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Shear bond strength of glass and resin based restorative materials to calcium based cement (biodentine)

Shear bond strength of Biodentine

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ABSTRACT

Aims: The aim of This study was to evaluate in vitro the shear bond strength of some resin and glass based restorative materials(resin composite, Glass Ionomer Restorative Filling material, Poly –acid modified resin composite and self adhesive resin cement) to a calcium-silicate based cement (Biodentine).

Materials and methods: Forty-eight Biodentine specimens were prepared and stored for 72 hours at 37C^{o} and 100% humidity. Then each group was divided into 4 subgroups of specimens, and each tested material was layered on each of the Biodentine preparations. The materials-Biodentine shear bond strengths were measured and were compared by using one-way analysis of variance.

Results: Post hoc comparison of the shear bond strength between biodentine and tested materials shows significant difference, self adhesive cement was significantly different from the other tested materials($p<0.5$). The value of shear bond strength was approximately one quarter of the shear bond strength values for other materials. The modes of failure mostly mixed within all tested groups.

Conclusions: under the conditions of this in vitro study, resin composite, Glass Ionomer Restorative Filling material and Poly –acid modified resin composite can be used over biodentine successfully.

Keywords: shear bond, Biodentine, resin, glass, calcium based.

INTRODUCTION

Biodentine is a calcium silicate-based restorative material that has been developed recently with improved physical and chemical properties.(1,2) It is a high-purity dental material composed of tricalcium silicate, calcium carbonate, zirconium oxide, and a water-based liquid containing calcium chloride as the setting accelerator and water reducing agent. Biodentine is indicated for use as a dentin substitute under different restorations and as a repair material because of it's good physical and chemical properties (good sealing ability, high compressive strength, short setting time(3,4), biocompatibility, bioactivity, and biomineraization properties(5,6).

To complete the final restoration in a single visit, an adhesive restorative material can be applied over partially set biodentine layer. Therefore it is important to identify materials that are compatible in relation to the interface between the two different materials. Undestanding such behavior will be of great importance to complete final restoration. (8)

Currently various adhesive restorative materials can be used. Resin and glass based restorative materials are very popular in restorative dentistry because of their esthetic properties(9).There has been an expansion in these tooth-colored restorative materials, which are also adhesive in nature with improved physical and chemical properties(10).Glass ionomer offers distinct advantages over other restorative materials(11), due to its compatibility, adhesive nature (chemically bond to tooth structure) and its fluoride release(12,13). However, GICs are brittle materials and are susceptible to fracture and wear especially in the load bearing areas(14,15).

On the other hand, to utilize the advantages of GIC and to overcome the disadvantages of poly –acid modified resin composites, (compomer) is becoming one of the most promising restorative materials. They were developed to combine the advantages of glass ionomer cements and composites(fluoride release, chemical adherence to tooth structure and it's biocompatibility of GICs,and ease of handling, esthetic properties, stability and strength of composite).(16)

Extensive clinical procedure might result in accidentally perforated or extensive loss of tooth structure that might need to be restored. Biodentine could be the material of choice for replacing missed tooth structure. Subsequently, indirect restoration needed to restore the remaining amount of the cavity.

Self adhesive resin cements have been introduced recently and used for fixation of indirect restorative materials. An adequate adhesion of luting agent is necessary to provide clinically proper retention of restoration. Due to the limitation of light penetration, many resinous luting agents polymerized through a dual curing process that requires light exposure to initiate the reaction.(17) It has been reported that the mechanical properties of dual-cure type resin agents improved after photo-activation compared with chemical-activation alone.(18) The longevity of adhesive restorations depend, partly, on the bond strength between the restoration and the substrate. (19) Therefore, it is important to know the bond strength of various available restorative materials with Biodentine as a substitute and repair material.(17)

The purpose of this study is to determine the bond strength of resin based and glass based restorative materials to calcium silicate-based cement(Biodentine).

MATERIALS AND METHODS

Preparation of Biodentine Specimens

Forty acrylic blocks 2x3cm have been prepared with a central hole measuring 6 mm in diameter and 2 mm in depth. The Biodentine capsule was mixed according to the manufacturer’s instructions, injected into the holes in the acrylic blocks. After complete setting of the material (after 12minute according to manufacturer's instructions) After complete setting of the material the area of bonding was defined using circular perforation of a self adhesive tape measuring 4mm in diameter so that the applied adhesive agents confined to a standardized area on the base. The specimens were further divided into 4 subgroups of 10 specimens each according to the adhesive material:

Group I:Resin composite (Composan ceram, Germany).
Group II: Glass Ionomer Restorative Filling material (Legend™, England).
Group III: Self adhesive resin cement (G-CEM Auotomix, Japan).
Group IV: Poly –acid modified resin composite (Dyract, Tokyo, Japan).

Placement of the tested materials:

Each material was mixed according to the manufactuerer instructions and applied to the Biodentine surface with an applicator. Then each was placed at the center of the Biodentine surface by packing the material into rubber mold with an internal diameter of 4 mm and a height of 4 mm. For group I and IV the rubber mold place after etching the biodentine surface with 37% phosphoric acid gel (Vivdent Ets, Schaan/Liechtenstein, Germany) for 15 seconds, rinsed for 20 seconds, then gently blown), and application of a total etch adhesive system (Excite, Ivoclar, Vivadent, Liechtenstein) according to the manufacturers instructions. The composite resin and poly –acid modified resin composites was packed directly against biodentine surface through the rubber hole using plastic instrument, adapted in two increments. Each increment of 2mm thickness was light polymerized for 40 second at 400mW/cm^2 using a Quartz-Tungsten-Halogen (QTH) light curing unit (Astralis 5, Vivadent, Schaan/Liechenstein, Germany). A second increment was covered with a transparent celluloid strip before light curing . To standardized the curing distance the tip of the polymerization unit was applied in contact with the surface of the rubber mold. Then the rubber mold and the adhesive tape were removed and the tested material polymerized for 10 second at four point all around to ensure that there was complete polymerization. For group III (self adhesive resin cement), the same procedure was done except that the placement of cement was done by injecting the material in the rubber mold without application of adhesive material. . For group II restorative glass ionomer cement mixed according to manufacturer's instructions and applied over the Biodentine surface through the rubber hole and allowed to set for 10 minutes within the rubber mold . Then the rubber mold and adhesive tape were removed carefully. All the samples were stored at 37C^o and 100% humidity for 24 hours to encourage setting. All samples were prepared by the same operator. The specimens were allowed to set for 10 minutes within the plastic tubes to ensure completion of the initial setting reaction. Then the rubber mold were removed carefully, and the specimens were stored at 37C^o and 100% humidity for 24 hours to encourage setting. All samples were prepared by the same operator.

Shear Bond Strength Measurement:

The specimens were mounted in a universal testing machine Digital Force Gauge Machine(Model ZP, Imada Co, LTD, Japan).All samples were tested at a cross head speed of 0.5 mm/min using a knife-edge blade until the bond between the Biodentine and tested materials failed .The values were calculated in newtons and converted into mega pascals (MPa).The means and standard deviations were calculated. The mean bond strengths of the groups were compared by using one-way analysis of variance (ANOVA) and LSD test at $p<0.5$.

Modes of failure:

Representative samples have been selected randomly to evaluate the modes of failure from each group using digital microscope camera, at 25X and 50X classified as follows: adhesive failure, cohesive (within the Biodentine), and mixed failure(within adhesive material and /or restorative material).

RESULTS

The means and standard deviations of the shear bond strengths between the restorative materials and biodentine are given in Table (1). Post hoc comparison shows significant difference self adhesive cement was significantly different from the other tested materials ($p<0.5$). the value of shear bond strength was approximately one quarter of the shear bond strength values for other materials.

Regarding failure mode analysis, the microscopic analysis of the interfaces reveled that in the all groups the failure mostly mixed within adhesive material and/or restorative materials as seen in Table (2). Figure (1) shows representative photograph for each type of failure.

DISCUSSION

Biodentine is a tricalcium silicate based dental material that could be both a temporary enamel restoration and a definitive dentine substitute. It's good sealing properties, high compression strengths and short setting time are suggestive of its potential as a restorative material.[20,21]

To complete the final restoration, we should use a material that is compatible with biodentine and can be applied over partially set material. Therefore, it is important to identify materials that can be applied over biodentine and can allow for immediate final restoration placement.[8] In addition, the longevity of the restorative materials depend partly on the bond strength of these restorations with the substrate.[19]

In this study the shear bond strength of poly acid modified resin composite compomer (Dyract), restorative GIC, resin composite and self adhesive cement(G-CEM Automix) to biodentine have been evaluated. Different methods are available to analyze the bond strength in-vitro. The shear bond strength test has been widely used for evaluation of the bond strength of dental materials. This method have the advantage of being more easy to perform than the microtensile method.[20]

The bond strength between two restorative materials is important. It has been estimated that a bond strength ranging from 17 to 20 MPa may be required to resist contraction forces to produce gap-free restoration margin.[21,22] In the present study the shear bond strength of poly acid modified resin composite, restorative GIC and resin composite exceeded this range, while the shear bond strength of the self adhesive cement was below this range. A contributing factor to this large variation could be due to the difference in specimen preparations or imperfections.[23] These bond values where similar with the results of a previous studies.[24,25] Additionally, for dual cure resin cement ,the possible decreasing effect of light curing at the area away from the light source may results in reduced bond strength.[26] Also the bond strength values of this type of cements is related to the degree of conversion of the monomer which in turn decreased when the distance from the light increased leading to poor physical properties.[24] Lack of pressure during placement of the self adhesive resin cement may also be a contributing factor in its low bond strength value. Pressure during cement application is necessary to avoid bubbles and open spaces on the interface, and may affect the longevity of the self adhesive resin cement.[27]

According to the results of our study, the lowest shear bond strength value(10.56 ± 1.59) was observed in G-CEM Automix cement, while for the Dyract compomer group was (41.44 ± 1.94) and for the resin composite group was (39.44 ± 6.52). This difference in the values between the tested materials could be due to the difference in the bonding mechanism of each material.[26]

Chitnis et al.(2006), compared the bond strength between GIC,PMCR and resin based composite and found that resin based composite had significantly higher shear bond values than the PMCR.[28] Parbhaker et al. 2003, observed that RMGIC exhibited higher bond values when compared to PMCR and resin –based composite.[29]While Almuammer et al. 2001[30] observed that PMCR had higher shear bond than GIC and RMGIC, but less than resin based composites.

Adequate polymerization of light curing materials depend on light source intensity, wave length, exposure duration, size, location and orientation of the tip of the source, and shade, thickness and composition of the material.[31] polymerization may also enhance the mechanical properties like the shear bond strength. [32]

In the present study, the most common mode of fracture in the self adhesive resin cement group was mixed failure at the interface between the tested material and biodentine, This result indicated that a strong chemical bond was not formed at the interface for many of the specimens in this group. In the other groups the most of the specimens showed cohesive and adhesive fracture this indicated strong chemical bonding present between biodentine and the tested materials.

CONCLUSION

Within the limitations of this in vitro, nnot used with biodentine due to the weak bond between them, while reself adhesive resin cement resin composite, Glass Ionomer Restorative Filling material and Poly–acid modified resin composite can be used over biodentine successfully because they reveal high shear bond strength with biodentine.

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Table (1): The mean and standard deviation of shear bond strengths in MP and LSD Test for the tested material to biodentine

Tested materials	Mean	±SD	Post Hock* comparison
Composite resin	39.44	6.52	a
Restorative glass ionomer cement	39.11	2.89	a
poly –acid modified resin composites	41.44	1.94	a
Self adhesive resin cement	10.56	1.59	b

*Different letter mean significant different.

Table (2): Percentage of mode of Failure among tested materials by shear bond test

Group	Adhesive Failure	Cohesive Failure Within biodentine	Mixed
Composite resin	**30%**	**30%**	**40%**
Restorative glass ionomer cement	**20%**	**30%**	**50%**
poly –acid modified resin composites	**-**	**60%**	**40%**
Self adhesive resin cement	**10%**	**10%**	**80%**

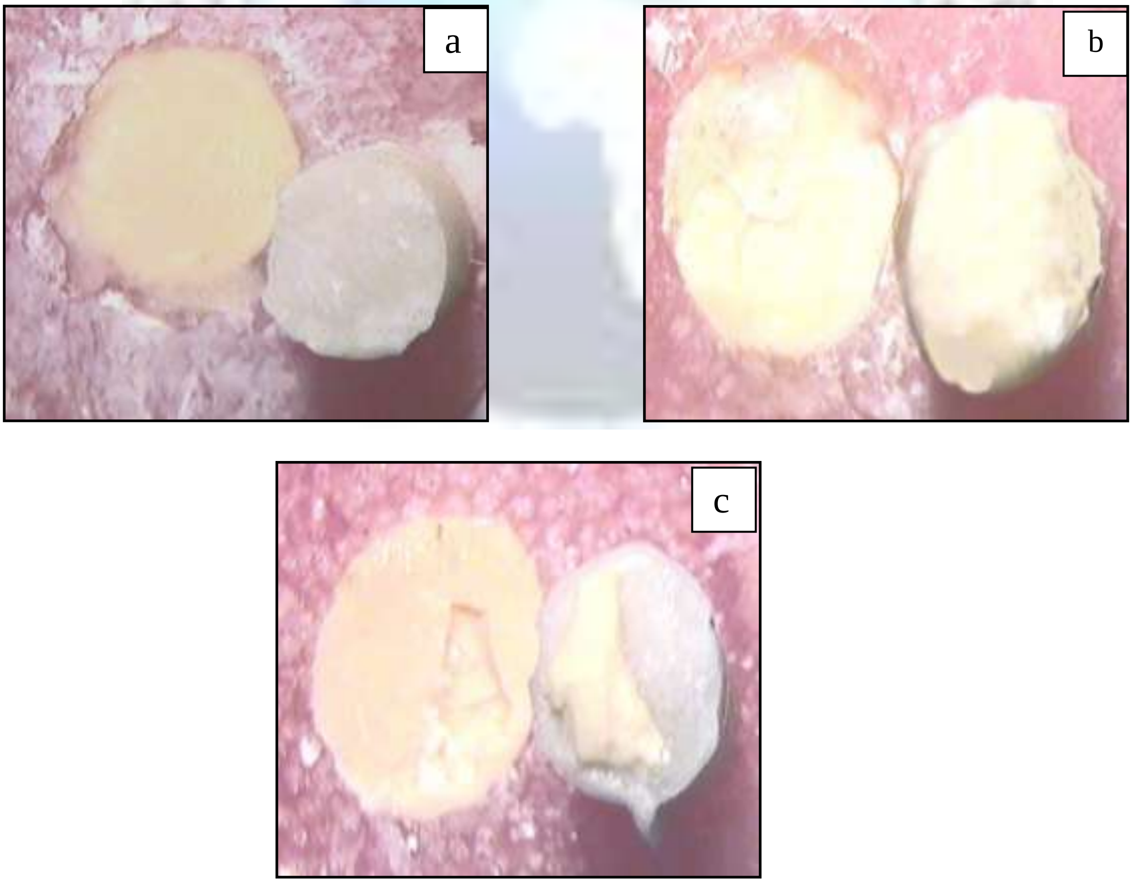

Figure (1): mode of failure. (a) adhesive failure (b) cohesive failure within biodentine (c) mixed failure