Original Article

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Comparative Evaluation of Shear Bond Strength of Resin Modified Glass Ionomer Cement and Biodentine as Dentin Substitutes to Bonded Silver Amalgam and Composite Resin

Dentistry Section

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ABSTRACT

Introduction: The bond strength between the restorative material and the tooth, as well as between the restorative material and the base, is an important factor and can determine the longevity of a dental treatment.

Aim: Comparative evaluation of shear bond strength of Resin modified glass ionomer cement and Biodentine as dentin substitutes to Bonded silver amalgam and Composite resin.

Materials and Methods: Acrylic resin blocks of dimension 3x1.5x1.5 cm were made. A total of 40 acrylic blocks containing a central hole (wells) with 4 mm diameter and a 2 mm height were prepared. The samples were randomly divided into two groups- Group 1 and Group 2 having 20 samples each. The wells of Group 1 and Group 2 were filled with Resin Modified Glass Ionomer Cement (RMGIC) and Biodentine, respectively according to manufacturer's instructions. The samples of each group were further divided into four subgroups (n=10): Group 1A, 1B, 2A, 2B. The surface of Group1A and 2A were etched and then treated with adhesive (Adper single bond-2, 3M ESPE) and restored with nanohybrid composite resin and specimens of 1B and 2B were etched and treated with adhesive (Meta P & Bond- MetaBiomed) respectively and were restored with silver amalgam. All the samples were stored in artificial saliva for 24 hours at 37.5°C, 100% humidity and were subjected to shear bond strength testing.

Results: Group 1A (RMGIC + Composite) showed the highest shear bond strength values-29.58 MPa followed by Group 2A (Biodentine + Composite resin) - 5.59 MPa, Group 1B (RMGIC + Bonded silver amalgam) - 3.96 MPa and least was seen in Group 2B (Biodentine + Bonded silver amalgam) - 0.445 MPa.

Conclusion: This study concluded that combination of Composite resin and RMGIC or Composite resin and Biodentine showed higher shear bond strength values as compared to a combination of RMGIC and Bonded silver amalgam or Biodentine and Bonded silver amalgam.

Keywords: Bond Strength, Dental bases, Universal testing Machine

INTRODUCTION

To maintain normal form and function of a tooth, enamel and dentin, need to be relained; if lost due to caries etc, they must be replaced. 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]. Various materials like; zinc oxide eugenol, zinc polycarboxylate, glass ionomers and few newer ones like MTA, biodentine etc., have been used as dental substitutes [2].

Glass ionomers are currently very popular products that not only bond ionically to the tooth structure but also are capable of releasing fluoride [3]. 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 [4]. 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 [5]. 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 [6,7]. 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 [8].

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) [10].

In order to withstand occlusal forces and restore the occlusal anatomy, restorative materials are placed above dentin substitutes. In areas of the mouth that are difficult to isolate, like molars or sub-gingival cavities, silver amalgam can be considered one of the best filling materials. Concerns about, its inability to bond to the tooth, leading to microleakage led to the introduction of adhesive systems that reliably bond to both dentin and enamel [11]. Some of the adhesives used for bonding silver amalgam include All-Bond 2 (Bisco), Amalgambond Plus with HPA (high performance additive) powder (Parkell), Panavia EX, Panavia 21 (Kuraray), Optibond 2 (Kerr), Meta P & Bond (Meta Biomed) [12]. Silver amalgam has drawbacks like unaesthetic appearance, marginal deterioration, concerns about the mercury toxicity, making the coloured restorative materials popular. At least half of posterior direct restoration placements now rely on composite [13]. The introduction of inorganic fillers which are well dispersed in a resin matrix has been shown to be very effective in improving the performance of composite resins [14]. To test the adhesion of dental adhesives, shear bond strength test can be carried out [15].

In-vitro bond strength tests are useful and essential for predicting the performance of adhesive systems and possible correlation with clinical issues [16]. No studies to the best of our knowledge has been done to evaluate shear bond strength of Biodentine to Bonded silver amalgam. Thus, the purpose of our study was to evaluate and compare the shear bond strength of Resin modified glass ionomer cement and Biodentine as dentin substitutes to Bonded silver amalgam and Composite resin.

MATERIALS AND METHODS

Institutional Ethical Committee approval was obtained before start of the study. (IEC no. -660/2015). The materials used in our study are shown in [Table/Fig-1]. A total of 40 acrylic blocks containing a central hole with 4 mm diameter and 2 mm height were prepared. The samples were randomly divided into various groups and subgroups as shown in [Table/Fig-2]. In Group 1 and Group 2, 20 samples were taken each and the holes were completely filled with RMGIC (Ionolux, Voco, Germany) and Biodentine (Septodont, Saint Maur des Fosses, France) respectively in accordance with the manufacturer's instructions. [Table/Fig-1]. For RMGIC group, light curing was performed for 20 seconds. The tip of the light curing unit was held as close as possible to the surface of the filling. To achieve a smooth, glossy surface, a mylar strip was placed over the sample and gentle finger pressure applied for five minutes to compact the cement mass and minimise the porosity. After waiting 12 minutes, which is the initial setting time of Biodentine as per the manufacturer, the surfaces of all samples of both Group 1 and Group 2 were then etched with 37% Phosphoric Acid (Eco-Etch, Ivoclar, U.S.A) for 15 seconds, rinsed with water and blot dried. Then the samples were divided into four subgroups (n=10) as given in [Table/Fig-2]:

Group1A- specimens of RMGIC + Composite

Group 1B- specimens of RMGIC + Bonded silver amalgam

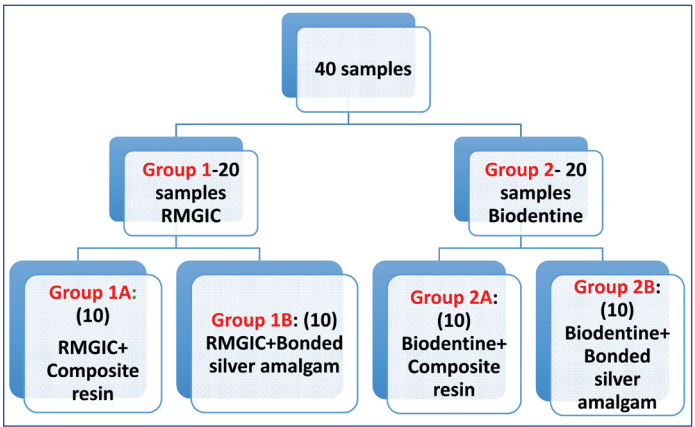
Group 2A- specimens of Biodentine + Composite

Group 2B- specimens of Biodentine + Bonded silver amalgam

The samples were pretreated with adhesive Adper Single Bond 2 (3M, ESPE, USA) for the samples to be restored with Composite resin and with Meta P & bond adhesive (MetaBiomed, USA), for samples to be restored with silver amalgam. Thereafter, light-curing (Elipar Highlight; 3M ESPE, Seefeld, Germany) was performed and the samples were restored with Bonded silver amalgam (High copper admixed disperse alloy, dentsply dental corp., USA) and Composite resin (Filtek Z350 XT, 3M ESPE, USA) respectively according to manufacturer's instructions [Table/Fig-1]. into a cylindrical shaped plastic tube with an internal diameter of 3 mm and a height of 2 mm with a plastic cement carrying instrument. All the samples were stored in artificial saliva for 24 hours at 37.5°C and 100% humidity.

Sl. No.	Material	Manufacturer	Method of application
1.	Resin Modified Glass Ionomer Cement (RMGIC)	Ionolux,Voco, Germany	Powder/liquid ratio 3.2 : 1 g/g), Light cured for 20 seconds
2.	Biodentine	Septodont, Saint Maur des Fosses, France	Mixing premeasured unit dose capsules in a high-speed amalgamator for 30 seconds.
3.	Adhesive system for composite	Adper single bond 2 ESPE, U.S.A.	Applied over the surface and light cured for 20 seconds.
4.	Adhesive system for Bonded amalgam	META P&Bond adhesive, METABIOMED, U.S.A.	Applied over the surface and light cured for 10 seconds.
5.	Silver amalgam	High copper admixed, Disperse Alloy, Dentsply dental corp., U.S.A	Preproportioned amalgam capsules were used to standardise the amalgam and they were triturated in an amalgamator. In all the samples, the amalgam was condensed by a serrated round condenser with a diameter of 1 mm by a single operator
6.	Composite resin	Filtek Z350 XT 3M ESPE, U.S.A.	Light curing for 40 seconds

[Table/Fig-1]: Materials used in the study.



[Table/Fig-2]: Illustration of samples randomly divided into various groups and subgroups

Shear Bond Strength Test

For shear bond strength testing, the specimens were held in a holder placed on a Universal Testing Machine (Instron 3366, USA) and the measurement carried out at a crosshead speed of 1.0 mm/minute. Shear bond strength in MPa was calculated by dividing the peak load at failure with the specimen surface area (F/r2). Specimens that underwent pre-test failures were excluded from the statistical analysis.

STATISTICAL ANALYSIS

All the analysis was done using SPSS version 20. A p-value of <0.05 was considered statistically significant. Intra and intergroup comparisons were done using Kruskal-Wallis, One-way ANOVA and Mann-Whitney U tests.

RESULTS

Upon considering the mean shear bond strength values amongst all sub-groups on intergroup comparison [Table/Fig-3], statistically significant difference was observed (p<0.001). It was seen that values of bond strengths obtained followed the order: 1A>2A>1B>2B. Hence, RMGIC bonded to Composite resin showed the highest shear bond strengths amongst all the subgroups and Biodentine bonded to Bonded silver amalgam showed the least shear bond strength. On intra group comparison also [Table/Fig-4], the differences obtained between all the groups statistically significant (p<0.001). Groups 1A, 2A attained higher bond strength values were obtained than group 2A and 2B. On comparing the shear bond strength values of Group 1B and 2B, Group 1B demonstrated higher shear bond strength values than 2B.

GROUP	Minimum-maximum value Megapascals (Mpa)	Median (q1,q3) (MPa)	p value
1A- RMGIC + COMPOSITE RESIN	26.61-33.44	29.58 (28.24, 31.04)	p<0.0001
1B- RMGIC+BONDED SILVER AMALGAM	2.91-5.85	3.96 (3.60, 4.30)	
2A- BIODENTINE+COMPOSITE	6.31-3.84	5.59 (4.38, 5.79)	
2B- BIODENTINE +BONDED SILVER AMALGAM	0.05-1.7	0.445 (0.11, 0.93)	

[Table/Fig-3]: Intergroup comparison of shear bond strength using kruskal-wallis one-way anova.

GROUP	GROUP	P value
RMGIC + COMPOSITE RESIN(1A)	BIODENTINE+COMPOSITE RESIN(2A)	p<0.001
RMGIC+BONDED SILVER AMALGAM(1B)	BIODENTINE+BONDED SILVER AMALGAM (2B)	p<0.001
RMGIC + COMPOSITE RESIN(1A)	BIODENTINE+BONDED SILVER AMALGAM(2B)	p<0.001
BIODENTINE+COMPOSITE RESIN(2A)	RMGIC+BONDED AMALGAM(1B)	p<0.001
RMGIC + COMPOSITE RESIN (1A)	RMGIC+BONDED AMALGAM(1B)	p<0.001
BIODENTINE+COMPOSITE RESIN(2A)	BIODENTINE+BONDED SILVER AMALGAM (2B)	p<0.001

[Table/Fig-4]: Intra-group variations in shear bond strength using Mann-Whitney U test.

DISCUSSION

Wide range of different classes of materials has been introduced for the replacement of lost dentin as dentin substitutes. RMGIC is the modification of conventional glass Ionomers in which resin monomers were added which not only improved the handling characteristics of the material, but also led to improved bonding with Composite resins as proven by numerous studies [17]. Where as Biodentine, has both therapeutic pulp capping capabilities as well as the ability to be used as a bulk filling material, thus simplifying the restorative process [18]. Thus RMGIC and Biodentine have been used as dentin substitutes in this study.

During sample preparation, manufacturer's instructions were followed for every material. No changes were made regarding the manipulation and mode of application. Adper single bond, fifth generation adhesive (3M ESPE, USA), was used to bond Composite resin to both resin modified glass ionomer cement and to Biodentine. Adper Single Bond Adhesive is a total etch, visible-light activated dental bonding agent incorporating 10 percent by weight of 5nm diameter silica filler along with Bis Phenol A Glycidyl Methacrylate (Bis GMA), Hydroxyethyl Methacrylate (HEMA), dimethacrylates, ethanol, water, a novel photoinitiator system and a methacrylate functional copolymer of polyacrylic and polyitaconic acids. A few materials have been developed for amalgam bonding specifically and have shown excellent adhesive properties to both tooth structures and enhancing bonding to amalgam alloys [12]. One such novel adhesive, Meta P & Bond (MetaBiomed, USA) was used in the present study for Bonding silver amalgam to both RMGIC and to Biodentine. It is an unfilled adhesive, composed of Bis Phenol A-Glycidyl methacrylate, Pyromellitic glycerol methacrylate, 2-hydroxyethylmethacrylate and ethyl alcohol.

It is recommended that these materials, when used as base or dentin substitute, should be restored with a permanent restoration, thus, in the present study, the two most frequently used restorative materials silver amalgam and a nanohybrid composite resin which has good resistance to wearing and offer good polishability have been used [19].

The bond strength between the restorative material and the tooth, as well as between the restorative material and the cavity liner or a base, is an important factor and can determine the quality and longevity of a dental treatment and hence, the shear bond testing was carried out between the dentin substitute and the restorative material in our study. Our findings demonstrated that RMGIC bonded to Composite resin (Group 1A) showed the highest shear bond strength median value of 29.58 MPa as compared to other groups. This could be attributed to the presence of monomer groups that ensure a stable and comprehensive chemical bonding between the substrates [20]. Unpolymerised HEMA on the surface of RMGIC intensifies the surface wetting capability of the bonding agent, leading to increased bond strength when polymerised [21].

On intra group comparison, our study demonstrated higher bond strength values for the groups in which the dentin substitute was bonded to composite resin where Adper Single Bond 2, fifth generation total etch adhesive (3M ESPE) was used which has silica filler as one of its components. Meta P & Bond adhesive, a fifth generation bonding agent is an unfilled adhesive. It has been proven that filled adhesives like Adper single bond act as an intermediate shock-absorbing elastic layer between resin composite and dentin, thereby increasing the bond strength to dentin [22]. Thus, it can be said that in Groups 1A, 2A, higher bond strength values were obtained than group 2A and 2B.

On comparing the shear bond strength values of Group 1B and 2B, Group 1B demonstrated higher shear bond strength values than 2B and the difference was statistically significant (p<0.001). It was seen that the shear bond strength of Group 2B attained very low values (0.445 MPa). It could be attributed to the fact that Biodentine's initial setting reaction takes approximately 12 minutes after mixing the powder and the liquid where a hydrated calcium silicate gel structure is formed which has weak physico-mechanical properties. For upto two weeks, the crystallisation of the calcium silicate hydrate gel structure continues, leading to maturation of Biodentine [23]. Hence, it's recommended that placement of permanent restoration over the Biodentine should be delayed for a period of two weeks. Also, the presence of monomer groups in both RMGIC as well as in adhesive Meta P & bond could ensure better chemical bonding of both the groups leading to higher bond strength values of group 1B as compared to group 2B [20].

LIMITATION

In the present study, bonding was performed to Biodentine immediately after 12 minutes to depict a single visit clinical procedure. However, being a porous material, it needs at least two weeks time for crystallisation of hydrated calcium silicate gel to attain bulk strength adequate enough to withstand the polymerisation stresses [23]. This could be the reason for low bond strength in the Biodentine group. Also, in future studies SEM evaluation can be carried out in order to further elucidate the reasons for the differences in the bond strength and observing the modes of failure.

CONCLUSION

The study concluded that: The shear bond strength of RMGIC to Composite resin is best followed by Biodentine to Composite resin with statistically significant difference (p<0.001) when bonded using Adper single bond 2 adhesive system. The shear bond strength of RMGIC and Biodentine to Bonded silver amalgam showed lesser values with statistically significant difference (p<0.001) when bonded using unfilled Meta P & Bond adhesive system.

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