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Comparative Evaluation Of Shear Bond Strength Of Biodentine And Resin Modified Glass Ionomer Cement Using Two Adhesive Systems In Premolars Restored With Composites: An In – Vitro Study

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Abstract:*Introduction: The success of the restoration depends on the proper bonding of the restorative material to the prepared cavity in order to provide pulp protection and achieving adequate seal. This was met with the introduction of new materials like resin modified glass ionomer cement (RMGIC) and Biodentine. The development of the adhesive agents for bonding of restorative material has rapidly evolved in recent years, which will increase the bonding between the RMGIC and Biodentine to the composite resin.*
Aim:
To evaluate and compare shear bond strength of tricalcium silicate-based restorative material and resin modified glass ionomer cement in premolars using two adhesive systems.
Materials and Methods:
Occlusal surface of crowns were ground flat. A cavity with 6mmX2mm is prepared over the flat surface and filled with biodentine and RMGIC according to the groups ascertained (Group A – Biodentine, Group B – RMGIC). It is then further subdivided into two subgroups (Group A1, B1 – total etch adhesive system and Group A2, B2 – self etch adhesive system). After the application of adhesives PVC molds were stabilized over filled cavity and it is restored with composite resin. Shear bond strength is evaluated using Universal Testing Machine.
Results:
Results showed that biodentine with adper single bond had a mean value of 12.488 and resin modified glass ionomer cement with universal bond had a mean value of 12.191, resin modified glass ionomer cement with adper single bond had a mean value of 9.507, biodentine with universal bond had a mean value of 7.283. On comparison within the groups, group A1 - Biodentine with Adper single bond showed better shear bond strength than with group A2 - Universal bond which was statistically significant (P = 0.03). On comparing between the groups, group B2 - RMGIC with Universal bond had a higher shear bond strength than group A2 - Biodentine which was statistically significant (P = 0.04).
Conclusion:
Group A1 – Biodentine with Adper single bond (total etch system) shows better shearbond strength which is followed by group B2 - RMGIC with Universal bond (self etch system) and group B1 - RMGIC with Adper single bond and then group A2 - Biodentine with Universal bond.

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I. Introduction

To maintain normal form and function of a tooth, enamel and dentin, need to be retained; if lost due to caries etc, they must be replaced. Various materials like; zinc oxide eugenol, zinc polycarboxylate, glass ionomers and few newer ones like MTA, biodentine etc., have been used as dental substitutes. A dentin substitute or a base when used reduces postoperative sensitivity caused by materials used to restore the tooth and also protects the pulp[1].

Glass ionomers are currently very popular products that not only bond ionically to the tooth structure but also are capable of releasing fluoride. However, the conventional auto-cure glass ionomer cements are susceptible to wear and have poor marginal integrity, due to which they cannot be placed over occlusal surfaces

involving centric stops. Also, to the changes in oral pH, glass ionomers will act like buffers, which will cause their surface degradation in areas where saliva cannot wash oral acids away. To overcome these disadvantages, resin modified glass ionomers were introduced which not only capable of releasing fluoride and providing good adhesion but also have better resistance to microleakage and have less solubility than a conventional glass ionomer. Also, superior bond strengths were observed with resin-modified cements bonded to composite resin (9.17 to 16.23 MPa) as compared to conventional glass ionomers probably due to the superior cohesive strength of these cements and due to the chemical bonding between the resin bonding agent and the non-reacted resinous phase of the glass ionomer cement [2].

Biodentine, a tricalcium silicate cement was developed by Septodont's Research Group as a novel material. Due to its good sealing ability with dentin, it is used as a dentin substitute [9]. Since Biodentine is recommended for use as a dental base under permanent restorations, studies were carried out to evaluate the bond strength of the material with different bonding agents, where on assessing the shear bond strength of an etch-and-rinse adhesive, a 2-step self-etch adhesive and a 1-step self-etch adhesive system to Biodentine at different intervals, it was seen that there was no significant difference between all of the adhesive groups at the same time intervals (12 minutes and 24 hours) [3].

In order to withstand occlusal forces and restore the occlusal anatomy, restorative materials are placed above dentin substitutes. To test the adhesion of dental adhesives, shear bond strength test can be carried out [4].

Aim of the study

The aim of the study was to evaluate and compare the shear bond strength of Biodentine – tricalcium silicate-based bioactive material (Septodent) and resin modified glass ionomer cement (Fuji II LC GIC) with two adhesive systems in premolars.

Objectives of the study

1. To evaluate the shear bond strength of Biodentine – tricalcium silicate–based bioactive material (Septodent) with Adper single Bond (etch and rinse adhesive system – two step) and Universal bond – 3M (1 step self etch adhesive system) adhesive systems in premolars.
2. To evaluate the shear bond strength of resin modified glass ionomer cement (Fuji II LC GIC) withAdper single Bond(etch and rinse adhesive system – two step) Universal bond – 3M (1 step self etch adhesive system) adhesive systems in premolars.
3. To compare the shear bond strength of Biodentine – tricalcium silicate–based bioactive material (Septodent) and resin modified glass ionomer cement (Fuji II LC GIC).

II. Material And Methods

Study Population:

40 extracted human premolars which was extracted due to orthodontic reasons were collected and it was divided into two groups – group A and group B. The study was conducted in the Department of Pedodontics and Preventive Dentistry, Vivekanandha Dental College for Women, Tiruchengode and Department of Plastic Engineering, Central Institute of Plastics Engineering & Technology (CIPET), Chennai.

Selection criteria of the tooth:

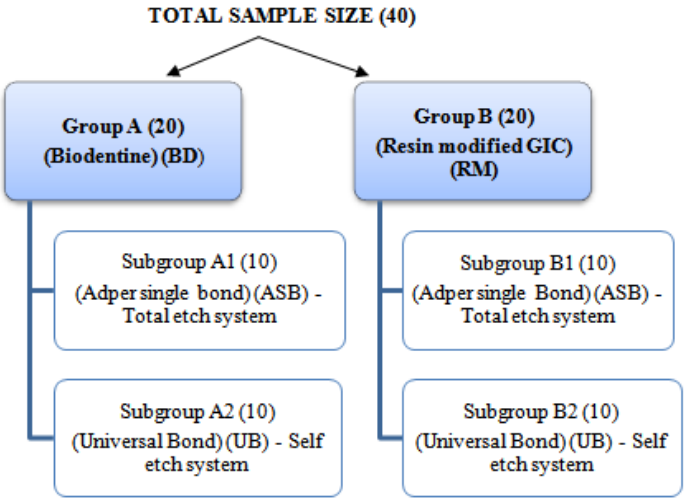
1. Premolars extracted for orthodontic purposes.
2. Teeth with sound structure.
3. Tooth without caries, cracks, restorations and fracture defects.

Sample collection and procedure:

40 premolars extracted for orthodontic purpose were taken for this study. The samples are then divided into two groups namely, Group A (Biodentine group) and Group B (resin modified glass ionomer cement) respectively. Each group is then further subdivided into subgroup1 (Adper single Bond - 3M) and subgroup 2 (Universal Bond - 3M).

Extracted premolars are selected, cleaned of debris and stored in distilled water at room temperature until cavity preparation.

Study design:



III. Methodology

For evaluating the shear bond strength, the root portion of each tooth was embedded into an acrylic mold with the occlusal surface of tooth parallel to the base. Molds were then filled with cold cure acrylic resin (DPI-RR cold cure) leaving the crown portion of tooth alone exposed. The mid-coronal portion of the occlusal surfaces of dentin was exposed by a flat cut perpendicular to the long axis of the tooth with a fine diamond disc in high speed with a copious water spray. Specimens were then stored in distilled water.

The mid coronal dentin of the occlusal surfaces of the premolar tooth were ground flat and a cavity of 6mm width and 2mm depth reference are prepared in the flat surface. It was then filled with a base material such as biodentine for group A (n=20) and RMGIC for group B (n=20) as per manufacturer instructions. Once the material sets, for etch and rinse group (subgroups A1 & B1) (n=10 for each subgroups), the filled cavity surface was etched with 35% phosphoric acid etchant for 15 seconds. It was then blot and dried for 10 seconds. Bonding agent was then applied over the base for 10 seconds and then it is dried with gentle air stream for 5 seconds and light cured for 10 seconds. For self etch group (subgroups A2 & B2), bonding agent is applied over the base for 10 seconds and dried with mild air for 5seconds and light cured for 10seconds. Once the application of bonding agent is done, a PVC (Poly Vinyl Chloride)mold of 3.5mm diameter by 3 mm height was positioned perpendicular over the base. It was then filled with composite resin which was then cured for 20 seconds. After that, the mold was removed with BP (Bard Parker) blade.

Shear bond strength is evaluated with Universal Testing Machine (INSTRON) using a steel knife edge (1mm thickness) at a cross head speed of 0.5 mm/ minute. Each sample was mounted in universal testing machine with the dentin surface parallel to the machines trajectory. A compressive load was applied, using a steel knife-edge placed over the sample's tooth-restoration interface so that the force of the shear was applied directly to the bond interface. Load was applied such that crosshead moving at speed of 0.5 mm/minute. Load was applied until restoration failure occurred and values were recorded.

IV. Result

Ten samples from each group were tested for shear bond strength and the values were recorded. Mean shear bond strength was calculated from the recorded values and statistical analysis was done with the paired“t”test

Table 1: Shear bond strength values for all groups

SAMPLE NUMBER	GROUP A1	GROUP A2	GROUP B1	GROUP B2
1	13.80	5.57	9.42	21.18
2	11.83	12.54	5.73	10.52
3	19.03	3.30	5.35	7.01
4	13.17	3.95	19.46	20.18
5	15.36	2.24	12.33	5.65
6	8.40	10.43	12.62	9.23
7	4.79	2.66	2.62	17.56
8	22.03	12.63	3.09	11.73
9	14.64	8.12	11.49	13.49
10	1.83	11.39	12.96	5.36

Table 1 shows shear bond values in Mpa for all 10 samples in each group.

Graph 1: Distribution of scores across various groups and samples

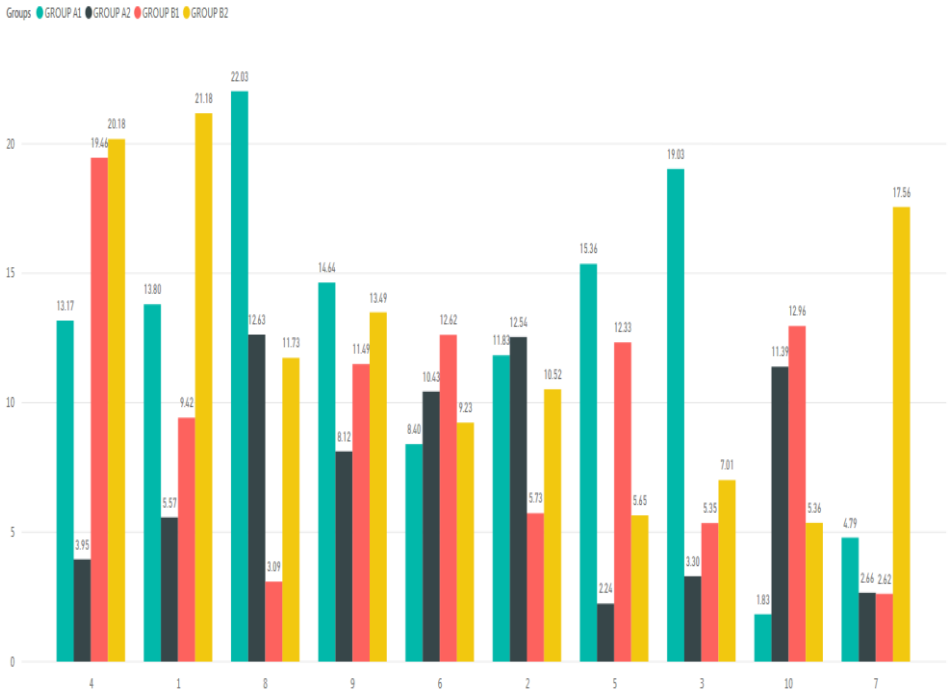


Table 2: Mean shear bond strength of Biodentine and RMGIC groups

Groups	N	Mean value
Group A1 – BD ASB	10	12.488
Group A2 – BD UB	10	7.283
Group B1 – RM ASB	10	9.507
Group B2 – RM UB	10	12.191

N – sample size

Table 2 shows Mean shear bond strength of Biodentine and RMGIC of groups. Mean shear bond strength was found to be higher in Group A1 and Group B2 followed by Group B1 and Group A2.

Table 3: Comparison of mean shear bond strength of Biodentine and RMGIC groups

Groups	P values
Group A1 Vs group A2	0.03*
Group B1 Vs group B2	0.14
Group A1 Vs group B1	0.15
Group A2 Vs group B2	0.04*

P – 0.05, * - significant

Table 3 shows that comparison of mean shear bond strength of Biodentine and RMGIC groups. On comparison within the groups, group A1 - Biodentine with Adper single bond showed better shear bond strength than with group A2 - Universal bond which was statistically significant (P = 0.03). Group B2 - RMGIC with universal bond showed better shear bond strength than with group B1 - Adper single bond which was not statistically significant (P = 0.14). On comparing between the groups, group A1 - Biodentine with Adper single bond shows better shearbond strength than group B1 - RMGIC which was not statistically significant (P = 0.15) and group B2 - RMGIC with Universal bond shows higher shear bond strength than group A2 - Biodentine which was statistically significant (P = 0.04).

V. Discussion

Dentin loss is perhaps one of the most important losses which hamper the integrity of the tooth structure to a significant extent. To be in the coronal portion or on the radicular one, the dentin loss must be substituted with an artificial material, which can restore the physiological integrity of the tooth structure. Over the past years, many materials have been for this purpose of study. While referring to the dentin loss in the coronal part, such as in case of deep carious lesions, materials like Glass-Ionomer Cement have been used extensively, but with its limitation of not stimulating any reparative dentin formation on its own [5].

The shear strength is defined as the maximum stress which a material can withstand before failure in a shear mode of loading. The actual stress level that initiates crack propagation can be several times higher than the nominal (or average) value. Therefore, nominal bond strength does not represent the failure stress and also bond strength values for a specific material can vary a lot among studies due to differences in the bonding substrate, specimen preparation, storage conditions, and loading method [6].

For evaluating the bond strength test, a composite cylinder was built on the bonding substrate. After a predetermined storage time, the specimen was positioned in a universal testing machine where a single-edged chisel, a flat-end rod, or a wire loop have been attached to the actuator which was used to dislodge the composite cylinder from the substrate [6]. In this present study knife edge chisel was used to displace the material.

The shear bond strength was assessed in a custom apparatus attached to a universal testing machine. The results showed that mean shear bond strength of Biodentine on Adper single bond was 12.488 MPa and Universal bond was 7.283 MPa. The present study showed that shear bond strength of RMGIC on Adper Single bond was 9.507 MPa and 12.191 MPa on universal bond.

A study done by Boinonet al got a shear bond value of biodentin on permanent teeth as 3.04 MPa[7].

RMGIC with total etch system exhibits less shear bond strength when compared to self etch system which is similar to Kerby and Knobloch (1992) study in which they demonstrated that the application of acid etching can decrease the bond strength through a partial elimination of HEMA and un-reacted methacrylate groups in air-inhibited layer and concluded that acid etching has no significant effect on bond strength of RMGI to composite [8].

Contrast to this study, a study by Kenshima et al (2005) reported that self-etch adhesives produced the lowest bond strength of resin to dentin. This may be due to highly acidic self-etching adhesives that contain higher solvent contents for promoting complete ionization of the acidic monomers. Thus, the adhesive layer after solvent evaporation will be quite thin, i.e. polymerization may be inadequate due to the formation of an air-inhibited layer. Consequently, unpolymerized acidic monomers will increase in this layer. All these factors compromise the polymerizing initiator system interfering with composite polymerization; thus, the bond strength of strong self-etching adhesives will be reduced [9].

Di Nicolo Ret al (2007) in his study reported that shear bond strength of RMGIC was increased when the dentin surface is acid etched separately, which is contrast to the present study in which shear bond strength was more in RMGIC with self etch adhesive group (universal bond) [10]. This may be due to a similar chemistry between RMGIC and the composite resin, which allows the strong bonding of RMGIC to composite resin. Both RMGIC and the resin composite are cured by a free radical initiator system, which provides a potential for the chemical bonding between these two materials and also due to silanes in adhesion promoters that contain two different reactive functional groups that can react and couple with various inorganic and organic materials. Silane coupling agents also improve the bond strength of coatings and adhesives as well as their resistance to humidity and other adverse environmental conditions.

This study is in accordance with the study conducted by and V Arora et al (2010) and MG Chandak et al (2012) in which they concluded that application of self-etch adhesive in between RMGIC and composite resin increases the shear bond strength between RMGIC and the resin composites, as compared to the total-etch type adhesive as well as without application of the adhesive agent. This may be due to the acidic pH of the self-etch adhesive. The acidic nature of adhesive agents makes the superficial surface of the RMGIC dissolve, thereby improving the bonding of RMGIC to the composite resin [11, 12].

The present study is similar to the study conducted by Boruziniat and Gharaei (2014) in which he evaluated bond strength between RMGI and composite using different adhesive systems and curing techniques and concluded that the application of self-etch adhesive systems and co-curing technique can improve the bond strength between the RMGI and composite. This may be due to the lower the viscosity adhesive used, the better the bond strength may be achieved and penetration of resin into RMGIs may improve the strength of these cements and therefore, the failure mode may change [13].

Ajami et al. (2013) have reported low bond strength values between RMGIC and pulp capping agents. The low values can be attributed to the lower etching capability of polyacrylic acid resulting from glass ionomer particles. Depending on this, insufficient preparation of the surface and creating the honeycomb pattern may affect bonding between two interfaces. In this present study RMGIC with universal bond showed better shear bond strength than with Adper single bond and on comparing between the cements, Biodentine with Adper single bond shows better shearbond strength than RMGIC [14]. The reason may be due to biomineralization ability of biodentine. The smaller particle size and uniform components might have a role in better interlocking of biodentine with the tooth.

In Gisovar et al (2014) study, the shear bond strength of etch-and-rinse adhesive systems were higher than self-etch adhesives which is similar to this study in which etch and rinse adhesive system with biodentin shows better shear bond strength than self etch adhesives [15]. This is due to formation of a hybrid layer and resin

tags which is essential for the establishment of a strong bond at the dentin level and may be achieved by complete dissolution of the smear layer and demineralization of intertubular and peritubular dentin by means of acid etching technique, resulting in an exposed collagen matrix which is then infiltrated by resin.

Similar to this present study, a study by Meraji and Camilleri (2017) the shear bond strength of all dentin replacement materials (Biodentine, Theracal LC, and Fuji IX) was lower when self-etch adhesive was used, especially in Biodentine specimens. This is due to the mechanism of action of self-etching adhesives in which hydroxyapatite minerals are removed from the collagen surface layers following the application of adhesive to the teeth. This results in diminished chemical interactions between minerals, hydroxyapatite and functional monomers in turn, thus, relying on mere micromechanical bonding in the absence of chemical bonding seems to lead to lower bond strength, which may contribute to the lower bond strength in strong self-etching adhesives **[16]**.

In contrast to the study by Juliana Godoy-Bezerra et al (2006) in which they evaluated the shear bond strength of resin-modified glass ionomer cement in a saliva-contaminated environment, using different enamel pretreatments and concluded that Enamel pretreatment with 37% phosphoric acid increased bond strength values than with the resin composite Transbond XT group **[17]**. It is due to the acidic nature of the etch and rinse adhesives. The acidic nature of the adhesives makes the superficial surface of the restorative material to dissolve, thereby improving the bonding of RMGIC.

In accordance with the present study, a study by Nekoofar et al (2018) etch and rinse adhesive system (Adper Single Bond 2) had higher micro-shear bond strength values on one week aged Biodentine specimens in comparison to the two-step self-etch adhesive (Clearfil SE Bond). The authors explained that the phosphoric acid agent may create more pronounced and retentive porosities on Biodentine surface into which the adhesive can penetrate compared to the dissolution depth obtained with Clearfil SE Bond **[18]**.

VI. Conclusion

The following conclusions were made from this study

1. RMGIC bonded better with composite when self etch adhesives was used.
2. Bonding of Biodentine with composite was better when etch and rinse system was used.

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