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Shear bond strength of composite resin to biodentine after different surface treatment

Running title: Shear bond of biodentine and composite

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Abstract

Aim of the study: The study's objective was to assess the shear bond strength (SBS) between composite and Biodentine after applying various treatments of the surface for the roughness of the latter material. **Materials and Methods:** Four groups of forty Biodentine samples were created by mixing the material according to the manufacturer's instructions and inserting it into plastic cylinders that were 3 mm in diameter and 2 mm in height, respectively. Group (1) was the control group without surface roughness of samples, Group (2) roughness treatment of the surface with thirty-seven percent of orthophosphoric acid, Group (3) roughness treatment of the surface by abrasion method with air by using aluminum oxide (Al_20_3) elements, and Group (4) roughness treatment of the surface with 9% hydrofluoric acid. Over the samples of groups (2, 3, and 4), a universal adhesive bonding agent was applied, curing the bond. Each sample was covered by fresh cylinders that measured 3 mm in diameter and 6 mm in height, respectively. A composite was then added in two layers, with 3 mm between each layer, and light-cured. After cutting and removing the plastic cylinders to acquire the two materials bound together as one block, a universal testing machine was used to evaluate the failure load between Biodentine and composite for all samples. Data analysis using the Duncan multiple range test and One-Way ANOVA.

Results: SBS (Shear Bond Strength) between groups was found to differ significantly (P≤0.05). Except for Gp(2) and Gp(3), which revealed no significant difference between the two groups, the largest and lowest SBS were related to Groups (2) and (1), respectively. **Conclusions**: The surface roughness treatments increase the SBS between composite resin and Biodentine within the parameters of this investigation. The GP phosphoric acid etching produces the highest SBS, which is followed by GPS air abrasion and hydrofluoric acid etching, in that order.

Keywords: Surface treatments, Shear bond strength, Biodentine, composite resin.

Introduction

Biodentine is regarded as a new cement base similar to dentine, it is regarded as a dentine substitute material consisting of tricalcium silicate-based cement in comparison to dentine's physical properties.(1)

Biodentine powder consists of calcium-carbonate, tricalcium-silicate, and zirconium dioxide whereas the calcium-chloride is the liquid. (2) One of the most important properties of Biodentine is its sealing effect and compressive resistance with low setting time and good biocompatibility and bioactivity.(3)

Biodentine accepts composite restoration after setting time in one visit, and concerning adhesive, Biodentine bonds to composite after etching with 35% phosphoric acid. The bond between composite and Biodentine depend on the type of adhesive and different surface treatment prepared before final restoration to improve seal and less microleakage.(4)

Conservative dentistry goal is to achieve good bond and seal between Biodentine and composite using a bonding agent, Biodentine has properties that activate transformed growth factor B1(TGF-B1) that facilitate differentiation of odontoblast and formation of secondary dentin. Biodentine has the ability to crystalize with dentine by locking into dentine thought open dentinal tubules to enhance bonding and make its compressive strength near the dentine. (5)(6)

The biological treatment in operative dentistry is to obtain healing pulp and stimulate reparative dentine ability. Biodentine is a new bioceramic material that is close to natural dentine in its microhardness and compressive strength that by, it's a natural dentine substitute material.[7]

Biodentine has a wide antibacterial activity with a low cytotoxic activity, to enhance its hardness it should cover with a final restoration as composite or other restorative material.[8]

This study aimed to assess the shear bond strength (SBS) between composite and Biodentine folowing the application of various treatments on the surface for the roughness.

Materials and Methods

Initially, 40 samples of Biodentine (Bioactive dentine substitute) (Biodentin e, Septodent Co; France) were prepared a s directed by the manufacturer. After mix ing, the Biodentine was put into plastic c ylinders made from insulin syringes (Mc Guff Pharma Co; USA) that had been c ut by a diamond disk (NTI Superflex dia mond discs, Sigema Kerr Co; USA) with measurements of 3 mm diameter and 2 m m height and allowed the Biodentine to set.

The Biodentine samples were divided into 4 GPS (ten samples for each GP), as shown in the table (1), after the top surface was flattened by pressing the glass slab with a pressure of (220Pa) over the celluloid strips for ten minutes to let excess material drain from the cylinders. Group (1) is the untreated control group for surface roughness. Group (2): Surface treatment with 37% orthophosphoric acid (Dline Co., Lithuania) for 15 seconds, followed by water washing and drying for 10 seconds. Group (3): Surface abrasion with fifty-micron Al_20_3 particles for 5 seconds at a distance of 0.5 cm and at an angle of 90 degrees above the samples. The surface was then washed with water and dried for 10 seconds.

In Group 4, the surface was treated for 10 seconds with 9% hydrofluoric acid (Porcelain Etch, Ultradent Co., USA), followed by a 10-second water wash and 10-second drying process. To minimize operator differences, all of these steps were completed by the same person.

Table (1). Samples of Research

Gps	Methods of roughness treatment	Applied bonding agent or not
Gp 1	Without surface roughness	without the use of adhesive
Gp 2	Etching with 37% orthophosphoric acid	with adhesive
Gp 3	Abrasion by air with Al_2o_3 elements	with adhesive
Gp 4	9% Hydrofluoric acid etching	with adhesive

All samples of Gps (2, 3, and 4) were coated with a single bond universal adhesive (3M ESPE Co; USA) using a dental brush in a scraping motion (TPC, China), which was followed by light curing (Eighteeth Led Curing Pen, Eighteeth Co; China) using an intensity of 1200 mW per cm2 for the twenty seconds over the samples at one cm in away. A radiometer was applied to account for the amount of radiation (Radiometer, Sptadent Co; China). The new plastic cylinders, which measure 3 mm in diameter and 6 mm in height, were placed on top of the Biodentine samples.

The nano-hybrid composite (Prime-dent, Prime dental Co; USA) was then layered over the Biodentine discs in these cylinders in two layers, each about 3mm thick, and cured by an eighth curing device with a power of about 1200 mW per cm2 for the 20s for every layer to produce the sample depicted in figure (1). The samples were then kept at room temperature for 24 hours.

Figure (1). Biodentine with composite as one sample.

A universal machine for testing (GT-Ko3B, Gester international corporation, China) was used to measure the failure load with a speed of 1mm/minute, as illustrated in figure (2). The SBS value of each sample is then determined by evaluating the failure load using the formula: Stress (MPa) = Failure load (newton)/surface area (mm^2). [9] For each GP, the mean SBS was calculated. The SPSS version 25 program was used to collect the data. With a significance level of $P \leq 0.05$, data were analyzed using One-Way ANOVA and the Duncan multiple range test among GPS means.

Figure (2). Universal testing machine.

Results:

One-Way ANOVA and Duncan multiple tests were used to analyze the data. Descriptive analysis of GPS revealed that SBS had a high mean value associated with Gp(2), followed by Gp (3 and 4), and had the lowest mean value for Gp (1). Standard deviations and mean values are displayed in the table (2). ANOVA analysis reveals a difference in significance between the gps, as observed in table (3).

Except for Gp (2) and Gp (3), where there was no significant difference between them according to Duncan's multiple range test, which is shown in table (4), a significant difference was seen between all groups.

Table (2). Descriptive analysis of the standard deviations and mean values for the SBS of gps.

Groups	N	Mean	SD
Gp (1)	10	0.02990	0.007549
Gp (2)	10	0.17680	0.044379
Gp (3)	10	0.15840	0.016290
Gp (4)	10	0.11150	0.021635

N: Number of samples, SD: Standard Deviation.

Table (3). One-Way ANOVA test of the mean values for the SBS of gps.

Groups	Sum of Squares	df	Mean Square	F	Sig.
Between gps	0.129	3	0.043	62.263	0.000*
Within gps	0.025	36	0.001		
Total	0.154	39			

df: degree of difference, F: F value at P≤ 0.05, Sig: significantly

*: Significantly different.

Table (4). The comparison between gps by Duncan multiple range test according to SBS.

Groups	N	Mean	SD_+	Duncan
Gp (1)	10	0.002	0.029	A
Gp (4)	10	0.006	0.011	B
Gp (3)	10	0.005	0.015	C
Gp (2)	10	0.014	0.017	C

*Different letter mean significant difference at P ≤ 0.05

Discussion:

According to the manufacturer's recommendations, using Biodentine necessitates placing a final repair after using an adhesive bonding agent. Evaluation of SBS of composite to Biodentine is one of the goals of this investigation.

The adhesion between tooth, filling material and pulp-capping agents is important to prevent clinical failures. [10] The adhesion between the materials also assists in spreading the occlusal forces equally. [11]

Studies have shown that the stress that occurs during polymerization shrinkage of different adhesive agents after maturity of the surface of Biodentine was around 2.89 to 3.49 MPa. When a resin composite is condensed over a layer of a newly mixed Biodentine, that leads to cracks and fractures in the material. Therefore, the best treatment is to place an intermediate restoration over

Biodentine and permanent restoration on the next visit. [12]

Hashem et al. found that the type of the bonding method is not that crucial for the improvement of the stability of the strength of bonding of a composite resin to Biodentine. [13]

The present study agrees with Camilleri's study that noted the first step in the total-etch technique is etching with 37% phosphoric acid before the placement of a composite resin that is to enforce the adhesion with the Biodentine and avoid leakage of microorganisms, by using a scanning electron microscope for examination of Biodentine, found the chemical and structural changes showed after the 20s of etching with 37% orthophosphoric acid. [14]

Çolak et al. showed that the 10-methacryloyloxydecyl dihydrogen phosphate (10-MDP) acid monomer found in the self-etch single bond should affect bond strength and could bind chemically to the Ca ions in Biodentine, forming chemical bonding and improvement in the micromechanical interlocking. [6]

The present study agrees with Cengiz and Ulusoy's study that noted higher micro shear bond strength of biodentine and other types from the silicate-based GPS to all types of glass-ionomer and composite resins, after the extension of the etching time regarding the total and self-etch methods, Scotchbond universal adhesive system with short application time result in high SBS. [15]

Kayahan et al study noted that etchants of Biodentine with phosphoric acid made deeper and retentive microscopic pores, also causing the selective removal of the matrix within the crystal basement, which lead to the success of adhesion by micromechanical attachment. [16]

Paridokht et al showed that Biodentine has a high bond strength value with the glass ionomer and flowable resin composite. Therefore, to obtain good adhesion, the use of a composite restoration over Biodentine is needed. [17]

Los and Barkmeier's study illustrates the smear layer result from the airborne-particle abrasion may play a role in the improved bond strength. [18]

Other studies showed that etching leads to micromechanical attachment due to the chemical and structural alteration resulting from Biodentine. [19,20]

Acid etching by hydrofluoric acid completely dissolves the outer layer of Biodentine because the high of acidity that leaves the surface flat without any porous or irregularities like phosphoric acid, for that reason the shear bond strength is low with composite resin as a result of lack of micromechanical interlocking between composite and Biodentine. [21]

Moreover, there is a lack of studies using air abrasion and etching by hydrofluoric acid of Biodentine, for this more studies are required to investigate the improvement of the bonding of Biodentine to dental structure and composite restoration after treatment of surface by air abrasion and hydrofluoric acid.

Conclusions:

Under the restrictions of this study, can be revealed the surface roughness treatment of Biodentine by diverse methods is adequate to improve the SBS with composite resin. The best method that improves the SBS is etching with phosphoric acid, followed by air abrasion with Al_2O_3 particles and the less effective one is the hydrofluoric acid technique, using bonding agent in a mix with these surface roughness treatments that lead to these results.

Conflict of interest: None.

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