10.21608/ADJC.2023.196819.1261 Advanced Dental Journal
Volume 5 (2023) | Issue 4| Pages 966-972

**Original Article**

# Influence of Diode Laser Irradiation on Shear Bond Strength of Activa and Composite Resin Restorations in Primary Molars: An In-Vitro Study

**Sally Ahmed Kotb[1], Randa Youssef Abd Al Gawad[1], Shaimaa Sabry Mohamed[1]**

[1]Pediatric Dentistry Department, Faculty of Dentistry, Cairo University, Cairo, Egypt.

**Email:** sally_ismail@dentistry.cu.edu.eg

**Submitted:** 27-02-2023
**Accepted:** 18-04-2023

## Abstract

**Aim:** The aim of this study was to evaluate the influence of diode laser irradiation on the bond strength of two esthetic restorative materials; Activa bioactive restoration and composite resin. **Materials and Methods**: 104 primary molars were collected and divided into two main groups (n=52) (Laser and No laser). Teeth were mounted in acrylic molds and prepared to expose enamel and dentin surfaces. Samples of each group were randomly distributed into 4 subgroups: Activa + enamel, Activa + dentin, composite + enameland composite + dentin. Enamel samples were etched, while universal adhesive was used for Activa and composite samples in dentin. Diode laser irradiation (980nm wavelength, 1W power, continuous mode) was applied after adhesive application and before polymerization. After thermocycling for 500 cycle, microshear bond was measured using universal testing machine and values were obtained in MPs. Statistical analysis was done using three ways ANOVA. **Results:** Mean bond strength of enamel samples were significantly higher than dentin samples ($p<0.05$). In Activa bioactive restoration samples, diode laser irradiation significantly reduced microshear bond strength in enamel and dentin. Irradiation with diode laser did not significantly improve the mean microshear bond strengthin enamel and dentin composite samples. **Conclusion:** Diode laser irradiation did not improve bond strength of composite restorations when applied beforeadhesive polymerization of primary teeth and had negative effect on bond strength of Activa bioactive restorations.

**Keywords:** Laser Irradiation, Bond strength, Deciduous Teeth, Diode Laser.

## *I. INTRODUCTION*

One of the main challenges in adhesivedentistry is obtaining a reliable bond between composite restorations and dentin. The efficacy ofthe adhesive system depends on the formation of hybrid layer interface. Commonly used bonding agents cannot fully penetrate into the porosities. Therefore, microsized gaps remain between thecomposite and dentin (Hardan et al., 2021) Recently, a different approach was suggested to promote better adhesion to dentin via lasers.

Earlier studies proposed the laser irradiation already infiltrated dentin adhesive systems, prior to their polymerization. (Zhang & Jiang, 2020; Silva et al., 2019) Bioactive restorative materials are a relatively new concept in dentistry. They are reported to release more fluoride than glass ionomers. Additionally, they react to pH changes in the oral cavity by uptaking calcium, phosphate, andfluoride ions to maintain the chemical integrity ofthe tooth structure.

Activa bioactive restoration (Pulpdent, USA) is one such restorative material which comprises of a patented bioactive shock- absorbing rubberized ionic-resin (Embrace resin) matrix that contains a small amount of water.mechanically (Alkhudhairy et al., 2019). Activa bioactive restoration can be used with/without a bonding agent; however, recently, the manufacturer has recommended using any type of bonding agent (Kaushik and Yadav, 2017). Also, some studies concluded that applying adhesive resin with Activa bioactive restoration showed a dentine bond strength and marginal seal. (Benetti et al., 2019; Tohidkhah et al., 2022)

Bonding to dentin have been extremely studied due to its difficulty as this presents a great challenge for the operator. Although many articlesstudied the effect of diode laser irradiation on bondstrength to dentin, few studies evaluated the effectof diode laser irradiation on bonding restorations to primary teeth. Thus, this study was held to spotlight the effect of diode laser irradiation on micro shear bond strength of Activa bioactive restorative materials and composite resin to primary teeth (enamel and dentin).

## *II. MATERIALS AND METHODS*

The study design was invitro study. This experimental study was conducted on discarded natural primary molars. Teeth were indicated for extraction due to normal shedding, orthodontic reasons and over-retention. Primary molars were cleaned with pumice withoutfluoride to remove any surface debris or contaminants and disinfected using 0.01% Thymol for one week. Teeth were then examined under magnification to ensure the molars were free from cracks, fractures or any defects and were stored at room temperature in isotonic salinesolution till use (Alkhudhairy et al., 2019).

According to sample size calculations, the sample size was chosen to be a total of 104 teeth, splitted equally into eight subgroups, each had 13 teeth. This was based on minimum detectable difference in mean bond strength and that the minimum value recommended for bond strength to dentin in primary teeth was 17.6 MPa. This sample size would be able to reject the null hypothesis with probability (power) 0.8. The Type I error probability associated with the test of this null hypothesis is 0.05.

Teeth were randomly divided into two groups (n=52); Group I: Laser & Group II: No Laser. Each group was divided into two equal subgroups according to type of substrate: Subgroup E: Enamel substrate & Subgroup D: Dentin substrate. Each subgroup was divided into two equal suborders according to type of restoration: Suborder A: Activa bioactive restoration (Pulpdent, USA) & Suborder C: Composite resin Filtek Z350XT (3M ESPE, USA).

For enamel samples, primary molars with intact buccal or lingual surface were selected and roots were cut at the cemento-enamel junction to facilitate placement of sample in the mold. Enamel samples were mounted horizontally (buccal or lingual surface facing up) in cylindrical-shaped mold filled with self-cured acrylic resin. In dentin samples, teeth were mounted vertically in the acrylic resin within the mold revealing 1-2 mm of the crown. Then the occlusal enamel of the teeth was removed perpendicular to the long axis of teeth with model trimmer to reveal the flat mid-coronal dentin under water cooling Morresi et al. (2014). All surfaces were wet grinded by 800-grit abrasive paper until an even surface with a diameter of at least 3 mm of the tooth dentin was exposed. The generated smear layer was not removed. (Figure 1).

Enamel samples were etched with 37% phosphoric acid (Meta Biomed Co., Korea) for 20 seconds and rinsed thoroughly, excess water was removed by high volume evacuation for 1 - 2 seconds, leaving the preparation visibly moist (AlHabdan et al., 2021). Two separate coats of All-Bond universal adhesive (Bisco, USA) were applied, scrubbing the preparation with a microbrush for 10 - 15 sec per coat. Excess solvent was evaporated by thoroughly air-drying with an air syringe for at least 10 seconds (Ramachandruni et al., 2019). Dentin samples were not acid etched, universal adhesive was used in self-etch mode following the same steps mentioned for enamel samples. After universal adhesive application, diode laser treatment was performed on the substrate surface in non-contact mode from a distance of about 1 mm perpendicular to the surface. Diode laser irradiation with wavelength 980 nm (Photon plus, Zolar Technology, Canada),power of 1 W and continuous wave mode along with 300 µm optical fiber tip was used in the study(Zabeu et al., 2019). The diode laser energy was delivered by a hand-piece at a speed of 1mm/second, testing area was scanned for 10 seconds in circular motion from thecenter outward and then inward (Figure 2) (Zabeu et al, 2019). Laser irradiation was followed by 10 seconds of light-curing with output power of 2300 mW/cm2. In the second group (No laser) all specimen preparations and bonding procedures were the same as group I except that universal adhesive was light cured without laser irradiation.

To create a clear plastic mold for Activa bioactive restorations and composite (Filtek 350XT) restorations, a size 6 FG urology catheter was used. Plastic catheter was cut with lancet to obtain cylindrical mold measuring 1 mm in diameter and 1-1.5 mm in length. Plastic mold washeld securely and immobilized using cotton pliers on the indicated substrate (enamel or dentin) after applying adhesive system and after diode laser irradiation in laser subgroups. Activa bioactivematerial was injected in molds using automix tips with bendable 20-gauge metal cannula and light cured for 20 seconds in Activa subgroups. Composite samples were packed with FiltekZ350XT composite resin and light cured for 20 seconds.

Thermocycling was done according to the ISO recommendations, using 500 cycles. Dwell times were 25 seconds. in each water bath with a lag time 10 seconds. The low-temperature point was 5o C. The high temperature point was 550 C.

Micro-shear bond strength test was carried out with universal testing machine (Model 3345, Instron Industrial Products, USA) and wire loop debonding. A shearing load was applied with a loadcell of 5 kN at a crosshead speed of 0.5 mm/min. After microshear bond strength test, specimens were viewed using a USB digital- microscope (U500x Digital Microscope, Guangdong, China) (magnification x45) to determine failure mode pattern according to the following categorization; adhesive (Interfacial), cohesive (within tooth only or restoration only) andmixed.

Comparisons between groups with respect to normally distributed numeric variables were performed by independent t test. Three ways ANOVA was used to study the significance of interaction of variables. All p-values are two-sided. P-values ≤0.05 were considered significant and confidence interval 95% (CI=95%).

## *III. RESULTS*

Mean values of micro-shear bond strength test and standard deviations of Activa and composite restorations bonded to enamel and dentin with and without diode laser irradiation were summarized in Table 1. Statistical analysis of comparison between groups revealed that bond strength of Activa restorations bonded to both substrates (enamel and dentin) with diode laser irradiation was significantlyreduced compared with no laser group (p=002 & p=0.003 for enamel and dentin respectively). On the other hand, diode laser irradiation showed no statistically significant difference in bond strength of composite restorations bonded to both enamel and dentin.

As for comparison between restoration types, composite restorations showed significantly higher bond strength to enamel compared to Activarestorations when no laser irradiation was performed(p=0.002). However, Activa restoration had significantly higher mean bond strength than composite restorations when bonded to dentin withdiode laser irradiation (0.00001). Mean micro-shear bond strength of Activa and composite restorations bonded to enamel was significantly higher that dentin.

Regarding failure mode, most of the subgroups had more adhesive failure as compared to mixed failure. A higher percentage of adhesive failure wasfound in (dentin-no laser-Activa) subgroup (76.9%) group followed by (Laser-dentin-composite) subgroup (75%). In comparison, (Laser-enamel- Activa) showed the lowest percentage of adhesive failure with (18%).

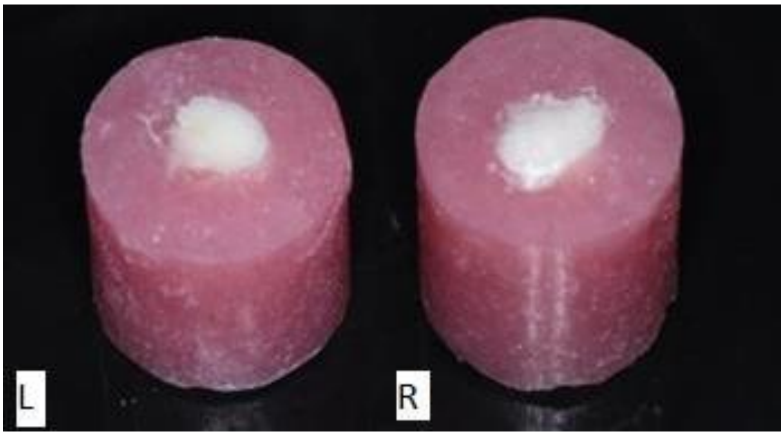


**Figure (1):** Photograph showing dentin sample after removal of occlusal enamel (Left), Enamel sample (Right).

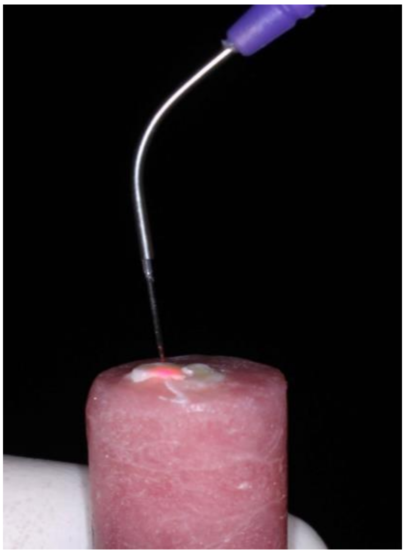

**Figure (2):** Diode laser irradiation after adhesive application and before light curing.

**Table (1):** Comparison between swabs from two groups during follow up time

| Subgroup | Suborder | Group | Mean ± SD | P value |
|---|---|---|---|---|
| **Subgroup E (Enamel)** | Suborder A (Activa) | GP I (Laser) | 19.68 ± 3.65 | 0.002* |
| | | Gp II (No laser) | 24.70 ± 2.92 | |
| | Suborder C (Resin composite) | GP I (Laser) | 18.44 ± 7.49 | 0.477 ns |
| | | Gp II (No laser) | 20.25 ± 3.68 | |
| **Subgroup D (Dentin)** | Suborder A (Activa) | GP I (Laser) | 13.61 ± 3.07 | 0.003* |
| | | Gp II (No laser) | 17.88 ± 3.46 | |
| | Suborder C (Resin composite) | GP I (Laser) | 19.74 ± 3.64 | 0.119 ns |
| | | Gp II (No laser) | 17.63 ± 2.63 | |

Significance level p≤0.05, * significant, ns=non-significantC.I.= 95% confidence interval

## IV. DISCUSSION

Diode lasers exhibit various advantages such as versatility, relatively small dimensions, and low costs that make them particularly useful in clinical applications. Since these lasers are widely utilized in dentistry, expanding the scope of their applicability can provide significant benefits (Malekipour et al., 2015). Different strategies have been proposed to improve the long-term dentin bonding strength. The association of lasers with dentin bonding systems has been investigated to achieve a more resistant hybrid layer. In order to develop a proper surface treatment procedure for each clinical situation, it is important to understand the effect of different strategies on the mechanical properties of different adhesivesystems.

The null hypothesis was adopted. For composite restorations, either for enamel ordentin. Laser and no laser subgroups showed no statistically significant difference in microshear bond strength, while for Activa bioactive restoration, either for dentin or enamel substrates, no laser subgroups showed higher microshear bond strength than laser subgroups.

It was also found that microshear bond strength of Activa restorations to enamel was significantly higher than composite restorations bonded to enamel when no diode laser irradiation was used. (p=0.002). This could be due to high calcium/mineral content in enamel. As Activa restorative forms a chemo-mechanical bond with the calcium and mineral content present in the tooth structure (Carvalhoet al., 2011). It may be suggested that the adhesion values found in the present study did vary due to the mineral/calcium content.

There was a statistically significant reduction in microshear bond strength of Activa bioactive restoration when substrates (enamel and dentin) where irradiated with diode laser after application of universal adhesive and before photopolymerization (p=.002 & p=.003 in enamel & dentin groups respectively). This could be attributed to the thermal denaturation of collagen fibers caused by laser irradiation. Chemical changes can also occur as a result of crystal liquefaction, that happen when the tooth is subjected to high temperatures. This liquefaction process could be responsible for obliterating the microporous surface and reduction in bond strength (Nijhawan et al., 2019; De-Melo et al., 2011). In general, diode laser irradiation did not improve bond strength of composite or Activa restorations in this investigation.

The results of present study were in agreement with (Malekipour et al., 2015) who reported that 808nm diode laser did not increase bond strength of composite to dentin. It was suggested that control group (non-lased) had higher bond strength due to partial closure of the dentinal tubules and lack of re-hydration of the laser radiated dentinal surface. Which caused morphological disturbance and prevented close adaptation between composite and dentin. It seemed also that using laser for heating the surface decreases the penetration ofthe bonding agent by creating morphological changes in dentin.

In line with the current study, (Zabeu et al., 2019) stated that 970nm diode laser treatment did not improve bond strength of non- simplified adhesive systems (4th and 6th generations). Scanning Electron Microscope (SEM) images showed a slight increase in resin tags length when diode laser was applied after primer in three-step etch-and-rinse adhesive system.

Contrary to the previous findings,(Maenosono et al., 2015) found that 970nm diode laser irradiation increased microtensile bond strength of two simplified adhesive. Where the author suggested that near-infrared lasers help in solvent evaporation and adhesive penetration. Also, (Kasraei et al., 2019) disagreed with the current study, as it was reported that application of 940 nm diode laserirradiation after bond application can significantly increase bond strength to dentin.

Ramachandruni et al., 2019 described opposite results to our present study as well. The author also suggested the formation of newlayer where in both the dentin and adhesive are fused, resulting in enhanced bond strength when compared to the non-lased group.

Many factors could explain the inconsistent results between authors who investigated the effect of diode laser irradiation on the bond strength. First, diode laser wavelengths and parameters were not the same in all these studies. 808, 810, 940 and 970nm wavelengthswere used in different investigations which could affect the amount of energy emitted to substrate. Also, power parameters, time of irradiation and diameter of fiber delivery tip were changed among studies. Using larger tip diameters would deliver less laser energy to thetarget tissue and vice versa. The influence of diode laser irradiation is related to absorption of laser radiation by hard dental tissues, which is dependent on the optical properties of the target tissue and on the characteristics of the laser, such as its wavelength, the emission mode (continuous or pulsed) and energy density (Verma et al., 2012; Malekipour et al., 2015).

## *V. CONCLUSIONS*

Within the limitations of this in-vitro study,it can be concluded that diode laser irradiation improved the microshear bond strength of composite restoration to dentin to a certain limitthat was statistically insignificant. On the otherhand, diode laser irradiation did not improve microshear bond strength of composite restorations to enamel when applied before adhesive polymerization. In addition to the factthat diode laser is expensive, and its applicationneeds certain safety precautions, it had negativeeffect on bond strength of Activa bioactive restoration to enamel and dentin.

**Conflict of Interest:**
The authors declare no conflict of interest.

**Funding:**
This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors

**Ethics:**
This study protocol was approved by the ethical committee of the Faculty of Dentistry- Cairo University on: 26-1-2021 approval number: 4-1-21

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