https://africanjournalofbiomedicalresearch.com/index.php/AJBR
Afr. J. Biomed. Res. Vol. 27 (October 2024); 940-945

Research Article

The Effect of Time Intervals on Bond Strength of Two Different Glass Silicate Materials Bonded to Resin Composite Using Self-etch Adhesives

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Abstract

Aims: Both Biodentine and (GIC) are often utilized as a lining or base material under the restorations of the resin composite as a substitute for the dentin. Waiting for the setting time of these materials (15 min. for Biodentine and 7 min. for GIC) can lead to complications. The use of an unset case for both materials with light-curing is recommended. However, moisture contamination throughout the setting could result in dissolution, and alteration of their physical characteristics which may be solved by using a self-etching adhesive system. So, the objective of this study is to compare and evaluate the bond strength of resin composite to underlying Biodentine and GIC in different interval times (before and after setting).

Materials and Methods: 40 acrylic blocks that contain a central hole with a height of 2mm and a diameter of 5mm have been prepared and categorized into four groups, each of them containing 10 samples based upon the material that has been utilized as Group A Biodentine after setting, Group B immediate Biodentine, Group C chemical cure glass-ionomer cement (GIC) after setting and group D immediate GIC. The resin composite of 4.0mm diameter and 2.0mm height has been bonded afterward to every one of the samples, with the use of a universal adhesive. The analysis of the shear bond strength (SBS) has been carried out at a 0.5mm/min crosshead speed.

Statistical Analysis: the statistical analysis has been carried out with the least significant difference (LSD) and one-way analysis of variance (ANOVA) tests were P>0.050 (Non-significant), P<0.050 (significant), P<0.001 (highly significant) using Statistical Package for the Social Sciences (SPSS) v. 20.

Result: No significant differences have been found in the shear bond strength mean value between set Biodentine group (4.21 Mpa) and the non-set Biodentine group (2.7 Mpa), p>o.o5. Regarding the GIC group, the set GIC group was showing no significant differences from the non- set GIC group, in which the shear bond strength values were (13.36 and 11.22 Mpa) respectively (p>o.o5).

Conclusion: The time intervals (set and non-set cases) have no significant differences for both Biodentine and GIC regarding the shear bond strength with light-curing composite using the self–etch bond.

Keywords: Shear bond, Biodentine, GIC, Self-cue, Cohesion, Adhesion

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Receiving Date: 18/10/2024 Acceptance Date: 24/10/2024

DOI: https://doi.org/10.53555/AJBR.v27i3.3187

Introduction

Calcium-silicate cement has been used in dentistry since the late 1990s. The first representative of this new class of materials was mineral trioxide aggregate (MTA ProRoot; Maillefer Dentsply; Ballaigues, Switzerland). Despite many positive properties, the disadvantage of all MTA products is that they cannot be used as a base material, due to their low compressive and flexural strength and modulus of elasticity [1]. Another benefit of the MTA is that it has a long setting time that can reach up to 228 min [2]. Biodentine can be defined as calcium silicate-based restorative material that was developed recently with improved physical and chemical properties [3-4]. It is a dental material of high purity, which is composed of powder that contains tricalcium and dicalcium silicate as the main material, zirconium oxide (radio pacifier), and calcium carbonate (filler). Its liquid component includes calcium chloride, distilled water, and a water-soluble polymer. The water-soluble polymer's role is to reduce the water/cement ratio, increasing the strength of the material. Calcium chloride plays the role of an accelerator that enables faster material setting.(5) Biodentine is indicated to be used as a replacement for dentin under a variety of restorations and as repair material due to its sufficient chemical and physical characteristics, high compressive strength, good sealing ability, short setting time [6]. Bioactivity, bio-mineralization, and biocompatibility, properties [7], based on the indications of the manufacturer, Biodentine's initial setting time is approximately 15 minutes; a final setting time of approximately 86 minutes was reported for Biodentine. For the purpose of completing the final restoration in one visit, an adhesive restorative material can be applied over a partially set Biodentine layer. This is why; there is a high importance in the identification of the materials that have compatibility according to the interface between the two different materials. Understanding such behavior will be of great importance to completing the final restoration [8]. Nevertheless, lining the unset calcium-silicate cement with a The materials which have been utilized in this comparative study are Biodentine, conventional type of GIC (type II for restoration), Composite resin, and self-etch dental adhesive, light-curing material can also be recommended for Biodentine, because in clinical uses, waiting 15 minutes for calcium-silicate cement to set may result in complications. Glass ionomer cement (GIC) is often utilized as a lining or a base material under the restorations of the resin composite as a substitute for the dentin, for sealing dentin with a material that has shown to form a reliable bond [9]. The concern with the traditional GICs is that they have low strength in the case of being subjected to loads. This is why, a resin composite overlay has been put on GIC for providing mechanical strength, aesthetics, and wears resistance, whereas GIC has the ability to seal the cavity, provide fluoride release, and reduce micro-leakage. The bond between resin composite filling material and the conventional GIC is micro-mechanical in nature. The lack of a chemical bond between the conventional GIC and the composite resin could result in interference in final restoration characteristics, and subsequently, its longevity [10]. For the purpose of optimizing the GIC/composite resin bond, the etching of the phosphoric acid has been carried out on the surface of the GIC [11]. Nonetheless, the contamination of moisture throughout the GIC setting could result in calcium polyacrylate chain dissolution, which alters their physical characteristics, thus, it is preferable to wait for the occurrence of the initial setting prior to performing the etching of the acid and washing [12]. The utilization of the self-etching adhesive systems could result in solving this issue that utilize the monomers of the acidic resin for the etching of the dentin and enamel and they require no step of washing. The method of self-etching results in reducing the sensitivity of the approach as well as the clinical time, which has been shown in the lab studies and the clinical trials [13]. The researchers showed that they exhibited that the strength of the dentin and enamel bond has been similar to the strength of the total acid etching (etching and rinsing) adhesive systems [14].

Materials and methods

their composition and mode of application are given in table (1).

Table1: Composition of the materials that have been utilized in the present study

Material	Product/ Manufacturer	Composition	Mode of application
calcium silicate-based materials	Biodentine®, ZiZine, France	Tricalcium silicate, Zirconium oxide (radiopacifier), calcium carbonate (filler), and a water-based liquid composed of calcium chloride as a water-reducing agent for shorter initial and final setting time, due to the fact that it as well accelerates the early strength development rate.	Mixing pre-measured unit Dodoes capsules in a high-speed algamator for 30s
Glass ionomer cement	Glass ionomer cement chemical cure ProMedica Germany	Powder: Ca Aluminum silicate containing fluoride and phosphate. LL Liquid: polyacrylic acid 5o%,itatonic acid co-polymer and water	mixing 1 scoop powder with 1 drop liquid for 40s
Nanofill composite resin	Filtek™ Z350XT, 3M ESPE, USA	The fillers contain: 20nm nano-silica fillers, 5nm–20nm agglomerates particles of zirconia / silica, 0.60um–1.40um clusters particle size The monomers contain: UDMA	Inject the material in the cavity in increments of 1mm Light cure each increment for 20s a Light polymerization for 20s

		TEGDMA, Bis-GMA, PEGDMA, Bis-EMA	
Universal dental adhesive system	Single bond universal 3 M ESPE, U.S.	MDP phosphate monomer, HEMA, di-methacrylate resins, filler, initiators, vitrebond copolymer, water, ethanol, silane, pH=2.7	Scrub in for 20s, air dry for 5s or to the point where the adhesive doesn't move. Light cure for 10s

Forty acrylic blocks that contain a central hole with a 2mm height and a 5mm diameter have been prepared. Half of them have been filled by the Biodentine, while the remaining blocks hole were filled with conventional GIC, after mixing based on the manufacturer's instructions. The collected groups have been divided to 4 groups of 10 each as followings:

Group A: Set Biodentine applying dental adhesive over it after setting time (12min),

Group B: None set Biodentine were used immediately by applying dental adhesive system over it

Group C: Set GIC applying dental adhesive over it after setting (7 min)

Group D: None set GIC used immediately by applying universal dental adhesive system over it

Resin composite application

After the bonding procedure, the resin composite was applied at the Biodentine center by placing the composite in a transparent plastic hole (2mm high and 4mm in diameter). so that the Composite could be packed into the hole in one increment (2mm thickness) using asmall burnisher, the composite was then covered with a celluloid strip and a microscopic glass slide, (200 gm.) pressure had been applied for one minute to expel excess material from the mold and to reduce voids [(15)].The tip of light-curing unit should be in intimate contact with glass slide. The specimens of the composite have been cured with a light-emitting diode light cure (China) with 1,200 mW/cm2 intensity for 20 seconds from the top surface, the final shape of specimen shown in fig (1).

Figure 1: Final shape of specimen

The specimens have been stored in 100% humidity at 37C for 24h in incubator. All specimens have been then loaded into a universal machine of testing for measuring shear bond strengths.

Shear bond strength test

Every one of the blocks has been secured in universal testing machine (Laryee, China). Utilizing stainless steel chisel-shaped rod with 0.5 mm/min across head speed [9] until bond failure were occurred in Newton as shown in figure (2), converted after that into MPa through dividing peak break load by bonded interface cross-sectional area (12.57mm^2).

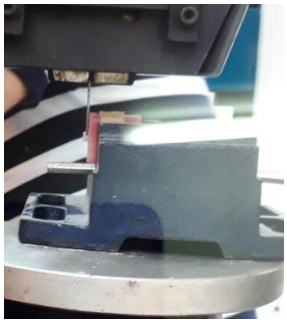


Figure 2: The specimen has been secured in a universal testing machine (Laryee, China)

Surface texture examination of Biodentine

Three additional specimens of Biodentine were prepared for stereomicroscope (at a 20X magnification power) demonstrates the superficial textures of Biodentine surface with different treatments and categorized as follow:

a. One specimen without treatment.

b. One specimen treated with self-etch bond immediately (before setting).

c. One specimen treated with self-etch bond after 12min. (after setting).

The specimens have been then stored at 37C in 100% humidity for 24h in an incubator, then examined under stereomicroscope at a 20X magnification power.

Mode of failure

All the broken parts were examined with 10X magnification to determine the type of failure between composite and Biodentine and GIC. Failure was assessed as either adhesive failure showing a completely smooth surface of composite, cohesive failure appearing as small particles of Biodentine or GIC was attached to all composite interfaces or mixed (combination of the adhesive failure and cohesive failure).

Statistical analysis

Data have been analyzed with the use of (SPSS, v. 19). The effects of the intermediate agents on the strength of the shear bond have been compared with the use of one-way ANOVA and LSD tests, in the tests above, $P>0.050$ (Non-significant), $P<0.050$ (significant), $P<0.001$ (highly significant).

Results

One-way ANOVA revealed that the intermediate agents had no significant influence on shear bond strength $p>0.05$. LSD test is shown in table (2). The set groups A and C resulted in shear bond strength mean values 9.28 Mpa that were no significant influence than the non-set groups (B and D) which resulted in shear bond strength 6.96 Mpa $p>0.05$. The set

Biodentine group (A) resulted in a shear bond strength mean value 4.21 Mpa that were no significant influences than the mean value 2.7 Mpa of the SBS of the non-set Biodentine group (B) p>0.05. Regarding GIC groups, the set GIC group (C) showed no significant differences with the non-set GIC group (D), in which the shear bond strength values were (13.36 and 11.22 Mpa) respectively p>0.05 as it is shown in figure (3).

Table 2: Effect of intermediat agent on shear bond strength (LSD test)

Groups	A after setting	Immediately	p-value
All groups	9.28	6.96	0.211
Biodentine groups	4.21	2.7	0.315
GIC groups	13.36	11.22	0.077

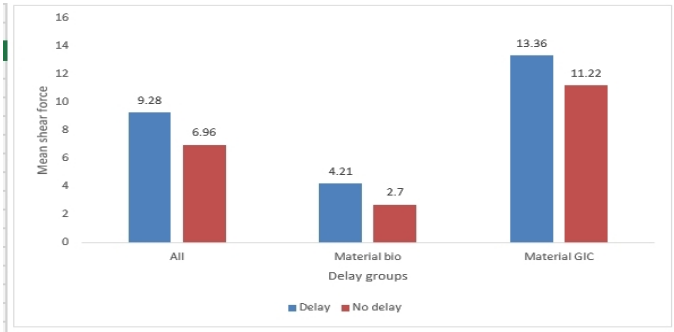
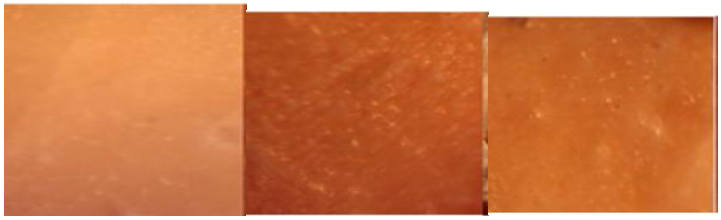


Figure 3: The relation between set and non-set material groups

The surface texture examination of Biodentine with different interval time treatments, using a stereomicroscope at 20X magnification is shown in figure (4). Microporosity clearly appears with group B and C, while group A (no treatment) appears smooth surface.



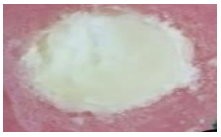
A **B** **C**

Figure 4: Surface texture examination of Biodentine with different interval time treatment A: No treatment; B: Immediately; c: Delay

The results of failure mode in our study were displaced by using the magnifying lens (10X), showed that the groups (A&C) showed 100% cohesive failure. While (B&D) showed mixed failure with cohesion predominant, figure (5)

A: 100% cohesion

B: Mixed



C: 100% cohesion

D: Mixed

GIC

Figure 5: The mod of cohesive failure A: cohesion failure of Biodentine; B: mixed failer of Biodentine; C: cohesion failure of GIC, D: mixed failure of GIC

Discussion

Biodentine can be considered as a successful material, in the case of being utilized as a substitute for the MTA. It has a reduced setting time, good bioactivity and placement, in comparison to the MTA [16]. Waiting 15 min, (initial set of Biodentine) before bonding application may lead to many complications, so it is better to use the adhesive immediately. In this study, we compare the SBS and composite in two different interval times (group A & group B). The result has shown that, there is not any significant difference ($p>0.05$). In the clinical practices, the Biodentine can be more successful and effective, in the case of being utilized as underlying material for the restorative materials. To optimize the bond of Biodentine, resin, phosphoric acid is performed on the surface of the material to create micromechanical porosity. But for unset, moisture may cause dissolution of the outer layer and destroyed the binding between them. So, self- etch adhesive is recommended. Single bond 3M ESPE was used in this study, although it is a moderate self-etch adhesive, ($1<PH<2$), it creates a mild porosity on the surface of Biodentine which is obviously seen in figure (4) during surface texture examination of the Biodentine. Stape et al., [17] have stated that the self-etch adhesives have different aggressiveness levels. Which is why, the researchers categorized the self-etch adhesives based on their values of the pH; aggressive self-etch adhesive (pH <1) moderate self-etch adhesive $1<pH<2$, and mild self-etch adhesive pH>2 [18]. Besides these micromechanical, there is a chemical adhesion between Biodentine and resin adhesive, as Hakan et al. study improve, (functional monomer 10MDP that has the ability to chemically bind to calcium ion of Biodentine), which enhance micromechanical adhesion [19], and this explains the 100% cohesion failure for both set and non- set Biodentine, figure (5). Nonetheless, the bonding between the traditional GIC and the resin composite has been limited as a result of the lack of the chemical bonding between those two materials and in addition to that, the glass ionomers ' low cohesive strength, which might be a result of the difference in the reactions of the setting between the conventional GIC and dental composites [20]. Because the contamination of the moisture throughout the setting of the GIC can result in the dissolution of the calcium polyacrylate chain and altering their physical characteristics, self-etch adhesive is recommended [21]. In this study. 3M ESPE self-etch adhesive has been utilized, because its functional monomer is MDP 10-methacryloxydecyl dihydrogen phosphate ($C_{14}H_{27}O_6P$), which is chemically bonding to Ca ion of GIC, table (1). The result showed that there is very good bond strength in both groups of GIC, table (2) and no significant differences between them in terms of time. The 100% cohesion failure of both groups of GIC, figure (5), improved the chemical bond between GIC and the adhesive. Manihani et al., [22] have shown that the composite's bond strength to the GIC has been considerably higher for the self-etching primer group that has been utilized on the unset GIC than to the set GIC. Kandaswami and others have concluded that using the mild self-etching agent of bonding over the unset GIC resulted in improving the strength of the bond in comparison with to the utilization of the intermediate and strong self-etching bonding agent [23]. Ruchi and Sonam found that shear bond strength of self-etch adhesive to unset GIC has been considerably higher compared to that of the set GIC, explained as the carboxylic monomer in self-etch primer could have chemically bonded to the calcium in unset GIC. A chemical union might be one of the possible reasons for higher bond strength [24]. Zahra et al., concluded that the self-etch adhesive type did not have any considerable effects on the micro-shear bond strength of the set glass-ionomer to the composite resin [25]. Our study disagree with Ruba, et el., study (2020) who said that the shear bonding strength of bonding composite to Biodentine was significantly reduced at the Biodentine primary setting phase or after prolonged time of exposure to the oral environment [26] on the other hand KAlqahtani at el concluded that The mean SBS of RC and RMGI to MTA groups was significantly higher than that of premixed Bioceramic also The SBS of delayed RC was significantly higher than that of immediate timing in all Bioceramic materials [27]. This study agree with Huei J. Tong and his fellow study (2022), they showed that Biodentine has high success ratio in any case of technique and no significant differences were found in the clinical and radiographic success rates between different intervals of time [28]. In another vitro study (2021) showed the application of universal adhesive using some alternative techniques may improve the bonding strength of dentin. The active application of adhesive together with the evaporation of solvent for a longer period of time up to 10 sec, could improve the bonding strength value of dentin above that, prolonging the curing time by up to 40 sec. is recommended. On the other side, shortened application time and application of desensitizers to the dentin should be avoided because bond strength could be impaired [29].

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