The Effect of Dentin Desensitizer and Nd: YAG Laser Pre-Treatment on Bond Strength of Ceramic Restoration Cemented with Two Self Adhesive Cements

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Abstract: *Objectives*: This in-vitro study evaluated the effects of desensitizing treatments on the shear bond strength (SBS) of ceramic restoration cemented with two different self-adhesive resin cements (SARC).

Materials and Methods: Sixty human molars' occlusal surfaces were ground to expose dentin; and were randomly grouped as (n=10); Group CU: no surface treatment (control) and applied Rely X U200 SARC, Group CP: no surface treatment (control) and applied Panavia SA SARC, Group TU: treated with Teethmate and applied Rely X U200 SARC, Group TP: treated with Teethmate and applied Panavia SA SARC, Group LU: treated with Nd: YAG laser and applied Rely X U200 SARC, Group LP: treated with Nd: YAG laser and applied Panavia SA SARC. Then, lithium-disilicate ceramics (IPS e.max CAD Ivoclar Vivadent: n= 60; 5 mm in diameter; 2 mm in height) were cemented. SBS test was performed and the data were statically analyzed (α=0.05). Failure modes were determined with stereomicroscope.

Results: Nd: YAG laser treatment groups showed significantly different SBS values than the control groups ($p<0.05$). However, there were no significant differences between TMD treatment groups and other groups ($p>0.05$). Multiple comparisons showed that no statically significant difference found between the SBS values of all groups ($p>0.05$). Group CP showed the lowest SBS value (14.97 MPa) and Group TU showed the highest SBS value (20.82 MPa) among all experimental groups. The overall failure types for specimens were "mixed" and" adhesive".

Conclusions: Teethmate desensitizer and Nd: YAG laser pre-treatment increase the SBS of ceramic restoration cemented with two self adhesive cements.

Keywords: Dentin desensitizing agent, dentin hypersensitivity, Nd: YAG laser.

1. INTRODUCTION

Dentin hypersensitivity (DH) is the common painful complaint characterized by typical short sharp pain on exposed dentin that is stimulated by chemical, thermal or osmotic stimuli which are attributed to the movement of the dentin fluid [1, 4]. There are many different etiologic and predisposing factors related to DH such as exposed dentin by abrasion, attrition, erosion, and denudation root surface [2]. In addition, DH which called postoperative sensitivity is still one of the major challenges after preparation and cementation [3].

The theoretical etiology of DH is based on the hydrodynamic theory which proposed by Brännström [4]. Based on this theory, the most common and reasonable DH treatment approach is occlusion of the dentin tubules with a number of different desensitization agents such as fluoride, oxalate, potassium nitrate and calcium phosphate [5].

Teethmate Desensitizer (TMD; Kuraray Noritake Dental Inc., Tokyo, Japan) is a recently developed calcium-phosphate containing desensitizing agent; tetracalcium phosphate [$Ca_4(PO_4)2O$] and dicalcium phosphate anhydrous ($CaHPO_4$), the combination of which spontaneously tconverted to hydroxyapatite [$Ca10(PO_4)6(OH)_2$] [6].

In addition to dentin desensitizing agents, it can be used in lasers and homeopathic medication might be used for the same purpose [7]. Er; Cr: YSGG, CO2 and Nd: YAG lasers can be used to reduce the symptoms of patients' hypersensitivity by their ability to partially or completely dissolve the peritubular dentin [8]. Nd: YAG laser which effects on DH is also by direct nerve analgesia, was reported to be more effective than the Er: YAG and CO2 lasers [9].

Self-adhesive resin cement (SARC) systems which designed to bond without any undergoing pretreatment, have been introduced to overcome the technical sensitive problems of multi-step applications and to shorten the duration of clinical application [10]. So, the desensitization might compromise the bonding of SARC s [11]. Many previous studies showed that, application of desensitizing agents, may alter the properties of the smear layer and may influence the bond strength of the SARCs [12].

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E-ISSN: 2311-8695/18

Therefore, the present in-vitro study aimed to compare the effect TMD and Nd: YAG laser application on shear bond strength (SBS) between dentin and SARCs. The null-hypothesis was that pretreatment of dentin with TMD or Nd: YAG laser application has no effect on SBS.

2. MATERIAL AND METHODS

2.1. Preparation of Tooth Specimen

Sixty extracted caries and restoration free human molars were used in this study. All teeth were disinfected with 0.5% chloramine-T solution (Merck, Darmstadt, Germany) for 48 h. The teeth were cleaned of residual periodontal tissues. Each specimen was sectioned using a low-speed saw (Megatome T180, Pressi, France) under water-cooling to obtain a standardized root length of 20 mm apical to the cementoenamel junction (CEJ). Then, the specimens were embedded with auto polymerizing acyrlic resin (Panacryl; Arma Dental, Istanbul, Turkey) in cylindrical teflon molds. After the acrilic resin polimerization the specimens occlusal surfaces grinded until the mid-dentin surfaces were exposed with a diamond rotary cutting instrument under water cooling. To standardize the dentin surface texture, the occlusal surface of each tooth specimen was ground finished with 320-grit silicon carbide abrasive paper (Atlas Ltd, Kocaeli, Turkey) in a mechanical grinder (Phoenix Beta; Buehler, Illinois, USA) at 100 rpm/min for 15 seconds under water. Specimens were ultrasonically cleaned (Branson 8510; Branson Ultrasonics, Danbury, USA) for 5 min. The specimens were randomly divided into 6 groups (Table **1**).

2.2. Application of the Dentin Desensitizer to the Tooth Specimen

Group TU and TP specimens dentin surfaces were treated with TMD respectively, according to the manufacturers' instructions [mix power and liquid, apply slurry with micro- applicator (15s), rub (60s)], and subsequently rinsed and dried.

2.3. Application of the Nd: YAG Laser to the Tooth Specimen

Group LU and LP specimens dentin surfaces were treated Nd: YAG laser (Dekalaser Smart File; DEKA, Calenzano, Florence, Italy) at 0.40 W/cm^2 Power (10 Hz Frequency, 40 mj/cm^2 Energy density) with a pulse duration of 50 µs by a non-cooled hand piece with 300 µm optical fiber. The beam was aligned perpendicular to the dentin at a distance of 1 mm and 1 mm2 was irradiated for 1 s.

2.4. Fabrication of Cad/Cam Ceramic Specimens

A total of 60 disk-shaped cylinder (5 mm in diameter; 2 mm in height) specimens were fabricated by cutting of IPS- e max CAD blocks with a cutting machine (Mecatome T180; Presi, France) under copious water. The one side of specimens was ground finished with 100, 320, 400 grit silicon carbide paper (Atlas Ltd, Kocaeli, Turkey) on a mechanical grinder at 100 rpm/min for 15 seconds under water cooling to standardize the bonding surfaces. Specimens were ultrasonically cleaned for 5 minute in distilled water and air-dried. After that, specimens were crystallized in a ceramic furnace (Program at P300, Ivoclar Vivadent, Schaan Liechtenstein).

2.5. Cementation Procedure

Two different brand of SARC (RelyX U200, 3M ESPE, USA and Panavia SA, Kuraray, Japan) were used in this study. RelyX U200 used for CU, TU and LU groups. Panavia SA used for other groups.

Before the application of the cement, the grounded surface of ceramic specimens were etched with 9.6 % hydrofluoric acid (Ultradent Porcelain Etch, South Jordan, UT) for 90 sec, then washed for 1 min and air-dried and Primer (Clearfil Ceramic Primer, Kuraray

Table 1: Identification of Specimen Groups by Dentin Pretreatment and Resin Cement

Group	Dentin Pretreatment	Resin Cement
CU	No pretreatment (Control)	RelyX U200
CP	No pretreatment (Control)	Panavia SA
TU	Teethmate Desensitizer	RelyX U200
TP	Teethmate Desensitizer	Panavia SA
LU	Nd: YAG laser	RelyX U200
LP	Nd: YAG laser	Panavia SA

Medical Inc., Okayama, Japan) was performed to the etched ceramic surface, and air dried for 60 s. Then the SARC was applied in a thin layer, and polymerized with a Led unit (Elipar S10, 3M ESPE, Neuss, Germany) at 1200 mW/cm^2 for 20 seconds. During the polymerization procedure, specimens were processed using a universal testing device (Autograph AGS X; Shimadzu Co, Japan) under 8 kg for 2 minutes. After polymerization, the specimens were stored in 37^{0}C distilled water for 24 hours before being thermocycled between 5^{0}C and 55^{0}C for 500 cycles with a 30-second dwell time. After thermocycling, the specimens were stored in 37^{0}C distilled water before SBS test.

2.6. Shear Bond Strength Test

The SBS test was done using a universal testing machine at a crosshead speed of 0.5 mm/min. The SBS values were calculated in MPa. Debonded surfaces were accessed using stereomicroscope (Leica SP1600; Leica, Wetzlar, Germany) at x25 magnification and pictures were taken (Olympus BX43). Failure modes of the specimens were classified as follows: 1. Adhesive (failure at interface between adhesive resin and dentin), 2. Mixed (exhibits some cohesive failure and some adhesive failure), 3. Cohesive (cohesive failure of dentin or resin).

2.7. Statistical Analysis

The SBS values were statistically analyzed with a statistical software (SPSS v20.0; SPSS Inc.). Firstly, the Levene's test of homogeneity was used for evaluating the normal distribution of the variables and a normal distribution was found for variables. Then the results were analyzed by two-way ANOVA for testing to evaluate the effects of the desensitizing treatment, brand of resin cements and their interactions. Finally, the mean of The SBS values were compared by using Tukey's multiple comparison tests (α=0.05 for all tests).

3. RESULTS

Table **2** presents the descriptive statistics of all test groups.

The results of 2-way ANOVA showed the significant impact of desensitizing treatment, brand of resin cement, and the interaction between desensitizing treatment and resin cement on SBS. There were no significant difference use of brand resin cement and interactions between desensitizing procedures and resin cement brands (p>0.05) (Table **3**).

TMD (19.32 MPa) and Nd: YAG laser (19.87 MPa) led to an increase in SBS values than control group (15.53 MPa). Nd: YAG laser treatment groups showed significantly different SBS values than the control groups (p<0.05). However, there were no significant differences between TMD treatment groups and other groups (p>0.05) (Table **2**).

There were no statistically difference from all experimental groups (p>0.05). The highest mean bond

Table 2: Descriptive Statistics, ANOVA and Tukey Test Results of SBS (Mean Value ± SD)

				Total	
	N	**RelyX U200**	**Panavia SA**	**N**	
Control	10	16.09±3.87^{a}	14.97±3.49^{a}	20	15.53±3.63^{A}
Teethmate	10	20.82±6.33^{a}	17.82±5.77^{a}	20	19.32±6.09^{AB}
Nd:YAG laser	10	19.87±6.38^{a}	19.86±5.04^{a}	20	19.87±5.6^{B}
Total	30	18.93±5.83$^{\#}$	17.55±5.12$^{\#}$		

* Results of Tukey post-hoc comparisons were shown as superscripts and values having same letters are not significantly different (*P*>0.05).

Table 3: Two-Way ANOVA Results for Comparison of Shear Bond Strength after different Dentin Desensitizing Treatment and Application of different Brands of Cements

	Sum of Squares	***df***	**Mean Squares**	**F**	***P***
Desensitizing treatment	222.724	2	111.362	4.008	0.024
Cement	28.436	1	28.436	1.023	0.316
Desensitizing treatment x Cement	22.917	2	11.458	0.412	0.664
Error	1500.405	54	27.785		
Total	21738.453	60			

strength was found in the TU group (20.82 MPa), while the CP group (14.97 MPa) showed the lowest mean bond strength (Table **2**).

Although there was no statistically significant difference between RelyX U200 (18.93 MPa) and Panavia SA (17.55 MPa) cement used groups, RelyX U200 cement used groups showed higher SBS values (Table **2**).

The failure mode of the debonded specimens are shown in Figure **1**. The overall failure types for specimens were “mixed” and“ adhesive”.

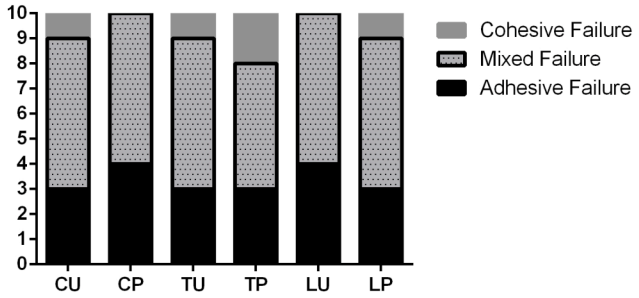

Figure 1: The failure mode of the debonded specimens.

4. DISCUSSION

According to the results of the SBS test in the present study, SBS values of the control groups were not significantly different from the other experimental groups. So the null hypothesis was accepted. Although there is no significant difference between experimental groups and the control groups, the groups in which treated with TMD or Nd: YAG laser showed higher SBS values than the control groups.

In the present study, recently developed calcium phosphate-containing desensitizing paste was applied to seal dentinal tubules before bonding with SARC. There are a few studies have evaluated the impact of TMD on the SARC-dentin interface.

According to the results, TMD led to increase bond strength but it was not significant. Siso *et al*. showed that the application of TMD significantly decrease adhesive resin microtensile bond strength with dentin [13]. Otherwise, some recent studies showed that use of TMD dentifrices led to an significantly increase in SBS values. This is the so-called chemical interaction created by TMD and smear layer and dentin [14, 15]. Previous studies have showed that synthetic hydroxyapatite materials such as TMD have the potential to remineralize dentin biomaterials by replacing matrix water with apatite crystallites. This change will increase the mechanical properties and prevent water-related hydrolysis, thereby increasing the bond strength over time [14].

Another desensitization treatment evaluated in this study was the Nd: YAG laser. The Nd: YAG laser was selected for this study because it has been investigated in many studies and reported to be effective in the treatment of DH *in vitro* and *in vivo* [16]. In general, low bond strength values have been reported when dentin treated with Nd: YAG laser [17-19]. This may be due to tubule blockage by melting. However, some studies demonstrated that SBS values did not differ after pretreatment with an Nd: YAG laser [20, 21]. According to the results, Nd: YAG laser treatment groups significantly increased SBS values than the control groups parallel to the previous studies [22-24].

The use of SARC becomes popular since they do not require any procedure such as acid-etching, primer, and bond application on the dentinal surface before cementation. Adhesive bond strength of SARC is associated with an acidic property of methacrylate monomer in its structure. This monomer provides demineralization and micromechanical retention through infiltration to dentin structure [25].

Rely X U200 and Panavia SA are SARC which used mostly in the clinic. The comparison of the different brand of SARC is others from our purposes in the present study. According to the results, there were no statistically difference between resin cements SBS values.

CONCLUSION

In the present *in-vitro* study, it was observed that the groups treated with TMD and Nd: YAG laser showed increased SBS. Further studies are required to determine the clinical success of the desensitizing treatment.

ACKNOWLEDGMENTS

None of the authors has financial interest related to this study to disclosure.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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Received on 31-05-2018 Accepted on 05-06-2018 Published on 31-06-2018

DOI: https://doi.org/10.12974/2311-8695.2018.06.1