Cumhuriyet Dental Journal: 2019; 22(2)
e-ISSN 2146-2852
Doi:10.7126/cumudj.537953

Original research

EFFECT OF DENTIN DESENSITIZERS AND Nd:YAG LASER PRE-TREATMENT ON MICROSHEAR BOND STRENGTH OF ADHESIVE RESIN CEMENT TO DENTIN

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Received : 11.03.2019
Accepted : 22.03.2019

ABSTRACT

Objectives: The aim of this study was to evaluate how microshear bond strength of different adhesive resin cements are affected by dentin desensitizers application and preparation depth.

Materials and Methods: One hundred and forty-four maxillary incisors were randomly divided into two groups according to dentin preparation depth (0.8 and 1 mm) and each group subdivided into four dentin desensitizers, Nd:YAG (Neodymium-doped Yttrium aluminum Garnet) laser and control groups. The dentin desensitizers used were Gluma [Glutaraldehyde/ Hydroxyethyl methacrylate (HEMA)], BisBlock (Oxalate) Vivasens-Potassium Fluoride (KF) and Admira Protect (Ormocer/HEMA), respectively. Three dual cure resin based luting cement (RelyX ARC; Variolink II and Maxcem Elite) were used to create a 0.7 mm diameter and 1 mm height cylindirical shape buid-up in tygon tubes (n=10). Micro-shear bond strength (µSBS) test was performed at a crosshead of speed of 0.5 mm/min using a Universal testing device. Then tooth surface was investigated by steromicroscope and scanning electron microscopy (SEM). Data were analyzed using Kruskal-Wallis, Mann-Whitney U and Chi-Square (X^2) tests. ($p = 0.05$)

Results: There was no statistically difference between the groups at 0.8 mm preparation depth. At 1 mm preparation dept RelyX ARC + Gluma groups' mean bond strength value (23.96 ± 6.66 MPa) was found statistically lower according to the other groups ($p<0.05$). RelyX ARC + Laser groups' mean bond strength value (37.33 ± 7.39 MPa) was found statistically higher according to the other groups ($p<0.05$).

Conclusions: The use of desensitizing agents affected the bond strength of the resin cements to superficial dentin. Gluma desensitizer affected negatively µSBS of RelyX ARC resin cement at 1 mm depth. Application of Nd:YAG laser to superficial dentin showed positive effects to the dentin surface and bond strength. Other desensitizing agents showed no significant effects on the resin bond strength ($p>0.05$).

Keywords: Dentin sensitivity, dentin desensitizing agents, resin cements, shear strength

How to Cite: Sarı F, Şahin O, Özdemir AK. Effect Of Dentin Desensitizers and Nd:Yag Laser Pre-Treatment on Microshear Bond Strength of Adhesive Resin Cement to Dentin. Cumhuriyet Dent J 2019;22:2:156-166.
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INTRODUCTION

Dentin sensitivity is a common problem experienced during routine clinical procedures, despite improvements in dentistry. Dentin hypersensitivity (DH) is characterized by sharp and short duration pain arising from exposed dentin induced by chemical, thermal, tactile or osmotic stimuli and that can not be defined as pathology or any structural defect. Stimulus initiates pain and relieves pain when it disappears.[1,2]

It was reported that up to 74% of the general population is affected by DH.[3] DH occurs due to reasons such as the gingival recessions, bleaching, tooth cracks, poor oral hygiene, acidic beverages and foods, erosion and attrision of teeth, excessive brushing. These factors cause dentine exposure. Hovewer, it is known that various dental procedures, such as tooth preparation, cementation of restoration can cause temperature increases on the teeth surfaces.[4] and then result in postoperative sensitivity in 15% of vital teeth.[5]

Several theories about the mechanism of dentin sensitivity have been proposed. The most widely accepted theory is the Brännström's hydrodynamic theory.[1] This theory is defined as the response of nerves to the alterance in pulpal pressure with the movement of the liquid in the dentinal tubules.[2] Therefore an approach to elimination of DH, it is essential to concentrate on a treatment to close the dentinal tubules and prevent the flow of dentinal tubul fluid.

Treatment modalities are mainly used to modify the fluid flow in the dentin tubule or to modify or block the nerve response of the pulp.[6] DH relieves with occlusion of opened dentine tubules therefore mechanism of occlusive therapies depends on diminishing dentin permeability. This could be accomplished by forming a diffusion barrier with the aid of medication or bonding agent.[7] There are many agents with comprehensive classified according their mechanism of action, such as: antiinflammatory drugs (corticosteroids), protein precipitants (strontium chloride, gluteraldehyde, silver nitrate,), tubule occluding agents (calcium hydroxide, sodium fluoride, potassium nitrate), desensitizing products (oxalates, potassium ions), tubule sealants (adhesive and resins), and recently, laser treatment.[8]

The structural components of the frequently used desensitizers also state the modes of use. Oxalate desensitizers, acidic resin-free oxalate potassium solution or gel is available for use as desensitizing which applied to dentin prior to adhesive procedures have been accepted as an alternative method of treatment to prevent fluid flow between the resin dentin interface and the adhesive layer.[9,10] Glutaraldehyde reacts with plasma proteins to precipitate them and serves as a biological fixative, which inherently blocks dentinal liquid flow where hydroxyethyl methacrylate promotes interpenetration into dentin tubules.[11] Potassium nitrate or potassium chloride block nerve response causing the release of some neuropeptides. Usually involves attempts to interrupt neural activation and pain transmission both.[12] Resin based desensitizers penetrate into tubular structure and form like resin tag extensions to seal dentin surface.[13] Laser assisted treatment approaches has been presented as a preferred method for partial or total obliteration of the dentin tubules.[14] The lasers used for treating DH are mainly investigated in two groups: low-output lasers (He-Ne or GaAlAs lasers and diode) and middle-output lasers (Nd:YAG or CO_2 lasers).[15] Low output lasers exhibit anti-inflammatory and biostimulation effects on tissues. However, medium output lasers block the dentin tubules with the impact of melting and re-solidification in dentin and has rapid analgesic effects.[16]

Adhesive resin cements are currently used for the cementation of many restorations. The bond strength between resin and bond interface is a crucial factor that intercepts the microleakage and the retention of the restoration.[5] Therefore for clinical applications, the effect of dentin sensitization agents on the resistance of resin-dentin is important. Even, there are conflicting findings in the literature about their usage together.

The purpoe of this study was to evaluate the effect of using different chemical desensitizing agents and Nd:YAG laser irradiation on μSBS of three different resin cements at two preperation depth. The null-hypothesis was that preparation depth and desensitizers has no effect on bond strength.

MATERIAL AND METHODS

One hundred and forty four intact maxillary incisors extracted periodontal reasons were used in this study. After extraction, the macroscopic tissue residues on the teeth were cleaned with a periodontal instrument (Scaler H6/H7, Hu-Friedy, Chicago, USA) and thoroughly washed under stream water. The teeth were disinfected in 1% thymol solution at room temperature for one week before use.

Preparation of Dentin Surface

The structural integrity of the labial surface of the teeth and the lack of restoration were considered inclusion criteria. Teeth presenting caries, cracks and wear on the crown were excluded. Orientation grooves were made on the buccal surface of the teeth using diamond burs (Horico, Diament, FG834018, Germany) with 0.8 and 1 mm cutting-depth were used under water cooling. The grooves formed on the labial surfaces of the teeth were united with a fissure bur and a flat dentin surface was prepared. After the preparation of each five teeth, the bur was changed. The teeth were embedded into 2.5 x 2 x 1 cm sized self-cured acrylic resin (Lead Dent, Hamle Tıbbi Cih. ve Malz. İzmir, Turkey) blocks with prepared surfaces upward. Thin layer of acrylic resin and enamel remnants on the surfaces of the teeth was removed by a 180 grit silicon carbide abrasive paper under running water. In order to form standardized flat surface and smear layer 300-400 and 600 grit silicon carbide abrasive paper were used respectively.

Microshear Bond Test

The exposed dentin surfaces were checked under an steromicroscope (SMZ 800, Nikon, Tokyo, Japan) at 30 X magnification to verify the clearance of exposed dentin. All specimens were kept in distilled to obtain humid environment conditions. Flattened dentin sapmples divide into six groups according to desensitizing protocols as follows: Gluma (Heraus, Germany), BisBlock (Bisco USA), Vivasens (Ivoclar Vivadent, Liechtenstein), Admira Protect (Voco, Cuxhaven, Germany), Nd:YAG laser (Smarty - A10, Deka Laser, Italy) and control group. Following by, these samples subdivided into three dual cured resin cement groups as follows: RelyX ARC (3M ESPE, USA), Variolink II (Ivoclar Vivadent, Schaan, Liechtenstein), Maxcem Elite (Kerr, USA). Before application of desensitizers, all the surfaces etched with 37% orthophosphoric acid (Total Etch, Ivoclar Vivadent, Liechtenstein) for 15 seconds and rinsed for 20 seconds to mimic exposed sensitiv dentin. The composition and manufacturers' instructions of the desensitizers and adhesive systems are summarized in Table 1.

Table 1. Study materials, including composition and application protocol information, as described by the manufacturer.

Material Manufacturer	Composition	Application procedures
Variolink II Ivoclar Vivadent AG	Base: Bis-GMA, urethane dimethacrylate, TEGDMA, inorganic filler, ytterbium trifluoride, initiator, stabilizer Catalyst: Bis-GMA, UDMA, TEGDMA, inorganic filler, ytterbium trifluoride, benzoyl peroxide, stabilizer	Dentin: Etch with 37% orthophosphoric acid* (15 s), rinse (20 s), gently air dry (5 s), apply syntac primer (15 s), air dry, apply syntac adhesive (10 s), air dry, apply Heliobond (10 s), remove excess bonding agent and polymerize (20 s).
RelyX ARC 3M ESPE, St. Paul, MN, USA	Base paste: Bis-GMA, TEGDMA, benzoyl peroxide; catalyst paste: Bis-GMA, TEGDMA, photoinitiator system, amine, peroxide, zirconia-silica filler 67.5% by weight	Dentin: Etch with 37% orthophosphoric acid* (15 s), rinse (20 s), gently air dry (5 s), apply Single Bond (15 s), remove excess bonding agent and polymerize (20 s).
Maxcem Elite Kerr Corp.	Resin: HDDMA, GDMA, DUDMA, GPDMA Catalysts: TMBHP, CQ, stabilizer Filler: FAlSiO4 glass, SiO2, Ba-glass, YF3 (67wt.%)	Gel state can be achieved by tack-curing excess with a curing light for approximately 2-3 s, or by allowing the cement to self-cure for approximately 2-3 min after application or until the excess cement feels rubbery.
Gluma Heraeus Kulzer, Hanau, Germany	Glutaraldehyde (5%) distilled water HEMA (35%)	Apply on dried dentin and leave for 30 to 60 sec. Apply air until the fluid film has disappeared. Rinse with water.
Nd:YAG laser Smarty -A10, Deka Laser, Italy	Neodymium-doped Yttrium aluminum Garnet	The dentin surface was irradiated with a pulse 25 Hz- 40 mJ- 1 W, with a total irradiation time of 60 sec to simulate clinical manipulation
Bisblock Bisco Inc., Schaumburg, IL, USA	Oxalic acid, potassium salt and water	Etch the tooth for 15 sec, and rinse with water. Gently air dry 2-3 sec. Apply on dried dentin and leave for 30 sec. Rinse with water.
VivaSens (Ivoclar Vivadent AG, Schaan, Liechtenstein)	Varnish (ethanol, water and hydroxypropyl cellulose) containing potassium fluoride, polyethylene glycol dimethacrylate, and other methacrylates.	Gently rub liquid into tooth for at least 10s, avoiding contact with gingiva. Evenly disperse the liquid and dry by gently blowing air on the treated surfaces for 10s.
Admira Protect Voco, Cuxhaven, Germany	Monomers (bisphenol A diglycidyl ether dimethacrylate, 2-hydroxyethyl methacrylate); organic acids; and ormocer	Remove excess water with an oil-free air jet. Do not over dry dentine. Apply on all dentine surfaces for 20 s. Disperse with a faint air jet. Light-cure with a conventional polymerization device for 10 s. Apply a second layer; disperse it with a faint air jet and light-cure for 10 s. Remove the oxygen-inhibited layer with a cotton pellet.

Polyethylene tygon (TYGON Medical Tubing Formulations 54-HL, Saint Gobain Performance Plastics, Akron, OH, USA) tubes (Ø=0.7 mm, 1 mm height) were used as matrices to build up cylindirical bonded resin cement units. Prior to resin cement application two or three segments of tygon tubes were placed on treated dentin surface (Fig 1). All polymerization procedures were carried out with a halogen curing unit (Hilux 250 Benlioğlu Dental Inc, Ankara, Turkey) with a light output of 500 mW/cm^2 for 20 seconds. All the bonding procedures were conducted by the same researcher.

Figure 1. Three or two cylinders were obtained for the microshear bond strength test in each Specimen

Specimens were stored in distilled water at 37°C for 24 h. then the tubes were removed with a sharp blade then µ-SBS test were performed using a universal testing machine (LF Plus, LLOYD, Instrument, Ametek Inc, England). A thin steel wire of 0.2 mm diameter was looped and wrapped around the lower half of resin cylinder. Care was taken to ensure that the wire is adjacent to the connection interface at the same time the wire and the load center were aligned as linear as possible. The components of the wire were fixed to the crosshead and shear force was applied to each specimen at a cross-head speed of 0.5 mm/min until failure occurred and data was recorded in MPa.

After the application of desensitizers, for each desensitizer group specimens were mounted on copper mold, sputter-coated, and examined by using SEM (JEOL Ltd., Tokyo, Japan). After micro shear test, fracture patterns were evaluated and classified using SEM and stereomicroscope (SMZ 800, Nikon, Tokyo, Japan) at 30X magnification. The failure mode was classified as one of three types: Adhesive failure (Less than 25% of the bonding cement on the surface of the tooth), Cohesive failure (More than 75% of the bonding cement on the surface of the tooth), Mix failure: (Certain areas show adhesive failure).

Statistical Analysis

Mean and standard deviation were used as descriptive statistical parameters. Statistical analyses were performed using SPSS 15.0 (Statistical Package for Social Sciences, SPSS Inc., Chicago, ABD). The non-parametric Kruskall-Wallis test of one-way analysis of variance was used to compare all values of three different cements. The Kruskall-Wallis test was used to compare each group of cements with their subgroups. Mann-Whitney U test was used to compare the groups. X^2 (Chi-square) test was used to compare the distribution of failure types of the groups. Results of statistical analysis were evaluated at a $p<0.05$ significance level.

RESULTS

The mean µSBS values and standart deviations of desensitizers resin cement combination are shown in Table 2 and Table 3. The bond strength values of all three resin cements after desensitizers treatment showed statistically no difference at two preperation depth ($p>0.05$). The mean bond strength value of RelyX ARC resin cement (23.96 MPa) was lower than the other resin cement groups treated Gluma desensitizer at 1 mm preperation depth. The difference between the bond strength values of RelyX ARC, Variolink II and Maxcem resin cements was found significant in the group where Nd: YAG laser was applied as a desensitizer ($p<0.05$). The mean bond strength of RelyX ARC resin cement in the Nd:YAG laser group was 37.33 MPa and significantly different from Variolink II and Maxcem resin cements' values. The percentages of the failure modes are presented in Fig 2. The predominant failure mode of sll groups' was adhesive. However, few cohesive and mix failure were found in all three resin cements groups. In all three resin cement groups similar failure types recorded. SEM images are presented in Fig3 and Fig4.

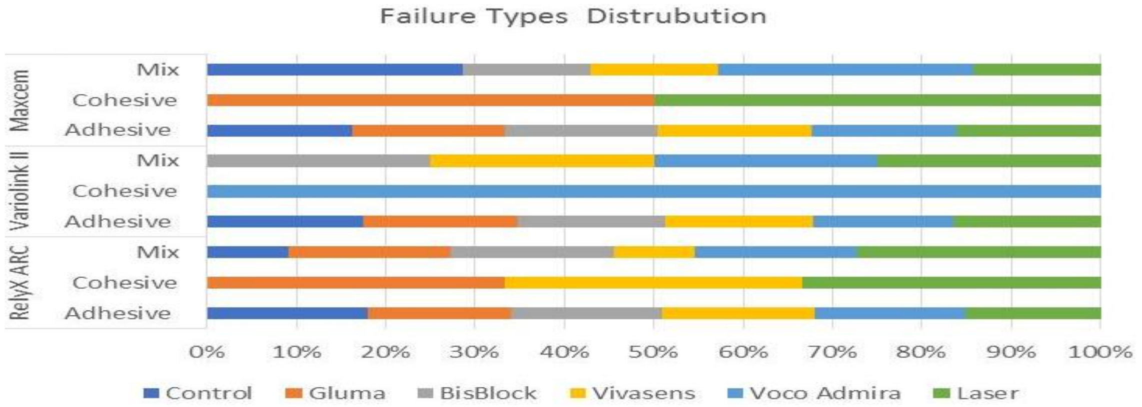

Figure 2. Graphical presentation of the incidence (%) of failure modes for each group. (n = 20).

Table 2. The mean microshear bond strength (megapascals) and standard deviation values for 0.8 mm preparation depth.

	RelyX ARC X(SD) (MPa)	Variolink II X(SD) (MPa)	Maxcem X(SD) (MPa)	KW
	0.8 mm			
Control	26.18 (6.5)^{a}	26.48 (6.5)^{a}	26.73 (4.8)^{a}	KW=0.24 p = 0.887
Gluma	28.22 (7.2)^{a}	26.04 (3.8)^{a}	28.17 (6)^{a}	KW=0.91 p = 0.632
Bisblock	26.74 (7.2)^{a}	23.88 (4.3)^{a}	25.35 (5)^{a}	KW=0.87 p = 0.647
Vivasens	28.67 (6.2)^{a}	24.06 (5.0)^{a}	26.06(4.8)^{a}	KW=2.74 p =0.254
Admira Protect	29.27 (6.1)^{a}	26.76 (5.6)^{a}	24.28 (4.8)^{a}	KW=4.04 p = 0.192
Nd:YAG Laser	30.71 (4.2)^{a}	26.40 (7.9)^{a}	25.1 (5.2)^{a}	KW=5.66 p = 0.059
KW	KW=4.15 p = 0.527	KW=3.03 p = 0.695	KW=3.38 p = 0.641	

*** Kruskall Wallis Test**, Means with the same superscript letters were not significantly different. SD: Standart deviation (*p*<0.05).

Table 3. The mean microshear bond strength (megapascals) and standard deviation values for 1 mm preparation depth.

	RelyX ARC X(SD) (MPa)	Variolink II X(SD) (MPa)	Maxcem X(SD) (MPa)	KW
	1 mm			
Control	27.98 (6.5)^{A}	30.20 (6.5)^{A}	25.99(6.2)^{a}	KW=2.40 p = 0.300
Gluma	23.96 (6.6)^{Ab}	27.53 (4.3)^{Aa}	29.98 (6.1)^{Aa}	KW=6.32 p = 0.042
Bisblock	28.89 (7.2)^{A}	24.47 (4.1)^{A}	23.00 (2.9)^{A}	KW=4.90 p = 0.086
Vivasens	28.22 (4.2)^{A}	28.37 (8.5)^{A}	25.95 (4.8)^{A}	KW=0.93 p = 0.628
Admira Protect	25.09 (5.3)^{A}	25.86 (5.1)^{A}	28.18 (6.3)^{A}	KW=1.47 p = 0.479
Nd:YAG Laser	37.33 (7.3)^{Ab}	23.75 (4.1)^{Aa}	27.74 (6.5)^{Aa}	KW=12.66 p = 0.002
KW	KW=16.99 p = 0.005	KW=8.12 p = 0.149	KW=5.51 p = 0.130	

*** Kruskall Wallis Test**, means with the same superscript letters were not significantly different. Lowercase letters indicate differences in rows; uppercase letters indicate differences in columns. SD: Standart deviation (*p*<0.05).

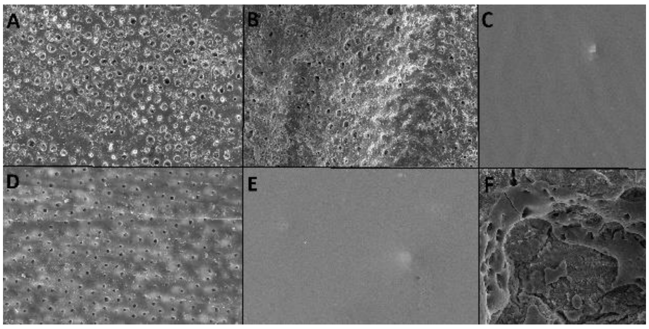

Figure 3. SEM micrograph of dentin surfaces that have been treated with desensitizers:
A; Control group X1000,
B; Gluma X1000.
C; BisBlock X1000.
D; Vivasens X1000.
E; Admira Protect X1000
F; Nd:YAG laser X5000.

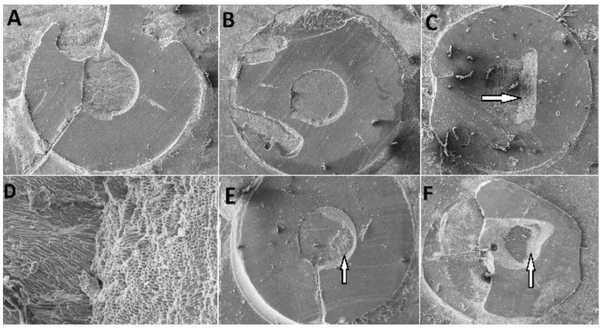

Figure 4. Scanning electron micrograph of failure surface after μSBS test:
A, B; Adhesive failure X90. Circular bonding area tracked.
C; Cohesive failure in dentin, arrow indicates fractured dentin area, X90.
D; Closer image of the cohesive area X800.
E; Mix failure, arrows indicate remnant resin cement on the dentin surface
F; Mix failure, cohesive and adhesive failure is seen together in the central part indicated by the arrow.

SEM disclosed that all the desensitizers appreciable occluded the dentinal tubules. It was seen that the dentin tubule orifices enlarged and the smear layer was removed in the control group. Dentin surface treated with gluma 50% of tubuls presented semi-closed or closed tubular orifices. In BisBlock group, it was observed that the dentin surface was completely covered with desensitizing agent. No dentine tubules were observed on the surface. Some tubular orifices became narrow on the dentin surface treated with Vivasens however, compared to the Gluma group, it was seen that more tubules were open. Admira Protect applied to the dentin surface was covered completely, on the surface, a small number of dentin tubules were partially closed. Nd:YAG laser removed smear layer partially. Solidification and recrystallization with mineral islands and microfracture after melting in superficial dentin layer were observed. In addition to this, it was observed that the orifices of the dentin tubules were narrowed or closed as a result of the melting of the surrounding tissue and the surface had a spongy appearance.

DISCUSSION

Post-operative DH is one of the major challenge that affect the success of prosthetic treatments. Several studies have verified that effective and vigorous occlusion of dentinal tubules offers the excellent promise for instant and sustained relief of dentine hypersensitivity.[17]

The present in vitro investigation compared the effect of Nd:YAG laser and various desensitizers chemical contents with gluteraldehyde, oxalic acid, potassium florur and ormocer on μSBS of three different resin cements at two preparation depth. The result of this study indicated that application of desensitizer is effective on occlusion of tubul orifices. It was reveal that preparation depth, resin cement and some of the desensitizers were not statistically significant predictors of μSBS. On the other hand at 1 mm preperation depth for RelyX ARC resin cement, Gluma and laser groups showed statistically significant μSBS values (p<0.05). Thus the null hypothesis is partially rejected.

Several studies[4,5] on veneer preparation have indicated that much dentin is exposed during routine preparation. A standardized technique using 0.5-mm-deep grooves consequenced in dentin being exposed on 50% of the preparation area.[18] Also Christensen[19] reported that reduction of enamel for maxillary incisors may be 0.75 mm. Natress *et al.*[20] stated that most of the time the dentin was exposed in the proximal and cervical region of the tooth after the preparation without standardization and reported that the enamel thickness in majority of the teeth were less than 0.5 mm. Pahlevan *et al.*[21] reported the mean thickness of enamel at the gingival third is 410 μ on the maxillary central incisor and 367 μ on the maxillary lateral incisor.

In this study, superficial dentin was used near the enamel-dentin junction by selecting similar teeth in size. The dentine was exposed on the labial surfaces and preparations were made 0.8 and 1 mm depth to mimic the clinical conditions.

Thus, all bonding area were designed in the superficial dentin. It is stated that structural differences of each tooth affect connection resistance.[22] In our study, 2 or 3 bonded samples were attached to each tooth surface to reduce the effect of these differences.

The histological structure of the dentin tissue is highly complex and due to its different chemical content, bond strength values are affected by many factors. Moreover, each individual dentinal tubule is an inverted cone with the smallest dimensions at the dentin-enamel junction and the largest dimensions around the pulp.[23] Dentin layers could be categorized as superficial, middle and deep dentin according to preparation depth. It was reported that the bond strength decreased due to dentin tubule fluid as it approaches to the pulp.[24] Controversy to this, in the present study there was no statistically difference between preparation depth. It can be explained by lack of respectable preperation depth difference. This may be attributed to the higher water content in deep dentin as compared to superficial dentin, as a result of the larger diameters of the tubules and their greater numbers per unit area in deep dentin.[25] Finally, the similar bond strength to dentin observed in both preparation depth may be due to similar dentin surface characteristics.

A number of variables can compromise resin cement adhesion, such as dentin morphology, humidity, adhesive system capabilities, compatibility of adhesive system and dual-cured luting cement.[26] The use of an adequate resin cement system is particularly important for cement adhesion because it directly affects the quality of the resin-dentin interface. The recent literature precisely verified the bond strength of resin cements changes from ranges of 7 to 40 MPa.[27] The results of this study are also found to be compatible with this finding. Even μSBS values corroborate the findings of some studies.[28]

The resin cements used in the present study comprised 2 total-etch (Variolink II and RelyX ARC) and 1 self-etch (Maxcem Elite) dual-cure luting cements frequently used in prosthodontic clinical practice.[29]

Differences in bond strength between other resin cements may be due to the physical properties of cements, such as elastic modules, filler sizes, filler ratios, film thicknesses and viscosities. In terms of chemical composition Variolink II resin includes urethane dimethacrylate, maleic acid, and glutaraldehyde in the dentin primer, and the adhesives that condition the tooth surface in order to improve adhesion to dentin. By contrast, RelyX ARC relies on ethanol contained in the adhesive for conditioning, The variations of bond strengths found in this study may be attributed to the adhesive type and composition.[30] However, the mean μSBS values to dentin of all resin cements tested in this study were over 17 MPa, which is considered as the minimum value for clinically adequate bond strength to dentin.[31] The relatively high bond strengths reported in this study and previous studies may be explained by microstructural variations in tooth structure, tooth storage conditions, time, temperature, and the dimensions of the adhesive surface.[30]

Previous in vitro studies[31,32,33] have reported that the resin cement shear bond strengths to dentin ranged from 5.4 ± 2.3 MPa to 13.78 ± 8.8 MPa for Variolink II, 4.0 ± 0.8 MPa for Panavia F, and 5.42 ± 6.6 MPa for RelyX Veneer resin cements, which are in line with the values obtained in this study.

In a previous study[32] Variolink II, self adhesive Panavia F2.0, RelyX Unicem, Maxcem, iCem resin cements were used and shear bond strength to enamel and dentin evaluted. Mentioned that Variolink II groups presented highest bond strength values to dentin (39.2 ± 8.9MPa). Maxcem resin cement showed the highest bond strength (22.3 ± 3.3MPa) among self-adhesive resin cements. According to Yan *et al.*[33] RelyX ARC, Panavia-F and Variolink II resin cements showed similar μSBS and micro tensile bond strength values. These results are close to the average bond strength values of our study.

Lorenzo *et al.*[34] measured the shear bond strength of Variolink II and RelyX ARC resin cements to dentin as 22 ± 7 MPa and 22 ± 4 MPa. In these two studies, the mean bond strength values obtained for RelyX ARC and Variolink II were similar to those obtained in our study.

Some ideal characteristics were proposed by Grossman[8], for a desensitizing agent, which would be viable for the treatment of DH currently. According to these, desensitizer would need to be easy to apply, be painless, fast acting, not be toxic for pulp, not change in the tooth structure or surface, and have a durable effect.[8]

Gluma desensitizer has been shown either to maintain or to improve bond strength to dentin.[23] In the literature, there are many studies[23,35] reporting that Gluma did not affect the resistance of resin cements statistically. Despite of several studies reporting that it decreases or increases the bond strength of resin cement.[26,36] The results of these studies are similar to our study.

In the study[36] that evaluate the effects of gluma, single-bond 2 and BisBlock desensitizers on the dentin tubules and the dentin bond strengths, it was stated that the BisBlock desensitizing agent closed the detin tubules substantially and the Gluma desensitizing agent partially closed the dentin tubules. In addition, the shear bond strength of the BisBlock dentin desensitizing agent was found to be higher than the control group (13.04 ± 2.76 MPa) and BisBlock affected positively the bond strength of resin cement. The findings obtained in this study compatible with the findings of SEM and bond strength values obtained in our study.

In the present study Gluma pretreatment decreased the μSBS of RelyX ARC resin cement. The researchers have attributed the increased bond strength values of HEMA promoted rehydration mechanism allowing time for the penetration of the primer into dentin.[37] Also application of an aqueous solution of 2-hydroxyethylmethacrylate (HEMA) and glutaraldehyde as a primer compound can promote effective dentinal bonding.[38] This result contradict to our study.

Previous studies[10,35,36] verified that potassium oxalate reacting with ionized calcium in dentin or dentin fluid composition as a result of chemical reaction that calcium oxalate crystals form. These crystals are deposite in the tubular orifices and they alter the surface texture and affect the bonding. In the previous study[39] it was reported that potassium oxalate pretreatment on etched dentin caused the crystal formation inside the dentin tubules rather than dentin surface and it is also stated that the crystal formation inside the tubules did not jeopardize the formation of typical hybrid layer.[39] Tay *et al.*[10] showed that when oxalates were used after acid-etching, micro tensile bond strength values were comparable to the non-treated dentin as well. However in the present study, BisBlock did not significantly affect the bond strength of the three resin cements.

Clinically, Admira Protect behaves as a primer that forms multiple tubular septa layers in the lumen of the dentinal tubules as a result of protein precipitation and by this way reduces dentinal fluid flow.[40] In a previous study.[41] In contrast to the findings of this study, it was observed that Admira Protect increased the bond strength of resin cements.[41]

Potassium fluoride reacts with the dentinal fluid and causes precipitation of calcium ions and proteins in the dentinal fluid that block the tubules.[42] SEM findings and mean bond strength values of this study same line with present study.[43]

Lasers are commonly used to treat DH. Treating the DH, Nd: YAG laser have been using by many researcher for treatment by obstructing or narrowing the dentinal tubules.[15] The Nd:YAG laser helps to obtain a non-porous structure by melting and resolidification the surface; also Nd:YAG laser application has an additional analgesic effect by blocking nerve conduction.[16] Also some previous studies[15,16,44] mentioned that the application of Nd: YAG laser prior to adhesive processes resulted a thinner hybrid layer and less resin tag formation. In addition to this it was observed that the bonding agent penetrated into the tubuls after application of Er: YAG laser controversy to the Nd: YAG laser group, the bonding agent was detected only on the surface so the dentin tubule orifices were closed.[45] The SEM images of this study and the dentin surface images mentioned in the literature compatible to each other. However, the bond strength values of Nd:YAG laser applied to dentin surface were found to be higher in our study compared to other groups. This difference can be explained by use of superficial dentin as bonding surface just below the enamel layer. Consequently it is known that intertubuler dentin forms a continuous collagen-rich network that presents favorable surface condition and less affected by Nd: YAG laser application than peritubular dentin.

Further studies should be carried out to evaluate the thickness and structure of the hybrid layer in deeper dentin layers. Due to the limitations of this study, we suggest further studies with larger sample sizes and longer follow-up periods and laser applications with different device settings and varied exposure protocols.

CONCLUSIONS

Dentin desensitizers can be used to eliminate postoperative sensitivity before the cementation of the restorations. Within the limititations of this study following conclusions could be drawn.

The bonding strengths of the three resin cements used in the study were not statistically different and both preparation depths did not affect the bond strength of resin cements.

The application of Nd:YAG laser as with RelyX ARC resin cement did not affect the bond strength of resin cement at the preparation depth of 0.8 mm preparation depth However, higher bond strength values obtained at 1 mm. depth with Nd:YAG laser and RelyX ARC resin cement combination according to other resin cements and desensitizers.

Gluma desensitizer affected negatively µSBS of RelyX ARC resin cement at 1 mm depth.

The SEM images showed that BisBlock and Admira Protect desensitizing agents closed the dentin tubules more than Gluma and Vivasens. However, Nd:YAG laser removed the smear layer and melted dentin after that it caused recrystallization, which closed or contrict tubular orificies.

92% of the samples presented adhesive type failure.

ACKNOWLEDGEMENTS

This work is based on a thesis submitted to the Cumhuriyet University Institute of Health Sciences, for the PhD Degree. and also supported by Cumhuriyet University Scientific Research Projects Governing Unit [Project Number: DIS.68].

CONFLICT OF INTEREST

The authors declare that they have no competing interests.

Dentin Hassasiyet Gidericiler ve Nd:YAG Lazerin Adeziv Rezin Simanların Mikro-makaslama Bağlanma Dayanımlarına Etkisi

ÖZ

Amaç: *Bu çalışmanın amacı adeziv rezin simanların bağlanma dayanımlarının dentin hassasiyet giderici uygulamasından ve preparasyon derinliğinden nasıl etkilendiğinin değerlendirilmesidir.* ***Gereç ve Yöntemler:*** *Bu çalışmada yüz kırk dört adet çekilmiş 9insan üst keser dişleri kullanıldı. Dişlerin labial yüzlerinde rehber frezler yardımıyla 0,8 ve 1 mm derinliklerinde preparasyonlar yapıldı. İki gruba ayrılan dişler RelyX ARC, Variolink II ve Maxcem rezin siman gruplarına ayrıldı. Her rezin siman için sırasıyla Gluma (Glutaraldehyde/ Hydroxyethyl methacrylate-HEMA), Vivasens (Potassium Fluoride-KF), Admira Protect (Ormocer/HEMA), BisBlock (Oxalate) ve Nd:YAG (Neodymium-doped Yttrium aluminum Garnet) lazer hassasiyet giderici grupları oluşturuldu. Rezin simanlar 0,7 mm. çapında 1 mm. yüksekliğinde tygon tüpler içerisinde her grupta 10 adet olacak şekilde dentin yüzeylerine yapıştırıldı. Örneklerin mikro-makaslama bağlanma dayanımları üniversal test cihazında 0,5 mm çapraz baş hızında ölçüldü. Kopma yüzeyleri stereomikroskop ve SEM aracılığıyla değerlendirildi. Elde edilen veriler Kruskal Wallis (KW), Mann-Whitney U ve Ki-Kare (X^2) testi ile değerlendirildi.* ***Bulgular:*** *Grupların ortalama bağlanma dayanımı değerleri karşılaştırıldığında 0,8 mm. preparasyon derinliğinde rezin siman ve hassasiyet gidericiler uygulanmış gruplar arasında istatistiksel olarak anlamlı bir farklılık bulunmadı. 1 mm preparasyon derinliğinde ise RelyX ARC + Gluma grubundaki ortalama bağlanma dayanımı değeri (23,96 ± 6,66 Mpa) diğer gruplara göre istatistiksel olarak daha düşük bulundu ($p<0,05$).1 mm preparasyon derinliğinde RelyX ARC + Lazer grubundaki ortalama bağlanma dayanımı değeri (37,33 ± 7,39 Mpa) diğer gruplara göre istatistiksel olarak daha yüksek bulundu ($p<0,05$).* ***Sonuçlar:*** *Yüzeyel dentinde hassasiyet giderici ajanlar rezin simanların bağlanma dayanımını etkilemektedir. Gluma hassasiyet giderci 1 mm preparasyon derinliğinde bağlanma dayanımı değerlerini olumsuz etkilemiştir. Nd:YAG lazerin mine-dentin birleşimine*

yakın yüzeyel dentinde uygulanması dentin yüzeyinde ve bağlanma dayanımında olumlu sonuçlar göstermiştir. Diğer hassasiyet gidericilerin bağlanma dayanımları üzerine etkileri istatistiksel olarak anlamsız bulundu.

Anahtar kelimeler: *Dentin hassasiyeti, dentin hassasiyet giderici, rezin esaslı siman, bağlanma dayanımı.*

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