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Original Research Article

The effect of diode laser on the shear bond strength of one step self adhesive systems to human dentin: An in vitro study

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ABSTRACT

Background: Adhesives are integral to modern restorative dentistry for enhanced functional and esthetic outcomes. The use of lasers for improved bonding is on the rise and there is a need to understand the effect of lasers on adhesives.
Aim: The study aims to evaluate the effect of diode laser irradiation on one-step self-etch adhesive before their polymerization on the shear bond strength between resin cement and dentin.
Materials and Methods: Thirty extracted human teeth were collected and the buccal surface was grounded till dentin was exposed. A window of 3mm x 3mm was made on all the specimens that served as test sites and were randomly allocated to three groups (n = 10); Group 1: G-Premio bond without laser irradiation followed by photopolymerization; Group 2: G-Premio bond with laser irradiation without photopolymerization, and Group 3: G-Premio bond with laser irradiation followed by photopolymerization. The Shear Bond Strength (SBS) was determined using a Universal Testing Machine. One-way ANOVA followed by post hoc Tukey test was used with a level of significance at $P \leq 0.05$.
Results: SBS was significantly highest among Group 3 followed by Group 1 and the least SBS was found in Group 2 ($P < 0.001$). A post hoc test revealed significant differences between all three groups ($P < 0.001$).
Conclusion: G-Premio bond irradiated with a diode laser followed by photo-polymerization exhibited the highest SBS.

1. Introduction

The ideas underlying dental adhesion, the most well-known subspecialty of restorative dentistry, were first developed by Buonocore[1] and then by Nakabayashi.[2] With advances to improve the outcomes of restorative dentistry, retention to enamel was achieved with ease however, retention to dentin was still a challenge owing to its higher organic content, tubular structure, and formation of smear layer post tooth preparation.[3] The smear layer is removed by using the total etch or etch and rinse approach which was considered the gold standard.[4] To overcome the demerits of the total etch approach viz: over- & under-etching and the need for a more simplified method, the self-etch (SE) technique was introduced.

These adhesive systems include single bottle systems which combine priming and bonding in one step SE priming systems, which combine conditioning and priming in one step, and SE adhesive systems which combine priming and bonding.[5] Self-etch adhesive systems (6^{th}, 7^{th}, and 8^{th} generation adhesives) seem to outperform etch and rinse adhesive systems in dentinal bonding.[5–8] Bonding agents with strong and/or mild acid etchants are often associated with complications like nano-leakage,[9] hypersensitivity,[5] breakdown of collagen

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fibers,[10] water-related bond deterioration after aging,[11] and breakdown due to bond interferences,[12] due to multiple factors respectively.

G Premio bond is an 8th-generation bonding agent that is compatible with total-etch, self-etch, and selective etch techniques. The shear bond strength of the 8^{th}-generation bonding agents is better than its previous counterparts (5^{th}, 6^{th}, and 7^{th} generation) owing to their better stability and adhesive properties.[13,14] In addition, lasers have been found to play an important role in dentin conditioning since lasers can provide micro-retentive surfaces that are free of smear layers.[13] In addition, lasers have been found to play an important role in dentin conditioning since lasers can provide micro-retentive surfaces that are free of smear layers.[15] Some authors have reported a significant improvement in the SBS of bonding agents after irradiating with lasers before curing and after bleaching.[16–19]

Most studies reported above have utilized Nd: YAG lasers to improve the mechanical properties, diode lasers are also commonly used as an alternative since they provide near-infrared irradiation with parameters almost similar to Nd: YAG in addition to their affordability, portability, and smaller size.[16,20,21] Due to the lack of predictability in dentinal bonding, newer materials and methods are required to increase its tensile strength and longevity. Thus, an effort was made to evaluate the effectiveness of laser in improving dentinal bonding on 8th-generation bonding agents and nanohybrid composite. The study aims to evaluate the effect of diode laser irradiation on one-step self-etch adhesive before their polymerization on the shear bond strength between resin cement and dentin.

2. Materials and Methods

The study was conducted in the Dept. of Conservative Dentistry and Endodontics, Mahe Institute of Dental Sciences, Mahe, Puducherry UT in 2024.

About 30 freshly extracted non-carious intact maxillary premolars were collected, and the teeth were cleaned, sterilized, and stored in distilled water. The buccal surfaces of the teeth were ground using a diamond disc under water coolant till the dentin was exposed (Figure 1a). Cylindrical plastic containers were used and filled with self-cure acrylic resin. All 30 teeth (henceforth specimen) were vertically fixed until the cementoenamel junction with the long axis of the tooth perpendicular to the floor. The buccal surface of all specimens was covered with nail polish except for an area of 3 mm x 3 mm at the center that served as a test site. The specimens were then divided into three groups of 10 specimens each with different colors (Figure 1b).

Group A – Control group (G Premio bond without laser application)

Group B – G Premio bond (laser application without led curing)

Group C – G Premio bond (laser application with led curing)

2.1. Method of adhesive application

Group A – Application of G-Premio bond adhesive according to the manufacturer's instructions and then polymerization with LED curing light unit for 20 seconds.

Group B – Application of G-Premio bond adhesive according to the manufacturer's instructions followed by irradiation with a diode laser (DenLase) in a non-contact mode for 60 seconds.

Group C – Application of G-Premio bond adhesive according to the manufacturer's instructions followed by irradiation with diode laser in noncontact mode for 60 seconds.

The laser was applied freehand in a non-contact mode for 60 seconds (Figure 1c). During laser application, the laser tip was held perpendicular (90° angle) to the specimen's buccal surface and then polymerized with an LED curing light unit for 20s.

2.2. Restoration placement

Following the aforementioned procedures, a 3 mm x 3 mm plastic straw was used to apply the composite resin in increments that were polymerized with an LED curing light for 20 seconds. The treated surface was then light polymerized for a further 60 seconds after the straw had been incised, peeled off, and removed, leaving a composite cylinder bound to it. The specimens were immersed in distilled water for 48 hours (Figure 1d).

2.3. Shear-bond strength testing

After storage, each sample was individually tested using a jig measuring 4 × 1/8 inch attached to the Servo Controlled Universal Testing Machine with a cross-head speed of "1mm/min" (Figure 2a). Each specimen was individually mounted so that the chisel rod was applied vertically to the dentin-composite interface (Figure 2b,c). The test continued till there was a failure in bonding. The values of shear-bond strength were expressed in MPa (Newton/mm^2). A statistical analysis was then performed on the shear bond strength results.

The data was analyzed using SPSS for Windows [version 18.0,IBMCorp.]. Shapiro Wilk test was used to determine the normal distribution of data. Comparison of shear-bond strength between the groups was done using the one-way ANOVA with a post-hoc Tukey test. The level of significance was set at $P < 0.05$.

3. Results

It was found that mean shear bond strength was the highest for Group C and lowest for Group B. The difference

in mean shear bond strength between the groups was found to be statistically significant (P = 0.001) (Graph 1, Table 1). In addition, it was found that when compared to group A, group B had statistically significantly lesser shear bond strength (P = 0.002) and group C had statistically significantly higher shear bond (P = 0.001). Furthermore, it was found that Group B had lesser shear bond strength than Group C which was statistically significant (P = 0.001) (Table 2).

Figure 1: a: Diamond disc; **b:** Tooth samples in group A (black), B (white), and C (red); **c:** Diode laser; **d:** 8^{th} generation bonding agent and composite instruments

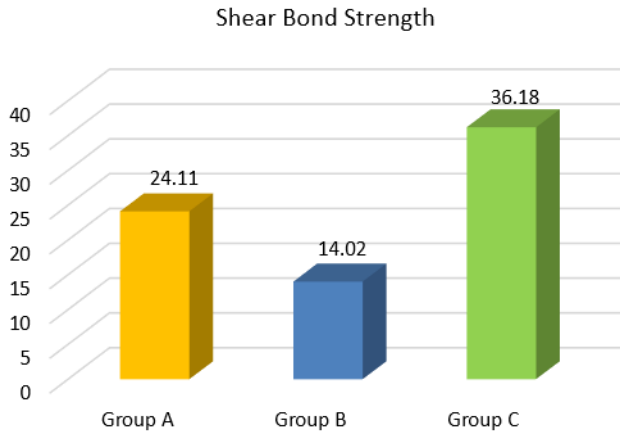
Figure 2: a: Universal testing machine; **b,c:** Tooth mounted with chisel-rod at dentin-resin interface on the universal testing machine

Table 1: SD-standard deviation; **statistically significant using one-way ANOVA

	Number	Mean	SD	F	P value
Group A	10	24.11	6.62	34.9	P = 0.001**
Group B	10	14.02	3.3		
Group C	10	36.18	7.1		

Table 2: MD-mean difference; *statistically significant using post hocTukey test

		MD	P value
Group A	Group B	-10.08	P = 0.002*
	Group C	12.076	P = 0.001*
Group B	Group C	22.16	P = 0.001*



Graph 1: Shear bond strength, highest in Group C

4. Discussion

Dental adhesives help create intimate contact between tooth structure and composite restorative materials thereby increasing the popularity of composite restorations. Shear Bond Strength (SBS) is one of the widely used methods to evaluate the bond strength of adhesives. Higher SBS can withstand higher stresses which is indicative of the clinical success of composite restorations. The present study was designed to evaluate the effect of diode laser irradiation before photopolymerization on the shear bond strength on a one-step self-etch adhesive system (8^{th} generation) to human dentine followed by the application of nanohybrid composite resin.

In the present study, the application of the G Premio bond (irradiated by laser and subsequent exposure to LED curing) showed the greatest SBS followed by the G Premio bond (with laser irradiation without LED curing) and the control group (G Premio only). Similar results have been documented by Srikumar et al.,[22] and Wiaam et al.,[23] who reported higher SBS among 8th-generation bonding agents when irradiated with a laser before photopolymerization. Various authors have also reported

higher SBS of 8th-generation adhesives when compared to 6^{th} and 7th-generation adhesives.[24] This increase in SBS can be attributed to the presence of a functional monomer 10-MDP (10-Methacryloyloxydecyl dihydrogen phosphate) that leads to the etching of dentin thereby permitting other components in the adhesive system to penetrate inside the demineralized structure.[25] A study conducted by Hegde et al in 2020 also reported higher SBS When G-Premio adhesives were used with the selective etch technique.[26]

G-Premio Bond are newer (8^{th} generation) self-etch dental adhesives used for direct bonding, hypersensitivity treatment, and for repair cases respectively.[27] 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. In addition, its HEMA-free formulation ensures the preservation of bonding layers and prevents any hydrolysis that might lead to discoloration.[28] Furthermore, 8th-generation adhesives are incorporated with SiO_2 nanoparticles promoting cross-linking with resin components thereby improving the mechanical properties of dentin bonding agents. In addition to having a higher SBS, G-Primeo bonding agents exhibited a higher micro tensile strength when tested after pre-etching on enamel surfaces.[29]

The use of lasers has been reported to improve the SBS of adhesives.[18,30,31] Franke et al., reported that direct heat supplied by laser irradiation leads to increased evaporation of the solvent and deeper penetration of bonding.[30] In addition, Reis et al also reported similar results with hot airflow on the surface of resin using the etch and rinse technique.[32] Several authors postulated that lasers promoted the formation of a 'substrate' arising from a fusion of dentin and adhesive due to heat from lasers. In addition, improved penetration of the dentin bonding system into dentin also improved the SBS.[30,33] Introducing lasers before photopolymerization has been suggested to promote evaporation of the solvent, increase the degree of conversion, improve mechanical properties, and improve the ability to adhere to dentin all of which justifies the effectiveness of lasers.[34–36] In addition, introducing Nd: YAG laser following the bleaching of the tooth surface also increases the SBS. The findings from the present study suggest that diode lasers are a promising substitute for Nd: YAG yielding similar results.

Other possible reasons could be due to the presence of silicate fillers,[37] low Ph,[38] and the ability of 10-MDP to chemically bond with dentin.[39] Maenosono et al.,on the other hand reported an increase in micro-tensile strength following the application of laser on the adhesives.[16] It can be speculated that a diode laser is a monochromatic source of light that generates the light in a single wavelength compared to LED which produces a broader band of wavelength and also has a broader optical spectrum might be the reason for the least bond strength seen in group B where laser irradiation after application of bonding agent was not followed by LED curing.

Laser irradiation showed promising results and may develop into a valuable clinical resource. To develop a more suitable methodology further in vivo and in vitro studies to provide a more appropriate protocol which is required to enhance the mechanical characteristics of the bonding system.

5. Conclusion

It can thus be concluded that irradiating 8^{th}-generation adhesives with a laser before LED curing results in higher SBS than curing the adhesives without irradiating with laser.

6. Ethical Approval

The permission to conduct the study was obtained from the Institutional Review Committee [MINDS/SS-iX/15042024/PG-011].

7. Conflict of Interest

None.

8. Source of Funding

None.

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