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Influence of Pre and Post Diode Laser Application on Microtensile Bond Strength of Etch and Bond and SelfEtch Adhesives to Dentin: An in Vitro Study

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KEYWORDS

Dentin bonding agent ,Diode laser, micro tensile bond strength

ABSTRACT:

Introduction: Dentin bonding agents have indeed seen significant advancements in recent years, leading to improved performance and clinical outcomes in restorative dentistry. It has led to improved formulation, stronger and durable bonds, improved moisture tolerance and reduced sensitivity. The idea of using laser irradiation to enhance the bond of adhesive to dentin before polymerization is an interesting approach. This method aims to improve the penetration of the adhesive into dentinal tubules, potentially leading to stronger and more durable bonds.

Objectives: To evaluate and compare the influence of pre and post Diode laser application on micro tensile bond strength of etch and bond and self etch adhesives to dentin.

Methods: 96 extracted teeth will be stored in 10% neutral buffer formalin. Decoronation done. The prepared teeth were then randomly divided into 3 groups. Each of the groups were again sub divided into two groups. Group 1a and 1b: Etching and bonding with etch and bond and self etch adhesive was done without the use of laser. Group 2a: Irradiation with laser first followed by etching and bonding with etch and bond. Group 2b: etch and bond applied followed by irradiation with laser prior to curing. Group 3a: Laser irradiation first followed by bonding with self etch adhesives. Group 3b: Bonding with self etch adhesives followed by irradiation with laser prior to curing.

Results: The mean micro tensile strength for Etch and Bond adhesives was found to be highest followed by self-etch adhesives.

Conclusion: Based on the results of the study, it can be concluded that using diode laser prior to curing after adhesive application resulted in higher micro tensile strength in both the adhesives (albeit higher for Etch & Bond)

1. Introduction

Dentin bonding agents have indeed seen significant advancements in recent years, leading to improved performance and clinical outcomes in restorative dentistry. It has led to improved formulation, stronger and durable bonds, improved moisture tolerance and reduced sensitivity. Bonding to dentin can be more challenging compared to bonding to enamel due to several inherent characteristics of dentin which are the tubular pattern, high water content, smear layer,

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pathophysiological changes such as hyper mineralization of dentin or formation of sclerotic dentin.

The introduction of 5th generation bonding agents represented a significant advancement in adhesive dentistry. These bonding systems, also known as etch-and-rinse bonding systems, were developed to improve the bonding procedure and enhance the quality of adhesion between dental restorative materials and tooth structure. 5th generation bonding agents typically involve a two-step etch- and-rinse protocol. One of the key advantages of 5th generation bonding agents is their ability to fill the porosities created on the tooth surface after etching.

Self -etch adhesive systems were introduced as a solution to address some of the challenges associated with traditional etch-and-rinse systems, especially concerning the depth of demineralization and resin infiltration. Deproteinization of the dentin surface is a technique used to reduce the organic content of dentin. Two common methods for deproteinization of dentin are: Chemical Deproteinization and Laser Irradiation.

The idea of using laser irradiation to enhance the bond of adhesive to dentin before polymerization is an interesting approach. This method aims to improve the penetration of the adhesive into dentinal tubules, potentially leading to stronger and more durable bonds. The use of laser irradiation on the adhesive surface after its application has been studied as a technique to enhance the bond strength in adhesive dentistry. This approach has been explored for its potential benefits, including better penetration of the adhesive into dentin and the evaporation of solvents.

The aim of this study is to investigate the influence of pre and post application of 940 nm diode laser irraditation on the Microtensile bond strength of adhesives of two different generations. The null hypothesis suggested that there is no influence of pre and post diode laser application on microtensile bond strength of etch and rinse and self etch adhesives to dentin.

2. Objectives

To evaluate the influence of pre and post diode laser application on micro tensile bond strength of etch and bond adhesives to dentin.

To evaluate the influence pre and post diode laser application on micro tensile bond strength of single bond adhesives to dentin.

To evaluate and compare the influence of pre and post Diode laser application on micro tensile bond strength of etch and bond and self etch adhesives to dentin.

3. Methods

The study was approved by the Institutional Ethics Committee (IEC),Ref No.- SU/SMS&R/ 76-A/2022/157, School of Dental Sciences, Sharda University.

This experimental study was conducted on 96 sound premolar teeth without caries, cracks, wear, structural anomalies, and restorations.

Specimen Preparation

The teeth after extraction were immediately immersed in 10% neutral buffer formalin solution at room temperature (23°C) for one week. All teeth were horizontally sectioned at their occlusal third by a disc. Decoronation of approximately 6mm was done. The teeth were randomly divided into three groups. Preparation of samples in each group (n=32) was done as follows: [Fig:1]

Group 1: Control group (N=32)

Group 1 was divided into two sub groups 1A and 1B with (n=16) in each group. In Group 1A dentin surface was etched with 37% phosphoric acid for 15 seconds, washed with water for 15 seconds and blotted dry with tissue paper. Two layers of adhesive (Ivoclar Vivadent Tetric N Bond Total Etch) bond was applied was cured with LED light curing unit with an output power of 3000 mw/CM2 for 10 seconds . The B3 shade of composite was applied for build up in three layers on dentin surface such that each layer had 2mm thickness.

In Group 1B Two layers of adhesive (Single Bond ,3M) bond was applied and the surface remained wet for 15 seconds and gently air dried for 5 seconds. Then, it was cured with LED light. The B3 shade of composite was applied and cured.

Group 2 (Laser and gen5. Bonding agent)

In group 2A, each group dentin surface was irradiated with diode laser (Biolase Epic X) with 940 nm wave length, 1W power, continuous wave mode and 400µm

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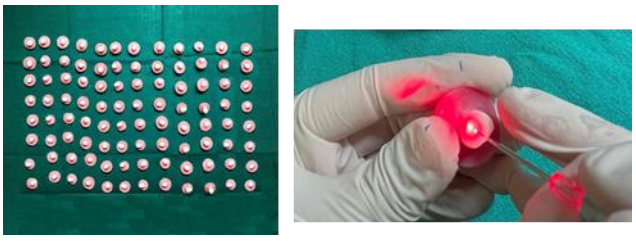
fiber tip size [Fig 1]. Irradation was performed in a circular motion from the centre outward and then inward. The surface after being laser irradiated was etched with with 37% phosphoric acid for 15 seconds. Two layers of adhesive (Ivoclar Vivadent Tetric N Bond Total Etch) bond was applied was cured with LED light curing unit with an output power of 3000 mw/CM2 for 10 seconds. The B3 shade of composite was applied for build up in three layers on dentin surface such that each layer had 2mm thickness.

In Group 2B , each group dentin was first etched with with 37% phosphoric acid for 15 seconds and two layers of generation 5 adhesive (Ivoclar Vivadent Tetric N Bond Total Etch) bond was applied. . The surface was then irradiated with diode laser[Fig:1]. The B3 shade of composite was applied for build up in three layers on dentin surface such that each layer had 2mm thickness.

Group 3(Laser and gen6. Bonding agent)

In group 3A, each group dentin surface was irradiated with diode laser (Biolase Epic X) with 940 nm wave length, 1W power, continuous wave mode and 400µm fiber tip size. Single bond was applied and the surface remained wet for 15 seconds and gently air dried for 5 seconds. The B3 shade of composite was applied for build up in three layers on dentin surface such that each. layer had 2mm thickness.

In Group 3B , each group dentin was first bonded with two layers of generation 6 adhesive (3m, Espe Adper Single Bond Universal Adhesive). Single Bond was applied and the surface remained wet for 15 seconds and gently air dried for 5 seconds. The surface was then irradiated with diode laser (Biolase Epic X) with 940 nm wave and 400µm fiber tip size.[Fig:1] The B3 shade of composite was applied for build up in three layers on dentin surface such that each layer had 2mm thickness.



(a) (b)

Fig 1: (a) Decoronated samples (b) Irradiation with diode laser

Measurement of Microtensile Bond strength

The samples were stored in distilled water for 24h at 37°C. the samples were then thermocycled for 1000 Cycles between 5°C and 55°C with a dwell time of 60 seconds in distilled water and a transfer time of 5 seconds.

The restored teeth were then sectioned in two directions to obtain dentin-composite dental sticks with a cross section of approximately $2\times2=4mm^{2.}$ The samples were selected and transferred to a universal testing machine Fig(2). The samples were glued to the device using cyanoacrylate adhesive. The bonding area was positioned vertically relative to the direction of application of tensile load. Tensile load was applied to the resin-dentin interface at a crosshead speedof 0.5 mm/minute until failure. Fig(2).

(a) **(b)**

Fig 2: (a) Dentin composite sticks (b) Universal testing machine

Statistical Analysis

The data was analysed using SPSS for windows (ver 22.0). The level of statistical significance was set at 0.05. One way ANOVA test followed by HSD post hoc , Tukey's test was done for evaluation of results.

4. Results

It was found that micro tensile strength was higher when diode LASER was exposed to adhesives after etching and bonding (35.7 ± 0.82) than when exposed before etching and bonding (26.15 ± 0.62). This difference was found to be statistically significant (P= 0.001). Similarly, it was found that micro tensile strength was higher when diode LASER was exposed to adhesives after application of self-Etching Adhesives (28.9 ± 0.79) than when exposed before (22.2 ± 0.79).[Table1, Graph 1] This difference was found to be statistically significant (P = 0.001).

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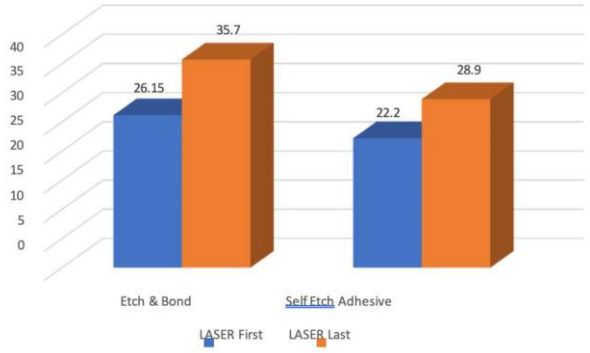
		N	Mean	SD	t	P value
Etch & Bond	LASER First	16	26.15	0.62	-37.06	P = 0.001**
	LASER Last	16	35.7	0.82		
Self-Etch Adhesiveness	LASER First	16	22.2	0.79	-16.2	P = 0.001**
	LASER Last	16	28.9	1.44		

N-number; SD-standard deviation; **Statistically significant at P < 0.01 using unpaired t-test



5. Discussion

This invitro study aimed in evaluating the effect of 940nm diode laser at various stages of application of etch and rinse and self etch adhesives on the microtensile bond strength of resin composite to dentin. The results showed an increase in the bond strength when dentin surface were irradiated with laser after application of adhesives prior to curing; thus rejectingthe null hypothesis. A statistically significant difference in the bond strengthwhen laser was irradiated on the dentin surface, after the application of bondingagent prior to curing was seen. It was also observed that the increase in bondstrength was significantly higher in etch and rinse when compared to self-etch adhesives. In a study done by Goncalves et.al., it was concluded that dentin treatment withlaser after the application of the adhesive system is efficient in achieving higher bond strength. This is because of the development of a new substrate, in whichdentin substrate and adhesive would be fused by the action of the laser.

Another study by Rafael Massunari et.al. ,it was concluded that diode laser irradiation is a promising technique for achieving better performance of adhesive systems on dentin. This research work is in coordination with the. where it was concluded that Nd-YAG laser irradiationon the surface of etched dentin leads to an increased penetration depth of adhesive system into dentin thus increasing the bond strength. The diode laser when compared to Nd-YAG has lower wavelength leading to more energy required and more penetration the laser beam and leading to an increased efficacy and efficiency. The use of laser after adhesive application increased the number of resin tags and improved the adhesive penetration into dentin and thus increasing the bond strength. The use of laser after adhesiveapplication, can improve the quality of hybrid layer which leads to an increase inthe bond strength.

The use of laser prior to etching leads to destruction of the organic components and morphological changes by laser because of the heat that is generated leading to recrystallisation of dentin and obstruction of dentinal tubules. The use of laser directly on the tooth surface prior to etching leads to loss of water content. This leads to the denaturation of the collagen fibres leading to dry bonding.

The bond strength of etch and rinse adhesives after laser irradiation was found to be higherwhen ompared with self etch adhesives. This result is in accordance with the studies done by Luhrs et.al. Perdigao et al. compared the enamel bond strength of self-etch adhesives with that of corresponding etch-and-rinse adhesives and reported that most of the etch-and-rinse adhesive systems bonded better to enamel than their corresponding self-etch adhesives. Tay et al. have repeatedly reported that dehydration of demineralized dentin results in osmosis of water content from deeper dentin, leading to weaker bonding due to osmotic blisters and hydrolysis of the adhesive.

With conventional etch- and-rinse systems, this depth of hybridization is typically reported to be in the range of 3–5 µm. However, with self-etch systems, the depth of interaction is shallower, ranging from1–2µm. Depth of interaction is even more limited with self-etch systems, reaching only 0.5–1 µm. An aqueous hydroxy-methyl methacrylate in total etch and rinse bonding agent promotes impregnation of resin into the exposed collagen and removal of smear layeraids in developing long resin tags by completely opening dentinal tubules.

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