Original Article

Comparative Study of the Shear Bond Strength of Flowable Composite in Permanent Teeth Treated with Conventional Bur and Contact or Non-Contact Er:YAG Laser

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Abstract:

Introduction: The aim of this study was to evaluate and compare the in vitro effect of the Erbium-Doped Yttrium Aluminum Garnet (Er:YAG) laser with different radiation distances and high-speed rotary treatment on the shear bond strength of flowable composite to enamel of human permanent posterior teeth.
Methods: freshly extracted human molar teeth with no caries or other surface defects were used in this study (n=45). The teeth were randomly divided into 3 groups. Group 1: treated with non-contact Er:YAG Laser and etched with Er:YAG laser, Group 2: treated with contact Er:YAG Laser and etched with Er:YAG laser, Group 3 (control): treated with diamond fissure bur and etched with acid phosphoric 37%. Then the adhesive was applied on the surafces of the teeth and polymerized using a curing light appliance. Resin cylinders were fabricated from flowable composite. Shear bond strength was tested at a crosshead speed of 0.5 mm/min.
Results: The amount of Shear Bond Strength (SBS) in the 3 treatment groups was not the same ($P<0.05$).The group in which enamel surfaces were treated with diamond fissure bur and etched with acid (conrtol group) had the highest mean shear bond strength (19.92±4.76) and the group in which the enamel surfaces were treated with contact Er:YAG laser and etched with Er:YAG laser had the lowest mean shear bond strength (10.89±2.89). Mann-whitney test with adjusted P-value detected significant difference in shear bond strength between the control group and the other 2 groups ($P < 0.05$).
Conclusion: It was concluded that both contact and non-contact Er:YAG laser treatment reduced shear bond strength of flowable resin composite to enamel in comparison with conventional treatment with high speed rotary. Different Er:YAG laser distance irradiations did not influence the shear bond strength of flowable composite to enamel.
Keywords: Er YAG lasers; flowable composite; enamel

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Introduction

Dental caries are the most common infectious diseases in adult individuals, worldwide[1]. In recent years, there was some great progress in caries removal techniques towards non-invasive and conservative techniques, which are aimed to preserve the tooth structures. Michael Buonocore in 1955, laid the foundation of acid-etching and adhesive restorative systems. This caused a new approach in cavity preparations, and today, operative and pediatric dentistry aim to use fast and effective caries removal techniques with a minimum smear layer formation[2, 3].

Despite all the progress made in dentistry, yet using carbide and diamond burs, is the most common caries removal technique in dental offices. Conventional high-speed rotary causes some disadvantages and discomforts for patients, such as: bone-conducted noise, tooth crack and fracture caused by hand-piece vibration and thermal damages to pulpal tissues. Erbium Lasers are the most practical alternative techniques for caries removal, which provide some advantages like no noise or vibration, no smear layer formation, decreased recurrent caries caused by increased resistance of cavity walls to acid, decreased tooth sensitivity caused by sealing dentin tubules and reduced need for use of local anesthesia[4-8].

Erbium lasers family has been the ideal technique in pediatric dentistry because of their low depth of penetration in tissue, highly hydrophilic characteristic and lack of thermal damages. This family includes Erbium, Chromium doped Yttrium Scandium Gallium Garnet (Er-Cr: YSGG) and Erbium-Doped Yttrium Aluminum Garnet (Er:YAG) with 2790 nm and 2940 nm wavelengths, respectively[9,10]. The high-speed rotary technique can be replaced by Er:YAG Laser, first developed by Zharikov et al.[11] in 1975, which has a great potential for removing caries and hard tissues. Caries and hard tissues removal by laser, is done through the ablation process, in which most of the laser energy is absorbed by the water present in dental hard tissue, and then collagen and hydroxyapatite[12,13].

Recently, a brand new resin composite with low viscosity has been produced, called flowable composite with some characteristics such as low viscosity, low modulus elasticity and easily applicable. There are not enough studies about this kind of composite, used to increase adhesion to hybrid composite or lased hard tissues[14-19].

There are various studies evaluating the shear bond strength of laser-treated dentin[12, 20, 21], but there are not sufficient studies about the effect of laser on shear bond strength of enamel. Pelagalli et al.[22] reported that Er:YAG laser was equal or better than high speed rotary in the tested procedures of caries removal, cavity preparation, and etching prior to acid etching. Dunn et al.[23] and Martínez-Insua et al.[24] reported a decrease in bond strength to Er:YAG laser-irrigated dental hard tissues.

According to our knowledge, the literature only contains a few studies about shear bond strength of flowable composite to laser-treated enamel[25], therefore the aim of this study was to compare the shear bond strength of flowable composite to enamel, treated with contact or non-contact Er:YAG laser and conventional technique.

Methods

Freshly extracted human molar teeth with no carries or other surface defects were used in this study (n=45). Any remaining soft tissues were removed from the teeth surfaces using rotary brushes and dental scalers. The teeth were stored in 0.5% chloramine-T solution for one week and then in normal saline solution and room temperature, up to the beginning of the experiment and were used within 6 months after the time of extraction.

The teeth were mounted horizontally, in blocks of self-polymerized acrylic resin (Acropars - Iran) in order to leave only buccal surfaces exposed. Then samples were randomly divided into 3 groups:

Group 1: treated with non-contact Er:YAG Laser and etching with Er:YAG laser

Group 2: treated with contact Er:YAG Laser and etching with Er:YAG laser

Group 3 (control): treated with diamond fissure bur and etching with acid phosphoric 37 %

In group 1, enamel surfaces of the teeth were treated with non-contact hand-piece, pulsed mode Er:YAG laser (DEKA, Italy) with air–water spray cooling (2940 nm, 500mj, 5 W, 10 Hz, 4 mm distance from the buccal surface, spot size 1 mm). The distance was standardized using an endodontic k-file attached to the tip of the hand-piece and the laser beam was perpendicular to the tooth surface[26].

In group 2, enamel surfaces were treated with contact hand-piece Er:YAG laser (DEKA, Italy) with air–water spray cooling (2940 nm, 5 W, 500 mj,10 Hz, with no distance from the buccal surface).

In group 3 or control, enamel surfaces were treated with diamond fissure bur no.1 in sweeping moves (4 moves) with high-speed rotary and air–water spray cooling.

In groups 1 and 2, the enamel surfaces were etched with Er:YAG laser (2940 nm, 5 w, 10 Hz, 50 mj,4 mm distance from the buccal surface).

In group 3 (control), the samples were rinsed and dried, then the enamel surfaces were etched with acid phosphoric 37 % (Vivadent- Ivoclar, Germany) for 20 seconds and rinsed with water for 20 seconds and then dried completely for 10 seconds with air spray[23].

Then in all groups, one layer of dental adhesive (Heliobond, Vivadent- Ivoclar, Germany) was applied on the etched enamel surfaces, dried with air spray for 5 seconds[23] and then polymerized with curing light appliance (Coltolux, OH, US, 400 mW/cm²) for 10 seconds, according to the manufacturer's instructions.

After what, plastic tubes with a diameter of 3 mm and a height of 3 mm were filled with flowable composite (Vivadent- Ivoclar, Germany) and was polymerized for 40 seconds (Coltolux, OH, US, 400 mW/cm^2) according to the manufacturer's instructions.

Samples were stored in distilled water at 37°C for 1 day, for final adaptations[27].

Shear bond strength of samples was measured using Universal testing Machine (Zwick-Germany) at a crosshead speed of 0.5 mm/s and was calculated from the peak load at failure divided by the sample surface area.

The mean shear bond strength in mega pascals (MPa) was calculated for each group. The data obtained were analyzed using Kruskal-Wallis Test and Mann-whitney test with adjusted P-value for paired comparison between study groups.

Results

The mean amount of Shear Bond Strength (SBS) in groups one, two and three was 11.93±4.14, 10.89±2.89 and 19.92±4.76, respectively (Table 1), ($P > 0.05$). According to Kruskal-Wallis Test the highest mean rank belonged to control group (group 3) and the lowest mean rank belonged to group 2.

According to the result of Mann-whitney test with adjusted P-value, there was a significant difference in shear bond strength between the control group and two other groups (groups 1 and 2) ($P < 0.05$) but there was no significant difference in shear bond strength between groups 1 and 2 ($P > 0.05$).

Discussion

In recent years, there was some great progress in dental materials, caries diagnosis and caries removal techniques towards non-invasive and conservative techniques, which are aimed to preserve the tooth structures[20]. In 1978, Simonsen[28] introduced preventive resin Restorations (PRR) using small burs and minimal invasive preparation methods, including resin composite, adhesives and sealants. This was a successful preservative method indicated by further reports[29]. Today, with the introduction of resin composites with low viscosity and high resistance to wear (Flowable composites), this technique has turned to an easier method[30,31].

Laser is recommended in order to increase the adhesion of resin composites to dental hard tissues. Also, it is recommended to use for etching tooth surfaces[25]. However using laser for these purposes is still controversial; some studies suggested the use of laser for preparing or etching dentin[32-34], but some other studies reported that it is not an efficient method[35-37]. Among minimal invasive preparation techniques, Erbium lasers family is the most trustworthy one[38].

Least thermal damage has been reported using this laser[39]. Because of more comfort, less working time, noise, pain and fear, the use of Er:YAG laser in pediatric dentistry has increased. The caries removal mechanism of Er:YAG laser is based on the absorption of laser energy by water molecules present in dental hard tissues. This leads to increased pressure in the radiation spot and micro explosions which cause dental hard tissue to eject as micro particles. This process is accomplished with minimal or no thermal damages[38]. Enamel tissue undergoes some structural changes during the Er:YAG laser ablation process such as no formation of smear layer, surface irregularities and enamel prisms exposure. These changes are supposed to increase the bond strength of resin composites[40] but in fact, these micro porosities generated by laser ablation, do not have the same ideal pattern obtained by acid phosphoric application. Therefore this heterogeneous structure in lased enamel, affects the bond strength of resin composite[24].

The result of restorative treatments could be predicted by evaluating the shear bond strength of resin composites applied with various techniques[2,41]. There are some studies evaluating the shear bond strength of resin composites to lased dentin[12, 20, 21], but there are not enough studies about the shear bond strength of flowable composite to lased enamel[25]. Therefore this study was aimed to

Table 1. The results of One-Sample Kolmogorov-Smirnov Test for SBS.

Group	Mean±SD	P-value
Treated with non-contact Er:YAG Laser and etching with Er:YAG laser (group 1)	11.93±4.14	0.992
Treated with contact Er:YAG Laser and etching with Er:YAG laser (group 2)	10.89±2.89	0.980
Treated with fissure bur and etching with acid (group 3)	19.92±4.76	0.990

evaluate and compare the shear bond strength of flowable composite to enamel treated with conventional method and Er:YAG laser.

Pelagalli et al.[22] reported that Er:YAG laser was equal or better than the drill in the tested procedures of caries removal, cavity preparation, and etching prior to acid etching. Dunn et al.[23] and Martínez-Insua et al.[24] reported a decrease in bond strength to Er:YAG laser-irrigated dental hard tissues.

Yazici et al.[25] reported that there are differences in shear bond strength of Self-adhesive flowable composite according to the dentin treatment technique and it is higher for silicon carbide abrasive group, but there are no such differences for conventional flowable composite. In the current study, we concluded that treatment technique could affect the shear bond strength of conventional Flowable composite too, and specimens treated by conventional method using high speed rotary had significantly higher shear bond strength than the ones treated with Er:YAG laser.

Lessa FC et al.[42] in their study evaluated the influence of Er:YAG laser irradiation distance on the shear bond strength of an adhesive restorative system to primary enamel. They reported that different Er:YAG laser distance irradiations did not influence the shear bond strength of adhesive restorative system to enamel. Basaran et al.[43] in their study reported that laser Irradiation distance influenced the shear bond strength of adhesion to enamel and the mean shear bond strength obtained with the Er:YAG laser at 1 and 2 mm distances groups and with the Er,Cr:YSGG laser at 1 mm distance group were comparable to the mean shear bond strength obtained with acid etching group. In the current study, the results were in accord with Lessa FC et al. study[42] and we concluded that different Er:YAG laser distance irradiations could not influence the shear bond strength of flowable composite to enamel.

Previous studies indicated that the Er:YAG laser treatment associated with acid-etching can improve the bond strength of resin composite to enamel[26, 44]. Therefore, it is mandatory that new researches and studies indicate the efficiency of Er:YAG laser treatment previous to acid-etching.

Conclusion

According to Kruskal-Wallis Test, the highest mean rank belonged to control group (group 3) and the lowest mean rank belonged to group 2 and according to the result of Mann-whitney test with adjusted P-value, there was a significant difference in shear bond strength between the control group and two other groups (groups 1 and 2) ($P < 0.05$), but there was no significant difference in shear bond strength between groups 1 and 2 ($P > 0.05$).

Based on the results of this study and considering the limitations of in vitro studies, it can be concluded that:

- The specimens treated with conventional technique using a bur previous to acid-etching had higher shear bond strength than the ones treated with Er:YAG laser (contact or non-contact hand-piece).
- Different Er:YAG laser distance irradiations did not influence the shear bond strength of flowable composite to enamel.

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