases. Furthermore, if the post-debonding residual adhesive amount is considerable on the enamel surface, it takes more time and effort to completely remove it. (Sobouti et al., 2016)

In recent years, the number of patients seeking esthetic treatments with mercury-free dental materials has increased dramatically, and the trend is still present. Additionally, advanced restorative materials such as veneers, crowns, porcelain veneers, porcelain bridges, amalgams, glass ionomers, and some composite resins are commonly applied in response to the needs of the patients (Poosti et al., 2014).

Also, the number of adult patients demanding for orthodontic treatments is steadily increasing and adult operation rates have grown rapidly in orthodontics (Rehman et al., 2016). The new orthodontic procedures require the bracket to bond to the non-dental (non-enamel) surfaces such as composite resin, amalgam, and porcelain. Consequently, it is imperative to achieve a reliable bond to the non-dental surfaces of the teeth (Usumez & Aykent, 2003). Due to the prevalence of these materials in recent years, the ability to bond orthodontic brackets to such materials including composites has been in rise (Ahrari et al., 2013). As a result of the new composite surface's low tendency to bond to the old composite surface; several methods are applied in order to improve the bond strength between two different composite surfaces. These methods involve using sandblast, fluid, flowable composites, creating roughness with diamonds, creating a channel with a depth of 1mm, hydrofluoric acid etching, dentin bonding systems (Ser-Od et al., 2016) and preparation with phosphoric acid (Gultz et al., 1991). The evolution of laser technology has led to the expansion and advancement of its applications in dental treatments, such as soft tissue treatments, composite restorations, enamel whitening and cavity removal procedures with minimal pain and discomfort (Aboush et al., 1991). Laser etching is suggested as a convenient substitute for enamel and dentin etching as it contributes to the formation of appropriate bonding surfaces. Etching enamel and dentin surfaces through laser radiation creates a meandrous channel and leads to the opening of fine dentin canals. As a result, the surfaces are very suitable for bonding. Additionally, the surfaces prepared through laser radiation are more resistant against corrosive material and cavities due to the enhancement of calcium to phosphorus ratio and the reduction of the carbonate to phosphate ratio, as well as the formation of less acid-soluble compounds (Lindauer et al., 1997).

Erbium chromium laser (YSGG: Cr; Er) was introduced by Ever sole in 1995 as a safe means for removing cavities and creating channels (Bin Abdullah & Rock, 1996). The relatively limited functions this laser made it possible to form irregular and uneven surfaces and create micro-mechanical hitches and gaps in the teeth (Osorio et al., 1999). The electron microscope scan results indicate that the radiation of this laser creates surfaces with higher levels of endurance (bonding) for composite and restorative materials (Gerbo et al., 1992). Carbon dioxide laser is further a gas laser that can be adapted for use in different areas and applications based on its power production features (Walls et al., 2001). According to Ahrari et al. (2013), the bond strength noted after the CO_2 laser radiation on the porcelain surface is significantly lower than of that when the surface is prepared by using hydrofluoric acid. Yet, the obtained bond strength is clinically sufficient. Accordingly, this type of laser can be used as an alternative to the hydrofluoric acid method (Wang & Tarng, 1991). Moreover, lab-based carbon dioxide laser radiation tests on monkeys and dogs have confirmed that applying this laser at a power rate of 3 watts causes no thermal damage in the pulp tissue (Gottlieb et al., 1991).

The purpose of this study was to determine the shear bond strengths of bonded ceramic brackets bonded on the composite surfaces prepared with CO2 laser, chromium erbium, and etching acid and further comparison of these strength values in three methods.

2. MATERIALS AND METHODS

In this laboratory study, 60 dentures (Ideal Maku, Tehran, Iran) were fashioned with class V cavities with dimensions of 2 × 6 × 7 mm on their buccal surfaces. These samples were etched with a 37% phosphoric acid gel (3M Unitek, Monrovia, Calif., USA). Next, they were recovered by applying the composite restorative material (Color A2, Unitek Z100, 3M, ESPE, USA) according to the manufacturer's instructions, using the LED Ortholux (Unitek 3M USA). In order to create the aging effect on the restorative composite surfaces in use, all of the samples were placed in the thermo cycling device (Delta TPO2 Nemo, Mashhad, Iran) and underwent the thermo cycling process (500 cycles between 5° C - 55° C). Following, the samples were mounted in acrylic blocks in order to gain a better control over the conditions (Ozcan, 2003). Then, the samples were randomly divided into three groups, 20 samples per each group.

Group I

The samples were prepared using a carbon dioxide laser in power settings of 3 W, 10600 nm wavelength and 20 Hz frequency. In the next move, the ceramic brackets of the central tooth (USA, Ortho American) with 3.22-4.53 dimensions and a standard 022 edge wise composite and (3M ESPE, St. Paul, MN, USA, Primer by mm Trans bond XT, 3M, Unitek, Monrovia, California, USA) bonded to composite surfaces of the tooth so that their slot could create a zero horizontal degree), K-21046; (universal testing machine of the blade device, Switzerland, Lohningen, Walterpbai). During the bonding, the bracket was compressed to the surface of the tooth in order to have the minimum composite width under the bracket. Next, the samples were arranged to go through 40 seconds of the mesial, distal, occlusal, and gingival positions while the Elite Cure device provided radiation exposure.

Group 2

In this group, the inhibited air surface was first removed using a diamond bur and then prepared with 37% phosphoric acid gel for 20 seconds before undergoing the etching process. The samples were washed with air-water spray for one second and dried with oil-free air. The rest of the steps were performed similarly to Group 1 (Matinlinna & Vallittu, 2007).

Group 3

All samples were prepared by using Erbium Chromium laser (Biolaser Europe GmbH, Paintweg 10, 92685 Floss, Germany) with power settings of 3W, wavelength 2780 nm, and energy 150 mJ, and frequency of 20 Hz for 10 seconds at a distance of one mm from the surface. The rest of the procedures were repeated as it was thoroughly discussed in Groups 1 and 2 (Matinlinna & Vallittu, 2007). After preparation, all samples were stored in distilled water for 24 hours in order to generate aging effects in composite bonds and were kept at 37 ° C in the incubator. Subsequently, samples were taken in the Delta TPO2, Nemo, Mashhad (thermo cycling machine of Iran) to enter the thermo cycling process (500 cycles at 5 ° C-55 ° C), (Matinlinna & Vallittu, 2007).

In the slot of all brackets, an stainless steel piece (0.021 × 0.025 inches, 3M Unitek, Monrovia, California, USA) minimizes the probability of the bracket's undesired removal/breaking during the debonding process by using 0.010 inches ligature wire (3M Unitek (3m Unitek Ulstermaker USA, California, Monrovia) were used. To determine the shear strength, a universal device with a blade tip speed of 0.5 mm/min was employed. Each of the samples was placed in the device and the shear forces were applied to the base of the brackets and the adhesion interface in the direction of Oculus and gingival through a head screw, allowing the bond failure to occur. The UTM machine calculates the necessary force amount to pull the brackets per newton, which by dividing this number into the cross-sectional dimension of the bracket base; the shear bond strength was obtained in MPa. After the samples were debonded, the teeth and brackets were evaluated with a magnification of 10 times under the stereomicroscope (VP) (1455 LEO Germany and the residual adhesive on the surfaces was proclaimed by the (ARI) (adhesive index remnant).

The ARI scale is defined as follows:

Grade 1: 100% of adhesive remaining on the composite surface (Fig. 1)

Grade 2: 90% of adhesive remaining on the composite surface (Fig. 2)

Grade 3: 10 to 90% adhesive remaining on the composite surface (Fig. 3)

Grade 4: Less than 10% of adhesive remaining on the composite surface (Fig. 4)

Grade 5: No adhesive remaining on the composite surface (Fig.5)

Finally, from each group, one sample was randomly selected for SEM examination. For this purpose, samples were then divided into two groups after measuring the shear bond strengths using a diamond blade. A group of them were selected for contact surface observations. The samples were coated with gold and coat-sputter method and tested for SEM and microscopic assessments to determine the quality of composite degradation and bonding failure location. The central dispersion indices (mean, standard deviation, minimum and maximum) were determined by applying the shear bond rate of ceramic brackets to composite restoratives following the use of surface preparation methods with conventional etching techniques and YSGG: Cr, Er, and CO2 lasers. The frequency and percentage of residual adhesive levels on the composite restorations were calculated and reported in each method: The shear bond strength of the brackets on the composite surfaces in the three groups with one-way ANOVA and the remaining adhesion indexes by the chi-square test. According to the remarkable differences seen between the ANOVA test results among the three groups, shear bond strength comparison of every two group was examined through Tukey test.

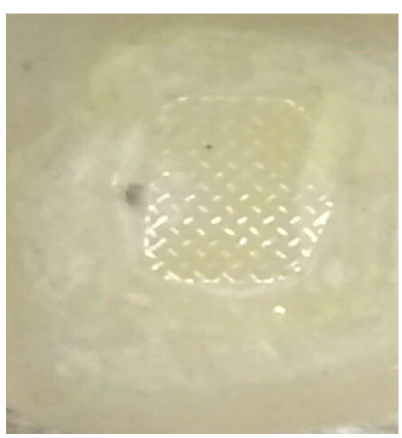

Figure 1 100% of the adhesive materials remains on the samples' surface.

Figure 2 90% of the adhesive materials remains on the samples' surface.

Figure 3 50% to 90% of the adhesive materials remains on the samples' surface.

Figure 4 Less than 10% of the adhesive materials remain on the samples' surface.

Figure 5 No amount of the adhesive materials remains on the samples' surface.

3. RESULTS

In the CO_2 laser radiation samples, the shear bond strength (± ± mean ± SD) on the composite restoration surfaces was 13.72 ± 4.10 ± 11.3 MPa. In the samples of the usual etching method with phosphoric acid as 12.34 MPa / 4.34, and in the YSGG: Cr; Er laser radiation samples, the shear bond strength of the ceramic brackets was equivalent on the surface of composite restorations, indicating 17.62± 5.08 Mpa (Table 1).

Table 1 Central dispersion indexes of shear bond strengths of ceramic brackets on composite surfaces under different surface preparation methods

Method of preparation	Number	Average	Standard deviation	The standard error	median	95% confidence interval	Minimum	Maximum
CO_2	20	13.72	4.10	0.91	12.60	11.80-15.64	6.21	20.31
Eching Acid Phosphoric	20	12.34	4.34	0.97	12.67	10.31-14.38	6.20	23.28
Er; Cr: YSGG	20	17.62	5.08	1.13	17.85	15.24-20.0	7.84	25.66

The results of the single-sample Smirnov-Kolmogorov test revealed that the shear bond strength data of ceramic brackets had been correlated to the composite restorations surfaces in the teeth under different preparation methods of normal distribution. Accordingly, the assumption of data compliance is confirmed by the normal distribution. Therefore, for comparing the shear bond strengths of ceramic brackets to composite surfaces, one-way ANOVA was used in different preparation methods. This test showed significant differences between the three groups ($p < 0.001$).

Tukey test was again employed to compare two methods of preparation (Table 2). The results of this test showed significant differences between preparation methods (p <0/02). There was a notable difference (p <0/02) between CO2 laser radiation and Er, Cr: YSGG, laser radiation, and YSGG: Cr, Er and etching phosphoric acid ($p < 0.01$). There was no significant difference between the methods of preparation through phosphoric acid etching and CO_2 laser radiation ($p = 0.6$).

Table 2 Comparison of shear bond strengths of ceramic brackets on composite surfaces prepared through different surface preparation methods, examined in pairs.

Method of preparation 1	Method of preparation 2	The average difference	Error Criterion	P value
Laser CO_2	Eching Acid Phosphoric	1.37	1.43	0.6
Laser CO_2	Laser Er; Cr: YSGG	3.90	1.43	0.02
Eching Acid Phosphoric	Laser Er; Cr: YSGG	5.28	1.43	0.001

In adhesive residue amount study on composite restorative surface prepared by phosphoric acid etching method, Index 2 in 1 sample (5%) and index 3 in 17 samples (85%) and index 4 in 9 sample (5%) were applied; in YSGG laser chromatograph, Cr; Er of index 2 in 1 sample, index 3 in 10 samples (50%) and index 4 in 9 samples (45%) were used; and in the CO2 laser radiation, the index was 1% of sample (5%). Example index 2 in 1 sample (% 50) and (sample 1 in the index of 3 in 19 samples (85%) and index 4 in 1 sample (5%) were observed (Table 3). According to the results of the chi-square test, chi-square significant differences were observed in the frequency of ARI index in different groups (P <0/001).

Table 3 Different Degrees of Residual Adhesion Index (ARI) following the use of different surface preparation methods of the composite in pair forms.

index ARI	Index 1	Index 2	Index 3	Index 4	Index 5	Total
Laser CO_2	0	1 (5%)	17 (85%)	2 (10%)	0	20 (100%)
Phosphoric acid	0	1 (5%)	10 (50%)	9 (45%)	0	20 (100%)
Laser Er; Cr: YSGG	1 (5%)	1 (5%)	17 (85%)	1 (5%)	0	20 (100%)

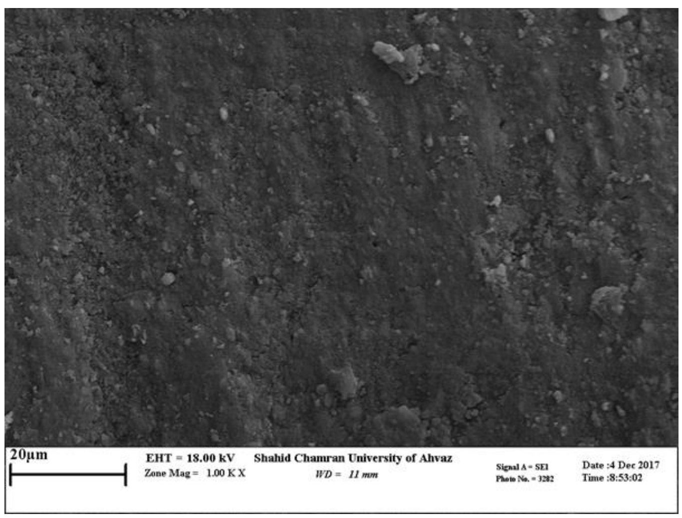

Figure 6 The electron microscope view from surfaces prepared with phosphoric acid.

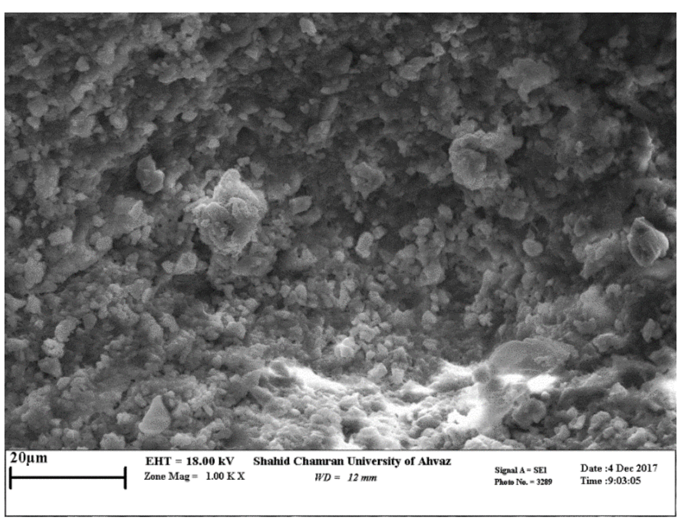

Figure 7 The electron microscope view from the surfaces prepared with YSGG, Cr; Er laser.

The 6-8 figures include the electron microscopy view of the composite restoration surfaces through the phosphoric acid etching and laser YSGG: Cr, Er, and CO2 methods.

In the phosphoric acid method, the prepared surfaces were smoother and superficial in comparison with the other two. However, in surfaces prepared through of YSGG: Cr; Er laser radiation methods, surface superficiality has been observed at more regular and uniform levels than CO2 laser radiation levels, resulting in more micro-mechanical hitches and gaps and less damage to restoration surfaces.

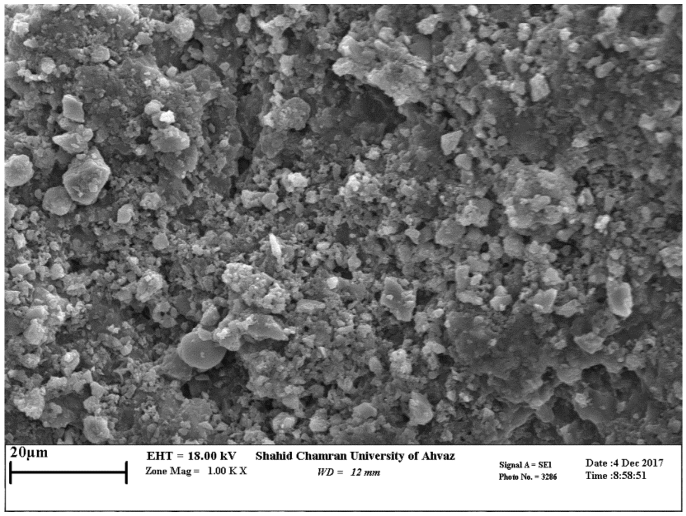

Figure 8 The electron microscope view from the surfaces prepared with CO2 laser.

4. DISCUSSION

According to the results of this study, the shear bond strength of ceramic brackets to composite restorations in YSGG: Cr; Er laser was significantly higher than those of phosphoric acid etching (17/62 Mpa vs. 12/34 Mpa) and CO2 laser radiation (17/62 vs. 13/72 Mpa).

The lowest shear bond strengths of the brackets were also observed in the phosphoric acid etching method. Various values have been reported for the strength of the orthodontic bracket bonds in previous studies. Maijer and Smith (1986) did acknowledge the 8MPa bond strength to be sufficient for brackets, and any lesser strength value was considered acceptable (Lindauer et al., 1997). According to Reynolds (1991), the bond strength of orthodontic brackets to enamel and restorative surfaces should be within the range 6-8 Mpa (Bishara, 2000). Germec et al. (2009) stated that the strength range acceptable for the bracket bonding was between 5-8MPa (Arici & Regan, 1997). Regarding the preceding criteria, the shear bond strength of the ceramic brackets is considered acceptable depending to the surface of composite restorations in teeth and preparation methods, such as through the use of phosphoric acid and YSGG: Cr, Er and CO2 lasers.

In Rehman et al.'s (2016) study, the shear bond strength of the fractured and re-bonded insulator tooth parts after laser radiation of YSGG: Cr, Er, and acid etching, revealed the laser radiation was a good alternative to acid etching whenever re-connecting the dental parts were necessary (Gerbo et al., 1992). In this study, YSGG laser radiation, Cr; Er was an acceptable substitute for the phosphoric acid etching in order to prepare ceramic brackets connected to the composite restorations in the teeth or on enamel.

In Sobouti et al.'s (2016) study, the shear bond strength of metal brackets to composite surfaces was studied following the use of diamond blade cut surface preparation methods, etching with hydrofluoric acid 9.6%, coating with aluminum trioxide particles and YAG: Er radiation with potentials 2 and 3 watts. It was determined that all surface preparation methods had sufficient bond strength between metal brackets and composite discs (Aboush et al., 1991), which is compatible with the results of the present study. In recent researches, metal brackets and YAG lasers: Er was employed rather differently from the present research. Ahrari et al. (2013) also evaluated the effects of CO_2 laser radiation on porcelain surfaces in shear bond strengths of orthodontic brackets, and proposed a CO_2 fractional laser radiation as an alternative to hydrochloric acid for the preparation of degledated feldspathic porcelain surfaces (Wang & Tarng, 1991). Further, in this study, laser radiation of CO_2 and YSGG: Cr; Er laser was introduced as an alternative method of phosphoric acid etching to connect ceramic brackets to the surface of composite restorations in the teeth enamel. In addition, Tehranchi et al. (2011) compared the effects of CO_2 laser radiation on ceramic brackets by conventional methods and showed that the radiation of this type of laser could be used as an alternative method for ceramic bracket bonding to dental surfaces (Wang & Tarng, 1991). In the present study, similar findings were reported. Despite the similarity of the bracket types in the recent researches and the present study, Tehranchi et al. (2011) have considered debonding at dental surfaces, which is different from the present study (debonding at the composite restorations on the teeth surface). The results of the two studies are consistent with each other. There were no significant differences in the shear bond strength of bonded orthodontic brackets to the enamel surfaces after preparation procedures that involved using phosphoric acid and CO_2 and YSGG: Cr, Er lasers (Anhoury & Nathanson, 2002).

In a recent study, YSGG lasers, Cr, Er and CO2, both with a power of 3 watts were applied on enamel surfaces. The radiation power of YSGG lasers: Cr, Er, and CO2 in the present study were determined as 3 Watts. Unlike the results of Mosjedi et al.'s study (2010), there were significant differences in bracket shear bond strengths to composite restorations after preparation with phosphoric acid and CO2 laser radiation and YSGG: Cr, Er in the present study. The differences seen in the results of the two studies can be explained as a result of the bracket types in use (metal brackets in recent research and ceramic brackets in the present study, besides the type of substrate in each study, respectively), the enamel and composite restoration surfaces in recent and the present study. Surface properties of enamel and the resin composite are different from each other, and therefore the bonding mechanism occurs in a distinct manner. In the enamel, the bonding mechanism is basically due to the presence of mechanical fasteners that hold the brackets on the surface, but in the resin composite, the chemical incliners may play a greater role. In a study by Serdar et al. (2002), YSGG: Cr, Er lasers with powers of 1and 2 watts respectively, it was revealed that the radiation of this type of laser with these capabilities does not provide sufficient bond strength during orthodontic treatment (Bishara & Olsen, 1999). Therefore, in the present study, the power of 3 watts for each of the YSGG lasers, Cr, Er, and CO2 is used in order to increase their efficiency in terms of shear bond strength. According to the results of this study and the observations made through the electron microscope, the group of surfaces prepared with phosphoric acid was smoother and more superficial than the other two groups. Moreover, in G: Cr; Er laser radiation, the surface roughness created in composite restorations was more regular and uniform than that of CO2 laser radiation, which caused more micromechanical hitching and less damage to the surface restorations. Yassaie et al.'s (2014) study focused on shear bond strength of ceramic and metal brackets following preparation processes of phosphoric acid and YAG: Er laser radiation, but no explicit differences were observed in the groups based on the results of electron microscopy (Bishara & Fehr, 1993). This difference in results could be explained as different laser rays were employed in two studies, respectively.

Most studies' results indicate the effectiveness of laser radiation to prepare enamel surfaces and restorations at the tooth surface. Of course, the changes in laser energy intensity levels, the exposure duration, the distance from the source to the surface, and the flow of water (Bordeavx & Moore, 1994) may be due to the formation of sufficient bonding in YSGG: Cr, Er and CO2 lasers on composite restorations. In the present study, there is no longer any need for superficial surface-to-surface composites to be applied using sandstone methods with aluminum particle coating or diamond blades, as well as the risk of ginning injuries following the use of etching acid.

The YSGG: Cr; Er laser is well absorbed by water and tough tooth tissues, and since water absorbs laser radiation better than dental tissues, this will reduce the increased temperatures of the tissues during preparation. Achieving smear-free surfaces, proper adhesion, lack of vibration, and no need for local anesthetic are, in most cases, other benefits of preparation with this type of laser.
On the other hand, in laser radiation, and in contrast to the use of phosphoric acid with etching of acid, the preparation time is significantly reduced (about 11 seconds per two minute), which is remarkable in clinical conditions for the patient and practitioner (Miserendion & Roberts, 1995). Due to the lack of significant differences in the time of acid etching processes, 11 seconds was considered as a basic data in this study. Of course, the total etching times were not recorded in the current study, but laser radiation leads to time savings because the reverse process of etching in the use of lasers no longer requires washing the surface of samples after etching. The approximate time for tooth extraction is about 15 to 30seconds, and the time required for the teeth to bond in the mouth under ideal conditions is about 300 to 600 seconds. It appears that the total amount of time-saving will be between five to 10 minutes, approximately.

It is important to treat the patient by implantation of the bracket in laser radiated teeth. Certainly, there is a need for a lot of research to determine the exact time of clinical work on this. The amount of adhesive remaining in different studies is based on Adhesive Remnant Index (ARI) as an indicator (Rizolu et al., 1998; Cobb, 2006). The application of this index facilitates the evaluation of defective levels and can be used to estimate several different indexes based on the amount of adhesion remaining in the level. Needless to say, comparing the results of various researches in this area is not easy, since most of them have changed the ARI index and reported different results. Plus, this index is very subjective and the separation between the teeth and resin is debonded and difficult to use (Chaconas et al., 1991). Concurrently, the index is reported differently in magnitudes of 10 and 20 (Chung et al., 2002). To prevent the breakdown or cracking of the enamel surface or restorations in the enamel surface, resin remains after the padding of the brackets on the dental surfaces (Bishara, 2000). It's necessary to note that the removal of detachable residue from the dental surfaces can be hard and time-consuming and may cause damage to the enamel or restoration surfaces. The adhesive material should have sufficient bond strength and resist the orthodontic forces as well as the strength of the mastic. After the treatment period, the withdrawal should be sufficiently comfortable and prevent damage to the enamel or restorations on the teeth. According to the results of this study, there are significant differences between the studied groups in terms of ARI index and the performance of the YSGG: Cr; Er laser, the radiation method yielded better outcomes than the other two methods in terms of the amount of adhesion left in the composite restorations. The role of other factors, such as the mechanism of the bracket, seems to be of importance in the values of the ARI index.

The results of this study indicate that none of the ARI indices (no adhesives on the composite restorations) were observed in samples prepared with phosphoric acid etching or YSGG: Cr, Er, and CO_2 lasers. Most of the samples in each of the three groups had an ARI index of three (10% to 90% adhesive on composite surfaces), and only YSGG: Cr, Er samples had a better residue rate than those of two other methods. 45% of samples provided with this method have an index 4 (Leave less than 10 % of adhesive on the composite surface), while the other two methods of preparation, 5% of the CO_2 samples and 10% of the phosphoric acid etching samples showed this index. On the other hand, phosphoric acid etching and CO_2 laser radiation yield similarly great composite surface outcomes, almost identical with each other. The greater frequency of ARI index of three in the samples studied in the present studies and in different preparation methods indicated that debonding is often used in surface treatment of composite restorations in resin. Clinically, this type of debonding is preferable, because, in these conditions, the need for cleansing the enamel or restoration surfaces of the debonded is less and thus, the risk of damage to the enamel or restoration time is reduced (Brunharo et al., 2013).

In clinical conditions, the prevalence of this type of debonding is higher due to the inability to control the humidity, temperature, time and movements of the patient fail to provide proper grounds for an optimal etching on the tooth surface (Hosseini et al., 2013). Conversely, the ARI indexes equivalent to 4 And 5 point out that the debonding has further occurred in the contact area of the tooth and resin, and the need to clean the deposited area is also insignificant and at the same time, the risk of enamel wearing or damages to the composite restorations surface is unlikely. In the present study, no case of Index 5 has been observed, and the incidence of Index 4 has been significant in the YSGG: Cr; Er laser radiation group. At the same time it is better to have the debonding in the contact area of the bracket-resin or inside the resin because, in the case of less adhesion on the teeth, the stresses affecting the enamel surfaces or restorations will be higher (Alizadeh Oskoee et al., 2013). Alsoö the reason for the base structure of the brackets is that the occurrence of debonding in the contact area of the resin and the bracket is less likely (Oshagh et al., 2013).

Sobouti et al.'s (2016) study, which aims to determine the shear bond strength of the metal brackets to the composite surfaces following the use of surface preparation with diamond blades, etching with hydrofluoric acid 9.6%, Sandblast with trioxide aluminum particles and YAG: Er radiation were performed at 1 and 3 watts, the lowest remaining adhesive values in the application of hydrofluoric acid (9.6%) and YAG (Er) laser radiation were observed at a power of 3 watts (Aboush et al., 1991). Due to the differences in the type of radiation laser and the type of acid used to prepare the surface, as well as the type of brackets in two studies, the comparison possibility of these results is not sensible. On the other hand, Tehranchi et al. (2011) reported the effects of CO2 laser radiation on porcelain brackets (ceramic) with the usual method and showed significant differences between the two groups in terms of ARI index (Merrill & Oesterle, 1994), which are consistent with the present study's results. In Hosseini et al.'s study (2011), there was no significant difference in the frequency of ARI indices in laser and acid groups, which is different from the present study (Hosseini et al., 2012). Gokcelik et al. (2007), higher degrees of ARI in the sample YAG: Er laser radiation was observed in comparison to the acid-ether group (Eslamian et al., 2012). Also, Alavi et al. (2014) compared the results of bonding of brackets to enamel following etching with acid and laser YAG: Er radiation. There is no mean difference in ARI indexes seen in the groups. Recent research's observations do not match the results of this study, which can be due to the type of brackets and substrates in two studies are different. Different types of brackets, as well as different laser radiation parameters, may cause the differences in research results in the ARI index.

5. CONCLUSION

In sum, all three surface preparation methods in the study have established the sufficient bond strength between the ceramic brackets and the composite restorations, and the YSGG: Cr, Er, and CO2 lasers are convenient methods due to their ability to create sufficient bond strength between the brackets and the composite restorations and advantages such as causing no damage to the gum tissues and their short procedure times suggested for clinical operations.

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