Journal of Dentistry and Oral Care Medicine
Volume 4 | Issue 1
ISSN: 2454-3276

Research Article Open Access

The Effect of Different Surface Treatments and Cement Materials on the Bonding between Dentine and Restorative Materials

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Citation: Özdoğan A, Yanikoğlu N, Yılmaz CB (2018) The Effect of Different Surface Treatments and Cement Materials on the Bonding between Dentine and Restorative Materials. J Dent Oral Care Med 4(1): 101. doi: 10.15744/2454-3276.4.101

Received Date: December 08, 2017 **Accepted Date:** May 24, 2018 **Published Date:** May 26, 2018

Abstract

Objective: The aim of this study was to evaluate the effect of different surface treatments and cement materials on the bonding between dentine and restorative materials.

Material and Methods: In this study, 135 extracted third human molars, three different restorative materials (Cr-Co alloys, composite and zirconia) were used. Acid etching and sandblasting were used the surface of materials and one group was identified to control group. After the surface treatments, restorative materials were bonded to dentine with three cement materials (self-adhesive resin cement, conventional resin cement and glass ionomer cement). The shear bond strength (SBS) test was applied by using a universal testing machine. The statistically analysis of obtained data were performed with use n-way analysis of variance test.

Results: The result of n-way analysis of variance test showed that there were statically significant differences either surface treatments or luting cements on the bonding dentine to restorative materials ($p=0.001$). The results showed that the lowest shear bond value (3.24±3.62 N) was identified in control group of zirconia materials bonded to dentine with glass ionomer cement. The highest shear bond value (94.66±68.36 N) was identified in acid etched composite materials bonded to dentine with conventional resin cement.

Conclusion: The obtained data presented that the different surface treatments and luting cements effect on the bond strength of dentine to restorative materials. The glass-ionomer cement decreases the bond strength of all restorative materials.

Keywords: Adhesives; Bonding; Cement; Ceramics; Dentin

Introduction

There are several restorative materials using in fixed prosthodontics. Metal alloys, composites, zirconia and all ceramic restorations are some of them. Ceramic restorations have been used in fixed prosthodontics because of their aesthetical properties. However, due to insufficient mechanical properties of the metal sub-structures are supported. The disadvantages include the potential biologic hazards, difficult handling and uncontrolled chromium oxide formation [1,2]. Alloys used in metal ceramic restorations are divided into two main groups: Noble metal alloys and base-metal alloys. Noble metal alloys of their own, high noble, noble and base divided into three groups. Base-metal alloys, is widely used at metal sub-structure nowadays. Chromium-Cobalt (Cr-Co) alloys are often preferred due to the feature of allergic reaction of Nickel. Porcelain, because of good biological compatibility, has to be one of the most used materials in dentistry. Porcelains are highly oxidized, corrosion-resistant, usually not allergic and toxic reactions forming materials [3]. The use of resin composite materials for dental restorations has increased during the last decade primarily as an esthetic alternative to dental amalgam but also as a low cost alternative to gold and ceramic restorations [4].

There are several surface treatments to improve coupling between restorative materials and dentine surface. Sandblasting is a process that, cleaning of surfaces of materials, applied for increasing the surface areas and micro-retentive structures [5]. 50-250 µm Aluminum oxide (Al_2O_3) used under 4-6 atmospheric pressure for sandblasting, as a result of this consist of notches for the mechanical retention [6]. Etching is another surface treatment. Acid etching with solutions of hydrofluoric acid (HF) or ammonium bifluoride can achieve proper surface texture and roughness [7-9].

There are three different mechanisms bonding dentin to restorative materials in fixed prosthodontics: Non-adhesive bonding, micromechanics coupling, molecular adhesion [10]. While glass ionomer, polycarboxylate and zinc phosphate cements use in metal and zirconium sub-structure, resin cements commonly use in all ceramic and zirconium sub-structure restorations.

Conventional cementation of zirconium oxide restorations with traditional luting agents (such as zinc phosphate or resin-modified glass ionomer cements) may provide adequate clinical fixation, adhesive cementation is preferable for ensuring better retention and marginal adaptation [11,12].

Until recently, all adhesive systems used in the past had three steps before restoration. These involved etching, priming and bonding. This was quite cumbersome. Hence, the thought process continued in the direction of reducing the number of steps involved in bonding before the restoration with better clinical results. Currently, there are two philosophies on simplification of the adhesive systems, namely; the Total-Etch Systems, with a separate etchant and a primer/adhesive and the Self-Etching Systems, which combines etching and priming in one bottle and have a separate adhesive agent or which combine all three steps in a single solution [13].

The purpose of this study was to evaluate the effect of surface treatments and cement materials on the bonding Cr-Co alloys, composite and zirconia materials to dentine. The hypothesis of this study, the surface treatments and adhesive cement will significant increase the bond strength of restorative materials.

Material and Methods

Dentine specimens

Totally, 135 extracted third human molars were used in this study. The teeth were gathered following informed consent according to the protocols approved by the review board of the Dental Faculty of Atatürk University. The teeth were stored in distilled water at +4 °C until use.

The occlusal enamel of teeth were removed and then the teeth were embedded with self-curing acrylic resin (Vertex, Dentimex, Netherlands) In a cylindrical pattern (15 mm diameter, 20 mm height). The embedded specimens were ground perpendicular to the long axis using 800-grit SiC paper under running tap water (16 °C) for 1 min. The plane sides of the specimens were ground parallel to each other, and checked with a slide-caliper [14]. The specimens were divided into three main groups according to different restorative materials (n=5).

Restorative materials

Three different restorative materials were used in this study: (I) Cr-Co based alloys, (ii) light curing hybrid composite resin (Quadrant Universal LC, Cavex, Germany), (iii) sintered Y-TZP zirconia ceramic. According to their nature, these materials were tooled, molded, cast or sintered in order to obtain cylinders (5 mm in height and in diameter) with two opposite flat and parallel surfaces.

Sandblasting and acid etching were used every group and one group was identified to control group. The all specimens were sandblasted with a 5^{o} µm Al_2O_3 powder under 0.4 MPa pressure for 10 s. All specimens were etched with 5% hydrofluoric (HF) acid for 20 s then rinsed for 10 s and dried for 10 s.

Cements

Three luting cements were used in this study: Self-adhesive resin cement (Rely X U200, 3M ESPE), conventional resin cement (CRC) (Clearfil Esthetic Cement, Kuraray) and glass-ionomer cement (GIC) (Meron, VOCO GmbH, Germany).

For the conventional resin cementation, dentine surfaces were etched for 15 s with a 37% phosphoric acid gel, rinsed for 15 s and blot-dried with a cotton pellet. The bonding agent was activated and applied to both substrate and dentine surfaces for 10 s. The solvents were evaporated with an air-stream for 3 s. The dentine adhesive layer was light-cured for 20 s using an LED unit.

The self-adhesive cement was simply mixed and directly applied to both substrates and dentine surfaces. The glass-ionomer cement was prepared and applied specimens.

Bonding

After surface preparation, luting cements were applied in a thin layer to material cylinder surfaces before setting up under finger pressure (approx. 20 N) the specimens were fixed in position with screws. Excess cement was carefully removed. The luting cements of Cr-Co, composite and zirconia groups were light-cured on two opposite sides for 20 s each. The cement joints of the alloy group were not light polymerized in order to simulate clinical conditions. Each bonded assembly was maintained for 10 min under constant pressure in the alignment device in air at room temperature.

The specimens were tested in shear mode in a universal testing machine (Model 2519-106; Instron Corp) at a crosshead speed of 0.5 mm/min (Figure 1). The data were recorded by the type of Newton.

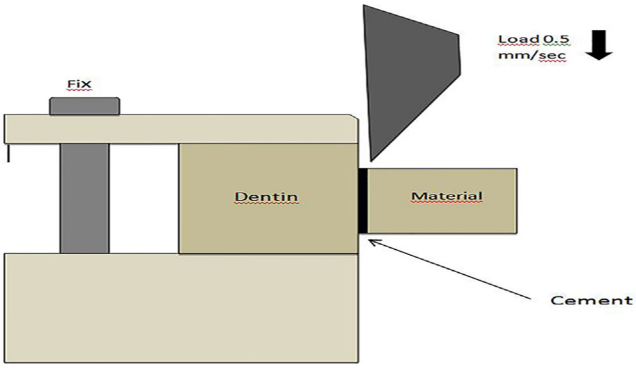

Figure 1: Apparatus for the shear bond test

Statistical analysis

The statically analysis of obtained data were performed with use n-way analysis of variance (ANOVA) and Tukey multiple comparison test (p<0.05).

Results

The result of n-way analysis of variance test showed that there were statically significant differences either surface treatments or luting cements on the bonding dentine to restorative materials (*p*=0.001) (Figure 2, 3 and 4). The results showed that the lowest shear bond value (3.24±3.62 N) was identified in control group of zirconia materials bonded to dentine with glass ionomer cement. The highest shear bond value (94.66±68.36 N) was identified in acid etched composite materials bonded to dentine with conventional resin cement (Table 1). The result of Tukey multiple comparison test showed that there were not statically significant differences between materials and surface treatments (p>0.05), but there were statically very highly significant differences between three luting cements; conventional resin cement, self-adhesive resin cement and GIC (p<0.001). The results were showed that, the glass ionomer cement decreased the bond strength of all restorative materials.

Materials	Surface Treatments	Cements	Mean
Metal	Control	Self	10.04 ± 2.74
		Conventional	31.70 ± 11.96
		GIC	6.88 ± 2.51
	Sandblasting	Self	46.50 ± 4.95
		Conventional	33.04 ± 4.01
		GIC	5.06 ± 2.42
	Acid Etching	Self	18.36 ± 16.80
		Conventional	38.40 ± 21.00
		GIC	14.18 ± 12.18
Composite	Control	Self	30.82 ± 12.90
		Conventional	17.44 ± 5.29
		GIC	5.24 ± 3.01
	Sandblasting	Self	32.90 ± 23.16
		Conventional	50.00 ± 6.07
		GIC	5.04 ± 3.53
	Acid Etching	Self	23.58 ± 10.88
		Conventional	94.66 ± 68.36
		GIC	5.18 ± 2.53
Zirconia	Control	Self	48.30 ± 35.23
		Conventional	36.04 ± 24.05
		GIC	3.24 ± 3.62
	Sandblasting	Self	66.60 ± 32.46
		Conventional	30.56 ± 19.22
		GIC	6.06 ± 1.43
	Acid Etching	Self	44.16 ± 18.80

Materials	Surface Treatments	Cements	Mean
		Conventional	13.60 ± 6.25
		GIC	6.12 ± 2.38

Table 1: The shear bond strength values of restorative materials (N=5)

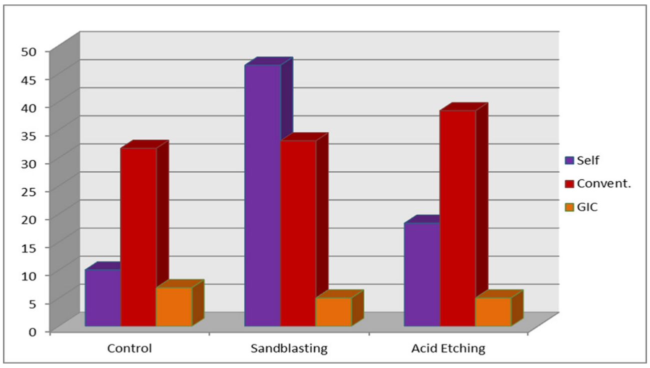

Figure 2: The shear bond strength of metal alloys restorative materials

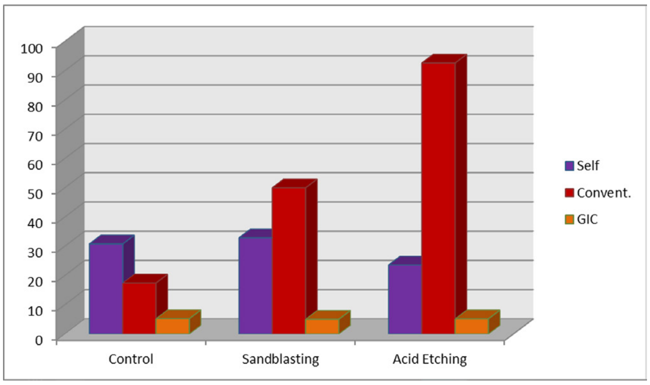

Figure 3: The shear bond strength of composite restorative materials

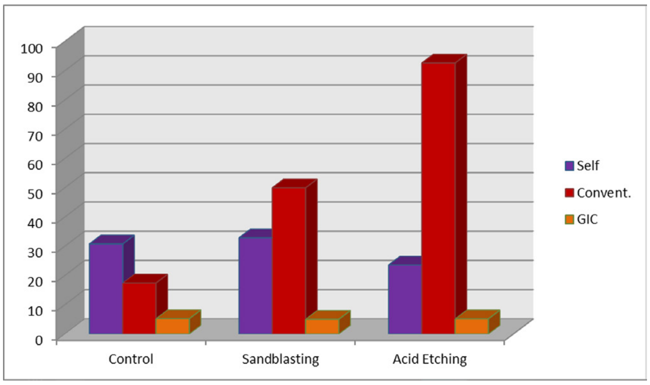

Figure 4: The shear bond strength of zirconia restorative materials

Discussion

This study evaluated the effect of various surface treatments and luting cements on the bonding different restorative materials. The hypothesis set as the premise of this study was accepted, the adhesive cements increased the bond strength of restorative materials, but the other hypothesis was not accepted, the surface treatments were not increased the bond strength of restorative materials.

The Ni is considered one of the most common causes of allergic dermatitis, appearing in researches as a component with the higher allergenic and toxic potential together with be [15]. At the present time Cr-Co alloys are preferred in fixed prosthodontics instead of Ni-Cr alloys because of these negative features of materials.

Therefore, the Cr-Co alloys were developed to become an option to the Ni-based alloys, and are considered secure substitutes for clinical use with favorable physical and mechanical properties [15], thus Cr-Co alloys were used in this study.

Surface treatment of the metal by sandblasting with particles has improved the effectiveness of the surface area of the metal, increased the energy of alloy surfaces and also increased the composite resin–metal bond strengths [16,17]. Kapoor *et al.* [18]

reported that the surface treatments increased the bond strength of alloys and resin cement exhibited greater tensile and shear bond strength than resin modified glass ionomer cement. Surface roughness is considered as another important factor for adhesion that increases the surface area, improves the wettability by reducing the surface tension and creates micromechanical retention. APA (Alumina particles air abrasion) is one of the common methods used to increase the surface roughness. Some investigators suggested that superior bonding to zirconia is obtained when surfaces are air abraded [19,20]. However, others concluded that this method does not have a significant effect to improve the bonding of resin cement to zirconia ceramic [21-24]. Kern *et al.* [25] in their study reported that by increasing the zirconia sandblasting pressure, surface roughness increased but no increase in bond strength was noted.

On the other hand, although HF is effective for porcelain surface treatment and creation of micromechanical retention [26,27], some previous studies show that treatment with HF provides statistically higher bond strength than other types of surface treatments [25].

Cura *et al.* [28] reported that HF acid etching of zirconia surface following glaze application significantly increases the SBS of resin cement to the ceramic, when the conventional silane-coupling agents are combined with the cement. Acid etching primarily serves to clean the composite surface, resulting in improved surface energy [29]. In this study, HF acid etching not increase bonding to dentine.

Kajiwara *et al.* [30] showed that sandblasting followed by silanization significantly increased the bond strength of zirconium oxide ceramics compared with #600 polishing or sandblasting and that the silane agent improved the wettability of bonding surface.

Since the discovery of glass ionomer cement (GIC) by Wilson and Kent [31] the family of GICs have evolved into a diverse group of dental materials that include direct restoratives, luting cements, liners, bases, atraumatic restoratives, and pit and fissure sealants [32]. GICs are able to bond chemically to enamel, dentin, plastics, and non-precious metals [33,34], but GIC was lower shear bond strength from the adhesive resin cements and GIC decreased the bond strength of all restorative materials in this study.

Ibarra *et al.* [35] claimed that without any conditioning, the self-adhesive cement RelyX Unicem (3M/ ESPE, Seefeld, Germany) showed improved sealing of dentin at the cervical margin when compared to a conventional resin cement. The RelyX Unicem showed bond strength to dentin not statistically different from the other resin based luting materials [36,37]. The similar results were found with this opinion in the study. Variations in application of the priming solutions depending on the chemistry of these dentin-bonding agents influence bond strengths [38].

Since the adhesive cements evaluated in this study are usually indicated for cementing crowns, a traditional shear bond test method was chosen because forces of displacement of crowns tend to be closer to shear than to tensile stresses [39].

Siwen *et al.* [40] investigated the effect of alumina sandblasting, silica powder abrasion, and silica-sol coating the surface modifications of zirconia and reported that alumina sandblasting followed by silica coating is an effective technique to increase the bonding strength between the zirconia ceramic and dentin. Subasi *et al.* [41] showed that surface treatment or cement selection could affect the bond strength between the resin cement and the zirconia. However, cement selection was more important than surface treatment, and phosphate monomer-containing cements (CEC and PF) were suitable for cementing zirconia. The cement selection was more important than surface treatments in this study.

Conclusion

Within the limitations of this study, it was possible to conclude that:

1. The different surface treatments effect on the bond strength of dentine to restorative materials, but there were no significant differences between surface treatments.
2. The luting cements the most effective agents on the bond strength of dentine to restorative materials.
3. Glass-ionomer cement (GIC) decreases the bond strength the all-restorative materials.
4. These conditions can be recommended for an ideal cementation:
    - The sandblasting and self-adhesive resin cement for Cr-Co alloys,
    - The acid etching and conventional resin cement for composites,
    - The sandblasting and self-adhesive resin cement for zirconia.

Acknowledgements

Presented at 22th Scientific Congress Of The Turkish Prosthodontic and Implantology Association (TPID) in Antalya, Turkey, November 12-15, 2015. The work was supported by Department of Scientific Research Projects (BAP 2013/259) Atatürk University, Erzurum, Turkey.

Conflict of interest

Author Alper OZDOGAN declares that he has no conflict of interest. Author Nuran YANIKOGLU declares that she has no conflict of interest. Author Cenk Burak YILMAZ declares that he has no conflict of interest.

Ethical approval

This article does not contain any studies with human participants or animals performed by any of the authors.

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