

INFLUENCE OF DIFFERENT BLEACHING SYSTEMS ON THE BOND STRENGTH OF LAMINATE VENEER TO ENAMEL

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ABSTRACT

Purpose: The objective of this in-vitro study was to examine the microtensile bond strength of a porcelain laminate veneer (PLV) to tooth surface bleached with photoactivation by blue light-emitting diode (LED) or diode laser. **Methods:** Eighteen extracted human central incisors were randomly divided into three groups. Two sticks were obtained from each tooth (n=12). Before surface treatments; teeth were prepared to provide space for PLVs. The first group teeth were bleached with Whiteness HP which is contain 35% hydrogen peroxide (HP) and then photoactivated with a LED for 20 seconds. The second group were bleached with Laserwhite 20 which is contain 46% HP and photoactivated with a diode laser for 30 seconds. The third group received no surface treatment and served as the control group. IPS Esthetic ceramic veneers were luted with Variolink II veneer cement. The teeth were sectioned to obtain porcelain-resin-enamel/dentin sticks and submitted to a MTB testing device. The maximum load at fracture was recorded. Data were analyzed using one-way ANOVA followed by the Tukey HSD post-hoc test at a preset α of 0.05. **Results:** One-way ANOVA revealed that there was significant difference between LED unit group and control group ($p < .05$) but no statistical differences were observed with diode laser group ($p > .05$). The LED unit group presented significantly lower bond strength value (6.49 ± 2.3 MPa) than diode laser (8.49 ± 3.1 MPa) and control groups (9.53 ± 2.7 MPa). **Conclusion:** The results suggested that bleaching therapy with activation by LED or diode laser reduced the bond strength of IPS Esthetic ceramic veneers to tooth surfaces.

Keywords: Teeth Bleaching; Photoactivation; Semiconductor lasers; Diode laser; Microtensile.

INTRODUCTION

Tooth whitening is one of the most popular esthetic procedures used in modern dentistry [1,2]. Tooth bleaching, laminate veneer restoration, all-ceramic restoration and tooth manicure are used for tooth whitening [3]. Despite major advances in porcelain veneers some difficulties still in progress such as treatment of teeth that have been heavily discolored by intrinsic staining (tetracycline) and endodontic treated tooth. In this way a minimally invasive procedure such as dental bleaching and porcelain veneers can be used together that should be an option when color is the main concern [4,5].

Any change in the surface properties of both enamel and dentin after bleaching is likely to have an impact on the bonding effectiveness. Previous studies have shown that carbamide peroxide (CP) bleaching agents in the

range of 10 to 35% adversely affect the bond strength of composite to acid etched enamel when bonding is performed immediately after bleaching procedure [6-8]. Again the studies utilizing 25 to 38% hydrogen peroxide showed that both shear and tensile bond strength of all composite restorative materials tested were significantly reduced when composite application (including acid-etching pretreatment) was performed within 1 day after completion of bleaching regime [9-16]. Tittley et al [17] reported that resin tags in bleached enamel subsequently acid etched with 37% phosphoric were less defined, more fragmented and penetrated to a lesser depth than in unbleached enamel controls.

Although home bleaching is effective and has become widely accepted during the past 10 years, in-office bleaching technique has more advantages compared with home bleaching. These include control by the dentist, avoidance of soft tissue exposure and material ingestion, reduced total treatment time and great potential for immediate results to patients [18-20]. In-office bleaching procedures seem to be an appropriate alternative to home bleaching applications with trays, foils or gels especially in the case of very severe discolorations, discolorations of single teeth, lack of patient compliance or if a rapid treatment is desired [21].



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Several different type of irradiation sources have been used to accelerate the in-office bleaching procedure and are claimed to reduce the total in-office bleaching time [18,22]. The activation of the chemical agent involved in the whitening process can be performed by heat, light or laser [20,21]. In early systems, a heated spatula or a heat lamp were recommended as catalyst. The temperature achieved by these instruments were high increasing the risk of cracks on the enamel surface and pulp irritation [23,24]. The main objective of using a light source is not to directly whiten teeth but to activate the whitening product. This is achieved via the light absorption process of the photosensitive agent (a dye) and the transference of the absorbed energy to the peroxide which result in an accelerated oxidation-reduction reaction [20,25,26].

Although there are many studies on bond strength of porcelain laminate veneers (PLVs) bleached enamel, there isn't adequate information about the bond strength between ceramic laminate veneers and bleached enamel with activated bleaching regimes. Thus purpose of this in-vitro study was to examine the microtensile bond strength (MTBS) of a PLV to enamel bleached with activation by light and a diode laser. The null hypothesis was that the MTBSs of ceramic laminate veneers to bleached enamel with activated bleaching gels would be lower than that of ceramic laminate veneers to unbleached enamel.

MATERIALS AND METHODS

Study design: A comparative cross-sectional experimental study

Ethical approval: All experiments using human dental tissues were approved by Institutional Review Board of Necmettin Erbakan University (NCU 2015/001) which was conducted in full accordance with the World Medical Association Declaration of Helsinki.

Study location: Study was done in Department of Prosthodontics care at Selcuk University and Necmettin Erbakan University, Konya.

Study period: Over a period between April 2015 to May 2017.

Sample size: Teeth of similar dimensions and shapes were selected for the study.

Inclusion criteria: Human central incisors were used in this study. Each tooth was free of dental caries or restorations, were lost by periodontal problems, were permanent teeth and had large enough crown to be microtensile applying.

Exclusion criteria: Small and primary teeth for central incisors, colored teeth because of tetracycline and trauma.

Methodology

Eighteen extracted human central incisors were used in this study. The teeth were brushed to completely remove soft tissue remnants and stored in distile water at room temperature immediately after extraction. Following cleaning, the teeth were sectioned 2 mm below the cemento-enamel junction with low-speed rotary saw (Isomet; Buehler Ltd) and crown parts were embedded into a self-cure acrylic resin (Meliodent; Bayer Dental Ltd) labial surface facing up. Teeth were randomly divided into three groups of six each.

Self-limiting depth-cutting disks (Laminate Veneer Kit 4151; Komet) of 0.5 mm were used to define the depth cuts, and then 1.2 mm chamfer diamond burs (Laminate Veneer Kit 4151; Komet) were selected to refine the preparation. All teeth preparations were completed without sharp line angles. Cervical finish lines were chamfered and the incisal finish was with a incisal bevel preparation similar to a previous stud [27].

Impressions of the 18 prepared teeth were made with a polyvinyl siloxane impression material (Elite HD; Zhermack SpA). Impressions were cast in vacuum mixed die material (Alpha Die MF; Schultz Dental GmbH) according to the manufacturer's directions with respect to powder/water ratio and mixing time. The stone dies were recovered from impressions and two coats of a die spacer (Cement Spacer; Kerr) were painted 0.5 mm short of the finish lines of the preparations.

The veneers were waxed (SU Ceramo Carving Wax; Schuler Dental), sprued, and then pressed after investment. All procedures were performed with IPS Empress Esthetic materials (Ivoclar Vivadent AG) and protocol, following the manufacturer's recommendations. After divestment, the ceramic veneers were finished with diamond burs (Shenzhen Perfect Medical Instrument Co Ltd) then veneers were glazed.

Teeth were randomly divided into three groups of six specimens each. Two of groups were assigned according to bleaching procedure. The bleaching agents and their activations systems were listed in Table I. One of group (G1) received no surface treatment and served as the control group. The control group was kept in distile water at room temperature for the same time period as the treated groups. The second group (G2) teeth were bleached with Whiteness HP (WHP) which is contain 35% hydrogen peroxide (HP), as the bleaching agent. The red activator was mixed the colorless bleaching gel at the moment of use according to the manufacturer's instructions. The mixture was applied on the prepared tooth surface with approximately 1 mm thick layer for 10 minutes and specimens were photoactivated with a blue light-emitted diode (LED) at 470 Mv/cm² for 20 seconds. Following this, the bleaching agents were washed off.

This procedure was repeated 4 times according to manufacturer's instruction.

The third group (G3) specimens were bleached with Laserwhite 20 (LW) which contains 46% HP. The caps were removed from both the activator and base gel syringes and were connected the 2 syringes together by twisting one syringe onto other until fully tightened. To mix, one syringe was pushed into other and reversed action for 25 times. Then it was applied approximately 1 mm thick layer on the specimen's surface for 5 minutes and then photoactivated with a diode laser (Ezlase™ Laser, wavelength 980 nm, average power 7 watt, energy setting 200 J, continuous mode) for 30 seconds. The bleaching agent was remained on the specimens surfaces for another 5 minutes and irradiated again for 30 seconds according to manufacturer's instruction. Following this, the bleaching agents were washed off. This procedure was repeated 2 times according to manufacturer's instruction. Finally, application teeth surfaces were washed with distilled water and dried with oil-free compressed air.

The dual-cure resin composite cement (Variolink II; Ivoclar Vivadent AG) was used in the cementation of the ceramic veneers. The teeth surfaces were etched for 20 seconds with 37% phosphoric acid, then rinsed for 20 seconds. A three-step bonding procedure was employed to ensure good adhesion of the resin cement in case dentin was exposed. The step of applications were respectively following: Primer (Syntac Primer; Ivoclar-Vivadent AG) for 15 seconds, adhesive (Syntac Adhesive; Ivoclar-Vivadent AG) for 10 seconds, bonding agent (Heliobond; Ivoclar-Vivadent AG). At the same time; on each ceramic veneer, the area designated for contact with the cement material was prepared with 4.9% HP (IPS Ceramic Etching gel; Ivoclar Vivadent AG) in gel, applied for one minute, then rinsed with water for 20 seconds and dried with oil-free air. After that, the silane (Monobond S; Ivoclar Vivadent AG) was applied to the conditioned surface and then a bonding agent was applied (Heliobond; Ivoclar Vivadent AG). Finally, the dual-cure resin composite cement, A2 shade catalyst and base was mixed with hand following the manufacturer's directions and placed on the internal veneer surfaces and the veneer was placed on the prepared teeth and pressed lightly with the finger. Excess cement was removed with an explorer and luting cement was polymerized both incisal, mesial, and distal surfaces for 40 seconds with a light-polymerizing unit (Bluephase; Ivoclar Vivadent AG) at 470 Mw/cm².

After cementation the bonded teeth were placed in distilled water for 24 hours. The acrylic blocks were mounted in an Isomet low-speed saw (Isomet 1000; Buehler Ltd) with a diamond-rim blade, two longitudinal and four horizontal cuts were formed across the bonded interface from the crown of tooth.

The bonded surface was divided into an array of 1.2x1.2x5 mm beams (Figure 1) [27,28]. Two beams were obtained from each teeth so 12 beams were obtained from each groups (n=12). The beam specimens were attached to tensile forces (Harvard Apparatus Co. Inc) with cyanoacrylate adhesive (Pattex; Henkel UA) at a crosshead speed of 1 mm minutes⁻¹ and the maximum load at break (kgf) was recorded. The values are converted to MPa from kgf.

The failure modes were analyzed under a stereomicroscope at 22x magnification (SZTP; Olympus) and scored according to one of three failure modes [24,29]: cohesive failure in bonding resin (CB), adhesive failure between the bonding resin and the enamel (AEB), cohesive failure in the tooth structure (CT).

Statistical Analysis

The data of each group were subjected to one-way analysis of variance (ANOVA; SPSS/PC, Vers. 17.0, SPSS) and a post-hoc test (Tukey HSD test at $\alpha = 0.05$) was used for pairwise comparisons.

RESULTS

The mean and standard deviation (SD) of the MTBS for the bleaching procedures are listed in Table 2. The MTBSs were as follows: G1 (Control), 9.53±2.7 MPa; G2 (LED), 6.49±2.3 MPa ; G3 (Diode laser), 8.49±3.1 MPa. The one-way ANOVA analysis revealed that there was statistically significant differences among the test groups ($F=3.789$, $p=.033$). The value of df (degree of freedom) was found 33 for within groups and 2 for between groups. The bond strength of ceramic laminate veneer to tooth was significantly affected by the type of bleaching regimes. The unbleached group [(control), 9.53±2.7 MPa] had the highest bond strength mean and statistically similar ($p>.05$) to diode laser group (8.49±3.1 MPa). The LED group presented the lowest bond strength value (6.49±2.3 MPa), and there were statistically significant differences in bond strength between control and LED groups ($p < .05$), (Table 2).

A stereomicroscope was used to analyze the type of fracture. Figure 2 presents scanning electron microscope images of the type of fractures. The predominant failure mode in all groups was the adhesive failure. In the control group; 10 specimens showed adhesive failures (AEB) between the bonding resin and enamel interface and two specimens showed cohesive (CB) in the bonding resin. In the group photoactivated with LED (G2); all specimens showed adhesive failures (AEB) between the bonding resin and enamel interface. In the group photoactivated with diode laser (G3); 10 specimens showed adhesive failures (AEB), one specimen showed cohesive (CB) in the bonding resin and one specimen failed cohesive

Table 1. Bleaching agents and their activation systems used

Material	Manufacturer	Type	Lot Numbers
FGM-Whiteness HP Joinville, Brazil	Dentscare LTDA, gel 35%	Hydrogen Peroxide	060210
Bluephase	Ivoclar Vivadent	LED Liechtenstein	
Laserwhite 20™ St.Ingbert, Germany	MT Promedt GmbH gel 46%	Hydrogen Peroxide	B63F1
Ezlase™ Laser Clemente, CA,USA.	Biolase, San	Diode laser	

Table 2. Mean microtensile bond strength values (MPa) and standard deviation (SD)

	N	Mean ± SD	Minimum	Maximum	Difference
G1 (Control)	12	9.53±2.7	6.66	14.72	a
G2 (LED)	12	6.49±2.3	3.12	9.68	b
G2 (Diode Laser)	12	8.49±3.1	2.36	13.41	a, b.

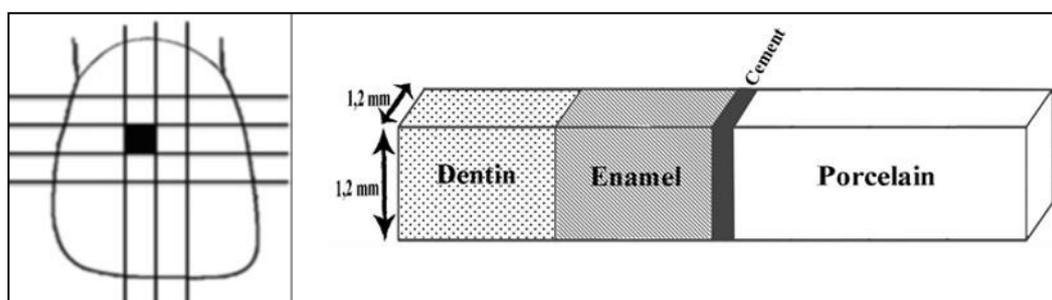


Figure 1. Specimen preparation for microtensile testing

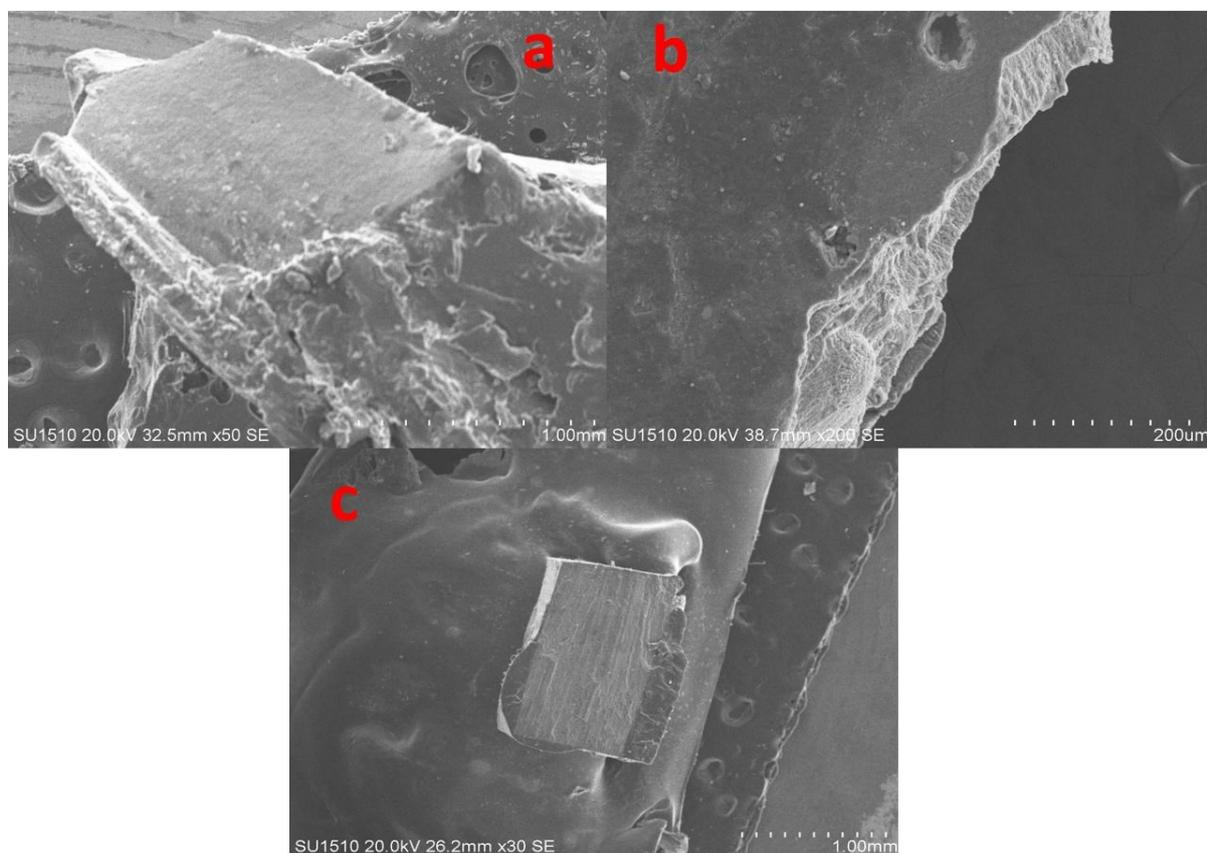


Figure 2. Scanning electron microscope images of the fracture types (a) adhesive failures (AEB), (b) cohesive failure in the bonding resin (CB), (c) cohesive failure in the tooth structure (CT)

(CT) in the tooth structure. The pre-test failure recorded was %0 for each groups.

DISCUSSION

The results of present study demonstrated that the microtensile bond strengths of PLVs bonded tooth surface bleached with a LED activated bleaching agent (Whiteness HP) was significantly lower than unbleached group. However the reduction in MTBS of PLVs bonded tooth surface bleached with a laser activated bleaching agent (Laserwhite 20) was not statistically significant. Therefore the null hypothesis was accepted for LED activated bleaching group however it was rejected for laser activated bleaching group.

Porcelain veneers are reliable procedure to provide esthetic anterior teeth [3]. Despite the long and common use of bleaching in dental procedure, there are some considerations about its interaction with enamel and its influence on the adhesive properties of cements and restorative materials applied to treated surfaces [2,10,17]. Previous studies have reported that dental bleaching procedures reduce immediate bond strength of restorative materials to enamel surface [7-12]. This possibly occurs due to presence of residual oxygen produced by the bleaching agent. Among the bleaching agents; hydrogen peroxide has been reported as the most effective and powerful oxidizing agent. When hydrogen peroxide decomposes into oxygen and water, oxygen free radicals are released which increases the PH. The composition of enamel may act as an important oxygen storage which is released after bleaching procedure progressively. The presence of residual oxygen might interfere with resin infiltration into enamel tags and might resin polymerization [12]. Thus the enamel surface may not available immediately after in-office or home bleaching treatment for adhesion of restorative materials and enhance to possibility of marginal leakage in restorations [3,12,13].

Demarco et al [29] reported that acid etching by phosphoric acid immediately after bleaching could not remove the smear layer, which they attributed to a chemical reaction involving hydrogen peroxide. Cavalli et al [7] reported that shear bond strengths of composite to enamel bleached with 10, 16, 20% carbamide peroxide agent significantly decreased. Titley et al [15] demonstrated that adhesion of bonding resin to enamel of bovine teeth bleached with hydrogen peroxide. They observed bleached teeth MTBs values were lower than non-bleached teeth. Again a previous study [4] showed that reduction in bond strength was like effect in enamel, present after an elapse of 7 days before application of the tested materials to the bleached dentin. Ozturk et al [13] found that significant interaction between ceramic and cements and that significant differences exhibited

bleached groups had a significantly lower mean when compared with unbleached groups. In this study indicate that the groups photoactivated with LED and diode laser (bleached groups) showed lower MTBs values than control group. This was in agreement with these previous studies [7-13,15,29].

On the other hand; laser activated bleaching procedure did not reduce the bond strength of PLVs significantly compared with the bond strength of control group. Photoactivation with LED is advantageous in the whitening process as compared with photoactivation with lasers and halogen lamp. LED photoactivation results in high whitening efficiency, a very small increase in intrapulpal temperature [20]. However in the current study WHP photoactivated by LED presented lower microtensile bond strength value than diode laser. This was probably due to the higher energy intensity of the diode laser compared with the LED in the bleach mode. Also diode laser application time is longer than LED' s application time. All these factors could cause higher the thermal effect in the underlying tissue layers than LED activation. Possibly, this heating could have resulted in a partial elimination of oxygen present through a process of evaporation in laser application diode [12,20,24]. Thus the reduction in amount of residual oxygen may be caused to reduce the effect of bleaching agent to bond strength of PLVs.

The analysis of failure mode after microtensile bond strength test indicated that most of the failures were adhesive in nature at the bonding resin/enamel interfaces which corroborates the findings of other studies [2,14,24]. Adhesive failure can exhibit a weak link between the bonding resin and enamel surface that it may caused by polymerization inhibition of the adhesive system by the residual oxygen from bleaching procedure [24].

There is still need more research to improve the bond strength between bonding resin and bleached enamel that depends on many factors: type of light source, different surface preparation, duration of photoactivation, thickness of bleaching agent, percent of content agent, extended, etching times, different color of bleaching agent, parameters of lasers, etc.

CONCLUSION

Based on the results obtained and within the limitations of this in vitro study, the following conclusions can be drawn. Both bleaching procedures (photoactivated with LED and diode laser) affected MTBS values for enamel adhesion negatively. Photoactivated with LED unit prior to the adhesive procedure of bleached enamel surface significantly reduced MTBS values compared with the control group. Photoactivation with diode laser proved to be some more advantageous such as speed and strong adhesion to enamel as compared with photoactivation

utilizing with LED when composite application is performed within 1 day after completion of bleaching regime.

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