Effect of Er:YAG Laser on Microtensile Bond Strength of Resin Composite to Recent Bleached Human Teeth

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Abstract: The aim of this study is to evaluate the effect of dentin surface ablation with low energy density Er:YAG laser on bond strength of resin composite to recently bleached enamel. In this study, 40 human anterior teeth , the enamel surface bleached using 30% carbamide peroxide. Samples were abraded with 300 to 600-grit abrasive papers to obtain flat dentin surfaces .The bleached samples were divided into two groups: group A: no Er:YAG laser ablation before resin composite application ; group B:dentin surface ablated with 50 mJ of Er:YAG laser before resin composite application .The adhesive system (Adper Single Bond 2) was applied and composite tubes were constructed with Filtek Z350 composite. The teeth were sliced to 1 mm width , along the adhesive interface, thin slices of dentin-resin and submitted to microtensile bond testing. Scanning electron microscope examination and analysis of the samples .The data were statistically analyzed by the ANOVA. The mean and standard deviation values of microtensile bond strength were 31.7 ± 4 MPa and 24.6 ± 3.8 MPa for lased bleached and non lased bleached dentin , respectively. it was concluded that Er:YAG laser irradiation prior to adhesive procedure of bleached teeth promoted a dentin surface with no smear layer and opened dentin tubules observed under SEM. **Conclusions:** Within the limit of this in vitro study Er:YAG dentin irradiation after recent bleaching procedures promote bond strength of dentin to tested adhesive system.

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1. Introduction

Tooth discoloration is becoming a greater concern as more emphasis is placed on esthetics. With the growing awareness of esthetic options, there is a greater demand for solutions to such unsightly problems as food staining, fluorosis, and tetracycline staining. Bleaching systems have been received by the public as a more conservative and economical method of improving the appearance of the dentition (1,2).

It is known that bleaching treatment is frequently recommended before adhesive esthetic restorations are performed. However, if adhesive restorations are made immediately after bleaching treatment, there are reports of a reduction in their bond strengths to enamel and dentin (3).

This bond strength tends to normalize after 7 to 14 days. Various antioxidant agents have been tested to reverse this effect, such as 10% sodium ascorbate and the catalase enzyme, although they are not yet applicable as routine clinical procedures (4,5).

Also Zimmerman et al reported that there is an evidence of an alteration on dentin after enamel whitening treatment penetration into dentin structure revealing a loss or denaturation of collagen by FTIR analysis, nanoindentation, and fluorescence microscopy (6) .

The presence of new technologies of conservative dentistry, such as lase, has brought indisputable benefits to modern dentistry. The use of Er:YAG laser has been widely disseminated in restorative dentistry for the removal of carious tissue, dental surface conditioning, enamel and dentin treatment in adhesive esthetic procedures, in this case, with the purpose of minimizing marginal microleakage and increasing bond strength (7) .

Er:YAG laser was approved by the Food and Drug Administration (FDA) for dental hard tissue and does not cause thermal damage under safe and studies protocols [8,9].

The Er:YAG was proposed by many investigators to be a promising type of laser for cutting hard dental tissues with minimal pain and thermal damage . This was presumed as its wave length 2.94 µm coincides with the absorption peak of the hydroxyaptite crystals , collagen and water which are the major constituents of dentin (10 -12).

The wavelength of the Er:YAG laser modifies hard dental tissue once it acts on their properties, including permeability, microhardness, and acid resistance (11). The Er:YAG laser at a low-energy setting can modify the dentin surface (13).

Considering the ablative effect of the Er:YAG laser on the dental, it is believed that the use of it could influence the post-bleaching bonding, by promoting substrate heating and causing alterations in dentin morphology. This laser treatment could be capable of eliminating the residual free radicals and neutralizing the immediate effects of 30% carbamide peroxide bleaching agents on bond strength, allowing restorations to be replaced immediately. Thus, the aim of this study was to evaluate the effect of Er:YAG laser ablation on the adhesion of bleached teeth.

2.Materials and methods

Sample selection and preparation:

Forty extracted human anterior teeth stored in saline solution were used in this study. The teeth were cleaned, and the roots were removed.. All samples were checked with a digital caliper and under 40× magnifications to eliminate those with flaws or irregularities. The samples were embedded into cylindrical polystyrene molds (Cristal, Piracicaba, SP, Brazil) and polished with 6, 3, ½ and ¼ µm diamond grit (Arotec, So Paulo, SP, Brazil).

Bleaching procedures:

All samples were bleached with carbamide peroxide at 30% (VivaStyle 30%, Ivoclar Vivadent, USA) for 2 application, one week interval, for 30 minutes /application. An elastomeric matrix was used to control thickness and flow of the bleaching agent. Samples were stored in 10 ml of artificial at saliva 37°C that was changed daily. The artificial saliva contained calcium and phosphate in a known degree of saturation to mimic the remineralizing properties of natural saliva (50 mmol/l KCl, 1.5 mmol/l Ca, 0.9 mmol/l PO4, 20 mmol/l tri- hydroxymethyl-aminomethane, pH 7.0) [14-16]. After finishing bleaching procedures, the buccal surfaces were ground using 300 to 600-grit abrasive papers to obtain flat standardized dentin surfaces [11,12]. The specimens were randomly divided into two groups (n=20), according to either laser dentin surface treatment:

– Group A: No treatment to dentin surface with Er:YAG laser
– Group B: Dentin surface were treated with Er:YAG laser

Er:YAG laser irradiation procedures on dentin surface:

The Er:YAG laser (KaVo KEY Laser II – KaVo, Biberach, German), Its wavelength was 2.94 µm in infra red region , and a pulse duration of 250–400 µs was used to irradiate the dentin surfaces, with beam diameter of 0.63 mm, The output power was 100 mJ, repetition rate fixed at 2 Hz.. All the area of the dentin was irradiated in uniform manual gridding pattern for 40 s by a single operator. In order to standardize the working distance of 12 mm of the handpiece from target, an endodontic K-file was fixed to the laser hand-piece [14].

Resin composite application:

Dentin surfaces were cleaned with water spray for 5 seconds and dried with oil and water-free compressed air for 3 seconds. Details of bonding adhesives and composite are provided in Tables 1 . Prior to application of the bonding resin on each specimen, hollow cylinders 4 mm in height were cut from micro-bore tygon tubing (Norton Performance Plastic; OH, USA) with an internal diameter of 0.75mm and were placed on the treated surfaces. Adhesive system was applied according to the manufacturer's instructions as follows:

The dentin surface was etched (using Scotchbond) for 15 s with 35% phosphoric acid, and rinsed with water spray for 15 s. Excess water was removed with cotton pellet or mini sponge leaving the dentinl moist. Bond (Adper Single bond 2)was applied with a disposable brush, 2 consecutive coats for 15 s with gentle agitation using a fully saturated applicator . Gently air thin for five seconds in evaporative solvents. Light cured for 10 s using a halogen light source (Visulux curing unit, Vivadent; Schaan, Liechtenstein). The output of the light curing unit was regularly checked (500 mW/mm2). The resin composite bonded teeth samples were stored in distilled water at 37°C for 24 h.

Table 1: Composition, lot number, and manufacture of the tested materials

Material	Composition	Lot number	Manufacture
Scotchbond etchant gel	35 % phosphoric acid	N 110268	3M ESPE
Adper Single bond 2	(10% colloidal nanofiller), BisGMA, HEMA, dimethacrylates,ethanol, water, a novel photoinitiator system and a methacrylate functional copolymer of polyacrylic and polyitaconic acids	N353034	3M ESPE
Filtek Z350 XT	(20 nm silica filler , 4-11 nm zirconia filler) as 72.5% by w filler, bis-GMA, UDMA,TEGDMA, PEGDMA and bis-EMA resins	N339145	3M ESPE

Microtensile bond strength test:

Each tooth was mounted on the cutting machine (Bronwill; E. McGrath Inc, 35 Osborne Street Salem MA 01970 v: 978-744-3546 f: 978-741-4020) (*figure1)*, and sectioned into a series of 1 mm thick slabs under water cooling. The sectioning was performed using a diamond disc of 4"diameter x 0.3 mm thickness x 0.5" arbor impregnated diamond cutting blades with wear-resistant Ti-C coating for low speed saw (IPDB40305, MTI Corporation 860 South 19 Street, Richmond, CA 94804, USA). Again, by rotating the tooth 90° and again sectioning it lengthwise, sticks of 1.0 mm^2 cross-section area were obtained. The central sticks from each specimen were selected and their thickness was checked using a caliper (Figure 2). The specimens were then subjected to the microtensile bond strength testing.

Figure (1): The cutting machine with diamond disc mounted

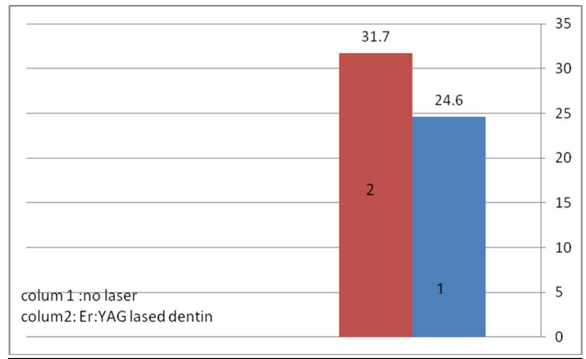
Figure (2): Beam width and breadth measurement before µTBS testing

Statistical Analysis:

Regression model using two-way Analysis of Variance (ANOVA) was used in testing significance for the effect Er:YAG irradiation on mean microtensile bond strength of resin composite to recent bleached teeth of adhesive system, dentin condition and their interactions on.

The significance level was set at $P \leq 0.05$. Statistical analysis was performed with IBM® SPSS® Statistics Version 20.

3.Results: The mean and standard deviation values of microtensile bond strength were 31.7 ± 4 MPa and 24.6 ± 3.8 MPa for lased bleached and non lased bleached dentin , respectively.



Figure(3): Bar chart representing mean values for comparison between microtensile bond strength of the Er:YAG lased bleached dentin and non lased bleached dentin

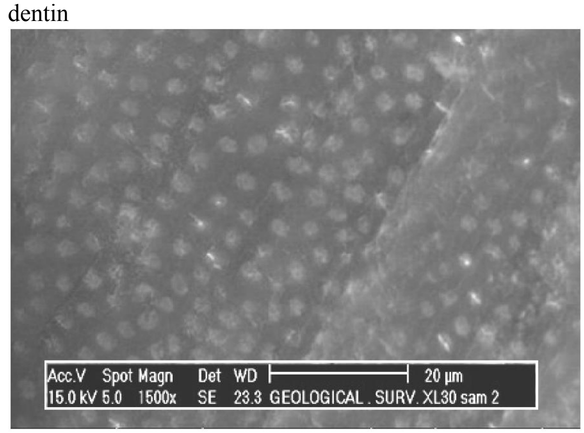


Figure (4): Scanning electron microscopic (SEM) photographs, magnification 1500, of the dentin surfaces of bleached teeth A smear layer is all over the dentin surface and occluded dentin tubules may be observed.

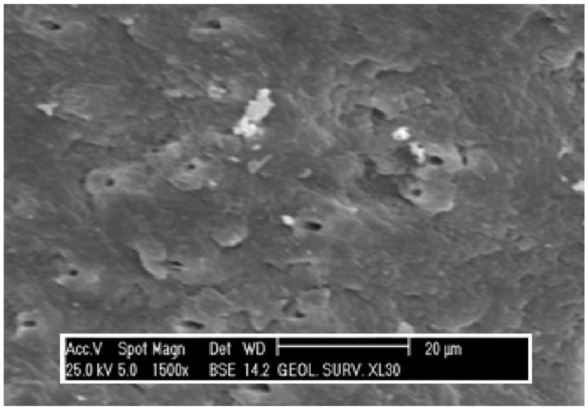


Figure (5): Scanning electron micrographs (SEM), magnification 1500, of the dentin surface of bleached teeth irradiated with Er:YAG . The Er:YAG laser created a surface with absence of smear layer, opened dentinal tubules, and irregular and microretentive morphological pattern. The intertubular dentin was removed more accentuated than the peritubular dentin. The peritubular dentin ,like a cuff, is more evident around dentinal tubules opening.

4. Discussion:

Sometimes, after bleaching treatment it is necessary to perform esthetic procedures using adhesive systems. Also Buchalla and Attin stated that optimal bleaching results cannot normally be achieved with a single application of in-office bleaching [18] However, restoring the original features of the tooth immediately after bleaching has been a hard challenge, due to difficulties in obtaining adequate bonding to dental substrate.

There is an importance of saliva usage in bleaching studies. Accordingly, this study utilized a multi-appointment procedure, artificial saliva containing an electrolyte composition similar to that of human saliva, and a bleaching agent with a neutral pH[19].

Vital dental bleaching with carbamide peroxide is a safe and conservative procedure for tooth discoloration [20]. Carbamide peroxide, widely used in modern dentistry today, is effective for the bleaching procedure at 10% but the use of increased concentration has been developed for faster brightens results [21, 22].

It was reported that the higher concentration and frequency of hydrogen peroxide application the quicker the bleaching result and the higher of side-effects and the residual peroxide might impair resin bonding to enamel and dentin if a restoration needs replacement to achieve optimal shade matching. This undesirable effect may occur because of the presence of residual hydrogen peroxide and its free radicals and also due to the less mineral content and more organic matrix, the dentin substrate may be more compromised .Also residual oxygen interfering in the process of polymerization of resin composites at the tooth–restorative material interface [23-26] . Thus, the adhesive procedures may be compromised when performed immediately after bleaching treatment, diminishing the bond strength and increasing the possibility of marginal leakage in restorations [27] .

In our study the Er:YAG laser acts on the dentin surface by creating a smear layer free area with open tubules with certain low-density energy output ,this coincide with Giachetti et al.who stated that the Er:YAG at a low-energy setting can modify the dentin surface irradiation and conditioning must have an output inferior to 200 mJ to tissue ablation [28]. The irradiation produces microexplosions during tissue ablation that can remove dentin . These microexplosions lead to the ejection of organic and inorganic tissue particles that can be noted in the scanning electron microphotographs' evaluations and created irregularities on the irradiated surface without smear layer and opened dentinal tubules [29-31] .

The higher lased dentin bond strength may attribute to that the heat generated by Er:YAG laser at low-energy help in vaporization and release of the residual bleaching agents and free radicals present in dentin substrate and these agents are very unstable . The modified dentin give better substrate to receive the adhesion procedures.

5. Conclusions:

Within the limit of this in vitro study Er:YAG dentin irradiation after recent bleaching procedures promote bond strength of dentin to tested adhesive system.

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