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Research Article

THE EFFECT OF ND:YAG, ER: YAG AND DIODE LASER IRRADIATION ON SHEAR BOND STRENGTH OF ONE STEP SELF ETCH ADHESIVE SYSTEM TO ENAMEL

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ABSTRACT

Objectives: To evaluate the shear bond strength of one-step, self-etch adhesive to human enamel surface treated with Nd: YAG, Er:YAG, and Diode Lasers. **Methods:** A total of 40 freshly extracted premolars were collected and after cleaning were randomly divided into 4 groups (N = 10). Group 1 (C), one step, self-etc adhesive was applied as per manufacturer instructions, without using laser system served as the control group; Group 2, the adhesive was irradiated using Er-YAG laser (E) (2940 nm, 10, Hz, 0.4w, 40 mJ), Group 3, the adhesive was irradiated using Nd: YAG laser (N), and Group 4, the adhesive was irradiated using Diode laser (D). Post irradiation, composite build-up was done and samples were stored for 24 hours in 37^{O}C distilled water. The shear bond strength was measured using the Universal Testing Machine and data were analyzed using one-way ANOVA and post hoc Tukey test. **Result:** Group 4 (Diode laser) had the highest shear bond strength of 34.79 Mpa followed by Group 3 (Nd: YAG laser) with a shear bond strength of 24.41 Mpa. Group 2 (Er: YAG laser) had the lowest shear bond strength of 9.347 Mpa respectively. **Conclusion:** Irradiating one-step, self-etch adhesive with a Diode laser or Nd:YAG Laser before curing with LED can improve the shear bond strength.

INTRODUCTION

The concept of dental adhesion was introduced by Buonocore and later by Nakabayashi about 7 decades ago. [1]Adhesion to dental tissues is still achallenge for modern day researchers. Clinically, the success of restorations is dependent on the durability and quality of the bonding interface i.e. the restoration tooth interface. [2]

To improve the bond strength between the resin and the tooth, a well-known simplified etch-and-rinse system was developed comprising two steps: total etching and washing/drying, followed by the application of a primer/bond. To further reduce the number of clinical steps more versatile adhesive systems were developed: the etch-and-rinse system (two steps), and the self-etching system (one step or two steps). The self-etch systems outperformed the etch-and-rinse system [3, 4] and were immediately accepted for clinical use due to reduced steps as well as the reduction of human errors during their application. [5, 6]The simplification has significantly enhanced the efficiency of dental procedures, offering practitioners a more straightforward and time-saving application process due to the lower level of technical sensitivity of self-etch systems,[7, 8]

The incorporation and use of lasers in restorative dentistry have shown promising outcomes in various domains.CO_2 laser, Nd: YAG (Neodymium: Yttrium-Aluminum-Garnet), Er: YAG (Erbium: Yttrium-Aluminum-Garnet) and Diode lasers are some types of laser systems currently used in dentistry. [9] Lasers have found their way into cavity preparations, cavity tissue removal, decontamination of the oral cavity, and etching of enamel respectively.[10] Lasers continue to exert their influence owing to advantages like their utility in surface processing, control over light frequency, a broad range of frequencies, high energy density, and the capability to focus light precisely onto a point.

The application of laser energy to bonding agents before the curing process has been studied before. It has been theorized that this approach may enhance bond penetration,[11] facilitate solvent evaporation, elevate the degree of conversion [12], and increase the modulus of elasticity of the hybrid layer.[13]In addition, studies have confirmed improvement in mechanical properties and adhesion of resin-based materials when heated using lasers.[14] Given the inherent challenges in achieving

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predictable bonding outcomes, there is a need for innovative materials and methodologies to enhance tensile strength and durability. Therefore, the present study aimed to assess the shear bond strength between nanohybrid composites and 8th-generation bonding agents irradiated with different laser systems.

MATERIALS AND METHODS

This in-vitro study was conducted in August 2023 after obtaining approval from the Institutional Ethical Committee [MINDS/PG-ETHICAL/007/2021-22].

Selection and preparation of samples

A total of 40 extracted human premolars free from any caries, cracks, calculus, fluorosis, restoration, and intrinsic stains were collected, washed, immersed in 0.2% thymol for 24 hours, and stored in distilled water at room temperature. Teeth were mounted in self-cure acrylic resin with enamel of the occlusal surface exposed and then fixed in a cylindrical plastic container. A 3 mm x 3 mm window on the buccal/labial surface was defined as a test area. These samples were randomly divided into 4 groups: Group 1 - Control group (C), Group 2 - Er: YAG laser (E), Group 3 - Nd: YAG laser (N), and Group - Diode laser (D) respectively.

Method of Adhesive Application

Group 1 – Control group (C)

The adhesive [G-premio bond (GC dental)] was applied according to the manufacturer's instructions without using a laser system. A layer of bonding agent was applied using a micro brush, and after 10 seconds the enamel surface was subjected to a stream of dry air for the excess solvent to evaporate. The enamel surface was then cured using a light-emitting diode for 20 seconds.

Group 2 – Er: YAG Laser (E)

The adhesive G-premio bond was applied according to the manufacturer's instructions followed by irradiation with Er: YAG Laser (Doctor Smile, Pluser) in a noncontactmode. The adhesive was exposed to a laser beam for 30 seconds with a wavelength of 2940 nm, frequency of 10 Hz, power output of 0.4 W, and energy level of 40 mJ that operated in short plus mode at a distance of 5 mm and utilizing a swiping motion for motion style.

Group 3 – Nd: YAG Laser (N)

The adhesive G-premio bond was applied according to the manufacturer's instructions followed by irradiation with Nd: YAG Laser (Fotona, Lightwalker) in noncontact mode. The adhesive was exposed to a laser beam for 30 seconds with a wavelength of 1064 mm, frequency of 10 Hz, power output of 1.2 W, and energy level of 40 mJ that operated in short plus mode at a distance of 5 mm and utilizing a swiping motion for motion style.

Group 4 – Diode Laser (D)

The adhesive G-premio bond was applied according to the manufacturer's instructions followed by irradiation with Diode Laser (Dentlase) in noncontact mode. The adhesive was exposed to a laser beam for 30 seconds with a wavelength of 810 nm, frequency of 10 Hz, power output of 0.7 W, and energy level of 40 mJ that operated in short plus mode at a distance of 5 mm and utilizing a swiping motion for motion style.

Placement of restoration and Following the aforementioned procedures, composite resin was applied and cured using an LED light for 20 seconds in incremental layers. The treated surface was additionally light polymerized for 60 seconds and then submerged in distilled water for 48 hours.

Testing of shear bond strength

A jig of 4 x 1/8 inch was affixed to the Servo-controlled universal testing machine. The shear bond strength was tested by fixing the jig as closely as possible to the intersection of enamel and testing material and a crosshead speed of 0.5 mm/min was applied until the testing material dislodged and the values were automatically recorded. In Mega Pascals (Mpa). The procedure was repeated for all specimens of all groups.

The data was analyzed using IBM SPSS ver 20.0 (IBM Corp., Armonk, NY]. Shear bond strength was compared between the groups using the one-way ANOVA and a post hoc Tukey test. The level of significance was set at $P < 0.05$.

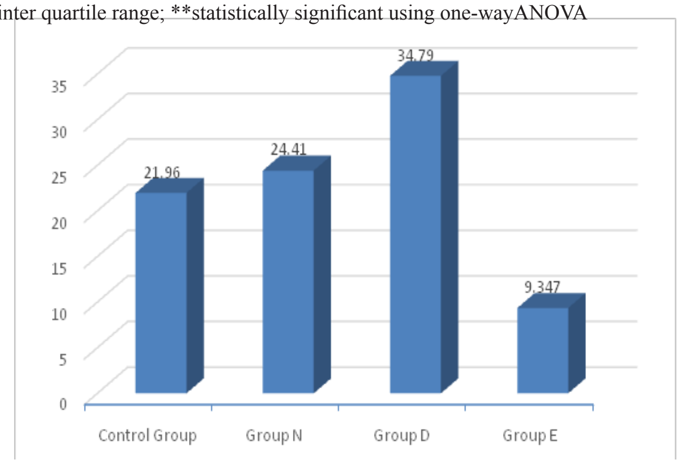
RESULTS

It was found that Group D had the highest shear bond strength followed by Group N while Group E had the least shear bond strength. The mean difference between the groups was statistically significant (P = 0.01). (Graph 1; Table 1)

Table 1 Comparison of mean shear bond stress by different laser systems

	Number	Mean	Median	IQR	P value
Group C	10	21.96	22.08	19.9 – 23.3	P = 0.001**
Group N	10	24.41	25.04	21.9 – 26.3	
Group D	10	34.79	35.02	33.7 – 37.7	
Group E	10	9.347	9.9	7.7 – 11.1	

IQR-inter quartile range; **statistically significant using one-wayANOVA



Multiple comparisons between groups revealed Group D had statistically significant higher shear bond strength than Group C (P = 0.001), Group N (P = 0.001), and Group E (P = 0.001) respectively. In addition, Group N was statistically significantly better than Group E (P = 0.001) and comparable with Group C (P = 0.42). Furthermore, Group C was statistically significantly better than Group E (P = 0.001). (Table 2)

Figure 1 Specimens divided into 4 groups: a.Control; b. Group E (Er: YAG); c. Group N (Nd: YAG); d. Group D (Diode laser)

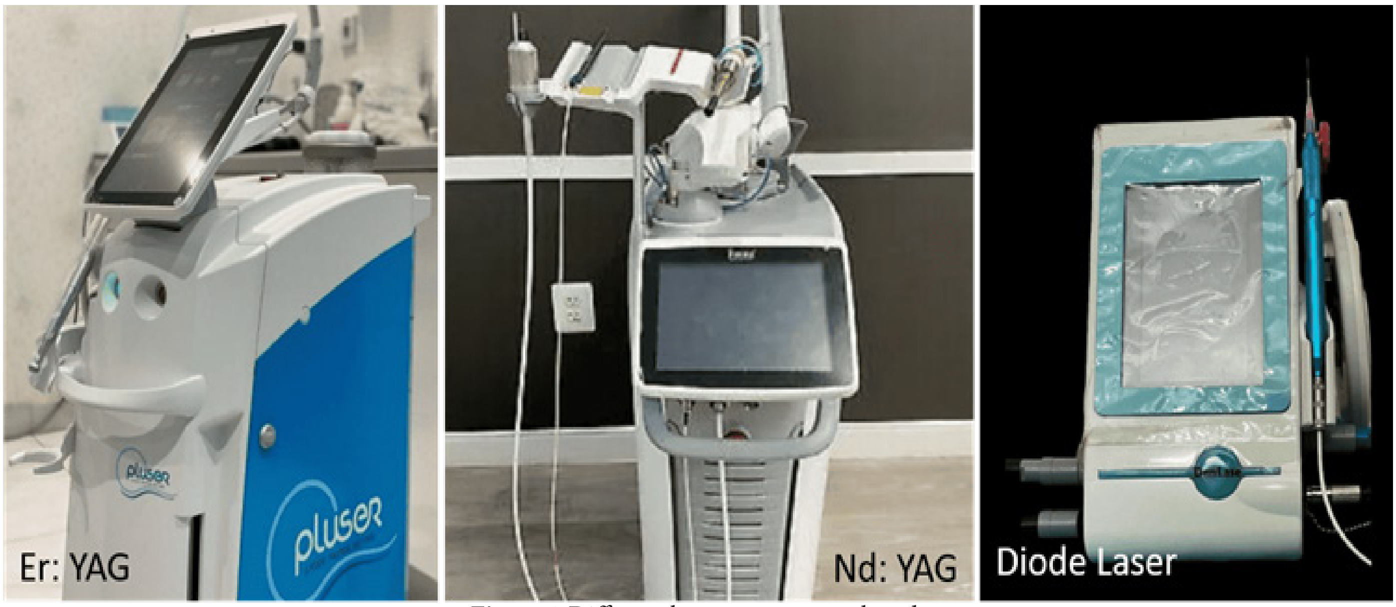


Figure 2 Different laser systems employed

Table 2 Multiple comparison between groups using post hoc Tukey test

		MD	P value
Group C	Group N	2.44	P = 0.42
	Group D	-12.8	P = 0.001*
	Group E	12.6	P = 0.001*
Group N	Group D	-10.38	P = 0.001*
	Group E	15.06	P = 0.001*
Group D	Group E	25.44	P = 0.001*

MD-mean difference; *statistically significant using post hoc Tukey test

DISCUSSION

The present study was designed to determine and compare the shear bond strength between nanohybrid composites and 8th-generation bonding agents irradiated with Er: YAG Laser, Nd: YAG Laser, and Diode Laser. Shear bond strength is a simple, quick, and accepted method to assess the bond strength of dental adhesives. [15] The higher the shear bond strength, the higher its ability to withstand stresses,ensuring therestoration's longer clinical success. The load used on the cross-head to determine the shear bond strength in the present study was 0.5 mm/min and were in the range of 0.45 mm/min – 0.75 mm/

Figure 3 a. Armamentarium;b. application of laser to samples; c. Universal Testing Machine; d. & e. jig with 4x1/8th inch with cross head of 1mm/min

min as recommended by the International Organization for Standardization. [16]

In the present study, G-premio adhesives irradiated with Diode lasers showed the highest shear bond strength followed by Nd: YAG, and the least shear bond strength was observed by Er: YAG lasers. The results of our study were in line with the

findings of Al-Ashou et al[1] and Srikumar et al [17] where G-premio adhesives when irradiated with diode lasers showed higher shear bond strength when compared to adhesives that were not irradiated.Another study by Ramachandruni et al reported that G-bond self-etch adhesives had higher shear bond strength when specimens were irradiated with diode lasers before polymerization with LED light as compared to those specimens that were not irradiated. [18]

G-Premio Bond are newer (8th generation) self-etch dental adhesives used for direct bonding, hypersensitivity treatment, and for repair cases respectively.[19] It can be attributed to its composition of three functional monomers 4 – methacryloxyethyl trimellitic acid (4-MET), 10-methacryloyloxydecyl dihydrogen phosphate (10-MDP), and Methacryloyloxydecyl dihydrogen thiophosphate (MDTP) that enables a stable bond with tooth structure, composites, metals (including precious), zirconia, and alumina. Its excessive fillers and photo-initiators help to obtain a strong bonding layer.[20] The 10-MDP monomer provides acidity that assists in etching the dentin surface thereby permitting the penetration of other components in the adhesive system inside the demineralized dentin. [21] In addition,the monomer also bonds chemically with the hydroxylapatite(HA) in the enamel and dentin forming 10 –MDP – Ca salts. Furthermore, the self-etch mode has the added advantage of 10-MDP chemically reacting with the remaining HA and improving the quality of bonding at a later stage. [22]

In the present study, three different laser systems were utilized. The use of diode lasers after bonding and before photopolymerization significantly improved the shear bond strength of adhesives. The results coincided with the findings of Maenosono et al, who reported an improvement in the shear bond strength after irradiating the adhesive before curing it with LED. [23] The use of lasers has been reported to improve the SBS of adhesives. [24] Resaei-Soufi et al in a study reported an improvement in shear bond strength when the adhesives were cured following irradiation with a diode laser. [25]This can be attributed to the role of heat and hot air creating a local hot spot which facilitates increased depth of penetration of adhesive systems thereby improving the bond. [26] In addition, a few authors hypothesize the creation of a new substrate due to the absorption of the laser beam which improves the dentin adhesive bond strength. [23, 26]

In the present study, the authors used Nd: YAG laser system which resulted in lesser shear bond strength than the diode laser but reported superior shear bond strength when compared to Er: YAG and the control group. This was partially in line with a study conducted by Marimoto et al [27]who reported better shear bond strength of Nd: YAG laser than the control group. In the present study, though, not statistically significant, Nd: YAG lasers reported improved shear bond strength than the control group. However, it was in contrast to the findings by Resaei-Soufi et al[25]who reported that Nd: YAG lasers had the lowest shear bond strength when compared to control and Er: YAG lasers respectively. Improved shear bond strength by both diode and Nd: YAG lasers can be attributed to similar wavelengths and absorption by water, melanin, and pigments. [28]

The use of Er: YAG lasers in the present study was associated with a reduced shear bond strength than the control group which was similar to findings by Resaei-Soufi et al,[25] Firat et al, [29] and Ramos et al.[30] The reduced shear bond strength can be explained by higher temperatures due to Er: YAG lasers that cause the evaporation of the solvent of the adhesives even before its penetration into dentinal structures. In addition, the ablative nature of Er: YAG laser might result in a modified dentinal surface which might not be conducive to bonding. Furthermore, Ramos et al postulated the creation of granular structures on dentin that might hinder with the bonding process. [30] It is imperative to understand that the effectiveness of laser irradiation as an adjuvant technique may vary depending on the type of laser used, the clinical situation, and the specific self-etch adhesive employed.

CONCLUSION

It can be concluded that both diode laser and Nd: YAG laser, when compared to the control group, positively influenced the shear bond strength observed between the tooth and composite. These findings suggest that incorporating either the diode laser or Nd: YAG laser as an additional step during composite restorations could be beneficial in enhancing the bonding performance in the studied context. The use of lasers in this manner might offer a valuable adjunct to traditional composite restoration procedures.

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