Research Article

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Evaluation of Shear Bond Strength of Resin Composite with Dentin Substitutes Using Universal Adhesive: An In-Vitro Study

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ABSTRACT

Aim: The in-vitro research aimed to determine resin composite bond strength with two separate cements of calcium silicate: Biodentine(BD), TheraCal LC(TLC) using universal adhesive and comparing it with that of SDR (Smart Dentin Replacement).

Materials and methods: The collection and division of 45 gelatin capsules in 3 groups with 15 in each group was based on the following material: group I SDR (control), group II Biodentine, Group III TheraCal LC. Using universal adhesive, composite restoration was then bonded to dentin replacement material. The strength of the shear bond strength (SBS) was measured at a rate of 1mm / min. Statistical analysis was done using statistical package for social sciences (SPSS) version 20 using kruskal wallis and post hoc mann whitney test

Results: There was a statistically significant difference between the study groups II and III. SDR exhibited higher values of shear bond strength (4.55N / mm2). The least bond strength values were shown in Group II (BD). Among the experimental groups the shear bond strength of Thera Cal LC was higher than that of Biodentine.But both groups displayed substantially less bond strength than the SDR which is a control group. TheraCal LC may therefore be used as a better alternative to Biodentine as a dentin replacement material.

Keywords: Biodentine, TheraCal LC, dentin replacement material, bond strength, pulp capping agent, SDR, dentin substitutes.

INTRODUCTION

For years, clinical dentistry has faced the challenges of substituting lost dentine. Several materials have been developed over the years to address this major problem in restorative dentistry. Dentin substitutes are necessary in deep cavities to protect the pulp and reduce the bulk of filling materials as shrinkage of conventional resin-based filling materials may result in debonding, microleakage, and pulpal damage.[1] The desirable properties of a dentin substitute are biocompatibility, antibacterial properties, stability, long-term impermeability, induction of hard tissue regeneration, non-absorbability, and ease of handling. These materials

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are layered with composite resin restorative materials.

Smart Dentin Replacement (SDR) is a recently introduced flowable resin composite material designed to minimize the effect of high polymerisation shrinkage by using a flexible monomer. It includes modified Urethane Dimethacrylate resin with photoactive groups. Compared to conventional methacrylate-based resins, these activated resin has resulted in 60-70% less shrinkage stress.[2] Despite all these advantages, post-operative sensitivity was reported when SDR was used as a dentin substitute material.

Hence the focus was shifted to usage of bioactive cements such as MTA, Biodentine and TheraCal LC with remineralising and pulp protective action to counteract the post operative sensitivity caused by resin based materials. When used as liners under composites, these bioactive materials seem to benefit the pulp more than conventional Glass Ionomer liners, as they are more biocompatible and have a superior remineralizing ability.

Mineral Trioxide Aggregate (MTA) is a material that has attracted attention when used as pulpal medication with its appropriate biological characteristics, beneficial histological and clinical results. However, the major disadvantages of MTA were long setting time, high dissolution during the setting process, staining potential in dental tissues and difficult to use. New calcium silicate based cements, including Biodentine and TheraCal LC were developed to overcome these disadvantages.[3]

Biodentine is an improved Calcium Silicate material with good mechanical properties as well as excellent biocompatibility and bioactive behavior. It does not cause tooth discoloration and sets in approximately twelve minutes. It is available as a powder and liquid containing tricalcium silicate, zirconium oxide, calcium carbonate and water based polymers and calcium chloride respectively.[4] This material can be directly placed in the cavity as bulk dentin replacement without preconditioning. This new biologically active material aids its penetration through open dentinal tubules, crystallise and interlock with dentin and provide good mechanical properties.[5]

TheraCal LC is a new mineral trioxide aggregate-filled, light cure resin-modified calcium silicate cement and was approved as a liner under composite restorations with the aim of achieving a bond between the different layers of materials and as a pulp protectant. The cement component is of Portland type, and it includes silicon oxide additive in a resin matrix and radiopacifying material.[6]

In order to withstand occlusal forces and restore the occlusal anatomy, restorative materials are placed above dentin substitutes.[7]The longevity of these laminate restorations depends not only on the strength of the bond between the liner and the dentin, but also on the quality of the bond between the liner and the composite resin. Resin composites used universal adhesives for bonding to prevent microleakage. Universal adhesives can be used in total-etch, self-etch, or selective-etch mode depending on the specific clinical scenario and they consists of single bottle, no mix, adhesive system. Universal adhesives are compatible with self cure, light cure and dual cure resin based cements and are used to place both direct and indirect restorations.[8]

In this current study the shear bond strength between TheraCal LC , Biodentine, SDR and resin composite was tested with a universal adhesive as bonding agent. 10-MDP in Universal adhesive has been shown to chemically bond to calcium silicate cements. It was hypothesized that bonding with a 10-MDP containing adhesive will enhance the shear bond strength of calcium silicate based cements, TheraCal LC and Biodentine and make it comparable to that of a resin based dentin replacement material SDR.

MATERIALS AND METHODOLOGY

This In-vitro was conducted in the Department of Conservative Dentistry and Endodontics , Government Dental College and Research Institute, Bengaluru.

METHODOLOGY

The materials used in the in vitro study included tricalcium silicate based resin dentin replacement material – TheraCal LC (Bisco), Biodentine (Septodont) and SDR (Smart Dentin Replacement, Dentsply) and Scotchbond Universal adhesive (3M

ESPE). Forty five gelatin capsules of 6mm in height and 7.3mm in diameter was collected.

Fig 1: Materials used in the study.

The samples are randomly divided into three groups with 15 samples in each group

Group I: control SDR(n=15)
Group II: Biodentine(n=15)
Group III: Theracal LC (n=15)

The gelatin capsule was placed on the glass slab with matrix band below it to allow easy removal of the material (fig 2)

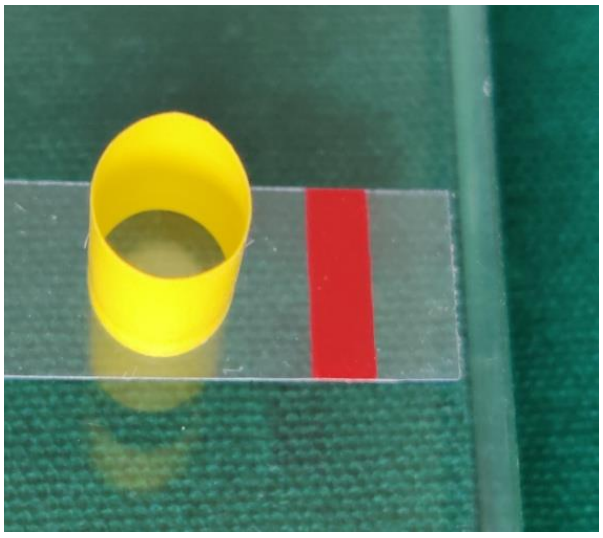


Fig 2: Gelatin capsule.

In group II Biodentine is mixed according to the manufacturers' instructions and is placed within the gelatin capsule upto 2mm and allowed to set for 12minutes (fig 3). In group III TheraCal LC is syringed onto the depth of the gelatin capsule upto 2mm in two increments. The cement surface is flattened using a metal spatula and polymerized with a curing unit for 20 seconds. In group I control, Smart Dentin Replacement material is added within the gelatin capsule upto 2mm in bulk and cured for 20 seconds.

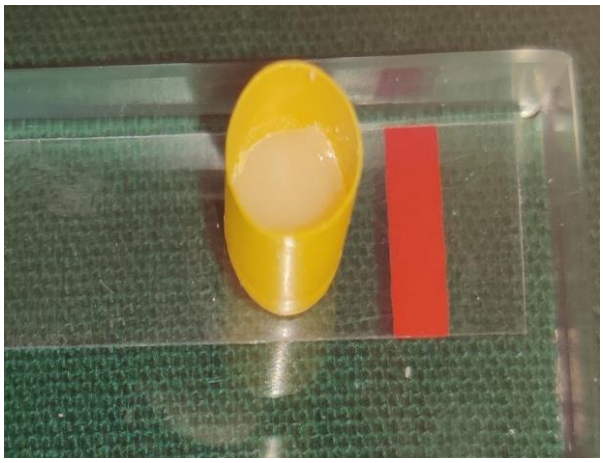


Fig 3: Placement of dentin substitutes.

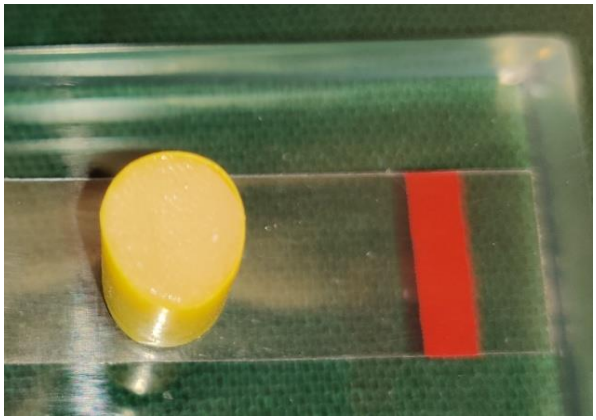


Fig 4: Dentin substitutes layered by composite resin after application of universal adhesive.

A single coat of Universal adhesive is applied over the Biodentine 24hrs after the material placement within the gelatin capsule to allow maturation. Application of Universal adhesive for Group I and Group III were done immediately after the material placement within the gelatin capsules and advised gentle air drying for 5 seconds and light cured for 20 seconds. After application of bonding system the dentin substitutes are layered with light cure composite resin upto 4mm in increments and cured for 20 seconds (fig 4). The specimens were mounted on the acrylic molds (fig 5) and thermocycled for one week to simulate oral conditions

Fig 5: Prepared working samples.

The specimens are attached to the Universal testing machine. A chisel with knife edge is gently held flush against the Resin composite-Biodentine/ TheraCal LC/SDR interface and loaded at the cross head speed of 1.0mm /min until bond failure occurred. The load at failure was recorded at N/mmsq.

Fig 6: Shear bond strength testing in universal testing machine.

STATISTICAL ANALYSIS

Data gathered through experiment was computerized and analyzed using SPSS 20.0 (Statistical System for Social Sciences). Kruskal-wallis and post-hoc mann-whitney test were used to compare the shear bond strength of the study groups. <0.05 probability value will be taken as statistically significant

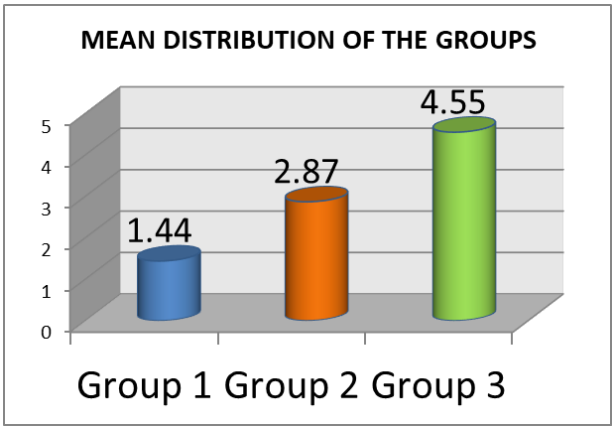
RESULTS

Multiple group evaluation for shear bond strength using kruskal-wallis showed that there was a major difference between the groups (p=0.001). The post-hoc mann-whitney test was carried out to determine a difference between any two given groups. Significant difference in bond strength between the experimental groups and with control group was observed in the result.

Control group(SDR) revealed the higher shear bond strength-4.55N/mm^2. TheraCal LC (2.87N/mm2) showed the high shear bond strength among the experimental groups than Biodentine (1.44N/mm^2) as shown in Table 1.

Table 1 : Mean shear bond strength of study groups.

	Minimum(N/mm 2)	Maximum(N/mm 2)	Mean(N/mm 2)
Group I	3.04	6.34	4.55
Group II	0.50	2.20	1.44
Group III	1.18	3.50	2.87



Graph 1: Mean distribution of the groups.

DISCUSSION

The current study evaluated and compared the bond strength of two different dentin replacement materials based on Calcium Silicate to layering composite and that of a resin-based dentin replacement, SDR. BD and TLC have been selected for the study owing to their beneficial properties such as calcium releasing ability, excellent sealing ability, compressive strength similar to that of dentin and being bacteriostatic which make them

favourable to the dental pulp. Previous studies showed that Calcium Silicate based cements were convenient, efficient and well tolerated as a substitute for dentin when layered with a composite.[5]

SDR which is used as a resin dentin substitute, includes a photoactive group in modified urethane dimethacrylate resin, TEGDMA, ethoxylated bisphenol A dimethacrylate. It has already been shown to have good bond strength to resin composite. But it does not have any advantageous properties on dental pulp like its bioactive substitutes.[7] Biodentine particularly designed as a dentin replacement material consists of tricalcium silicate, zirconium oxide, calcium carbonate which is mixed with a liquid containing water based polymers and calcium chloride.[3] TheraCal LC is a novel light-cured MTA-filled resin modified calcium silicate cement also contains HEMA and it has been approved to be used as a liner beneath composite restorations.[9]

The bonding agent used in this study is a 3M ESPE Scotchbond Universal adhesive, which contains methacryloyloxydecyl dihydrogen phosphate(MDP) in it. A 10-MDP based self etching adhesive shows chemical bonding to the oxides of Al, Ca^{2+} , and Zirconium. Wettability of the adhesive is improved with the help of silane part present in the adhesive by acting as a adhesive promoter and chemically binding to materials which contain silica and the methacrylate functionality of adhesive allows chemical bond with resinous substitute.[8] When using Calcium Silicate materials with bonding agents, particularly containing 10-MDP functional monomer, Calcium Silicate cements' binding capacity to restorative materials will be enhanced.[10] Hence in this study it was hypothesized that by using a 10-MDP based adhesive the bond strength of Calcium Silicate cements to composite resin will be improved and made equivalent to that of SDR to layering resin composite.

The present study results showed that Group II Biodentine displayed the lowest shear bond strength i.e 1.44Mpa when compared with TLC group (2.87Mpa) and SDR group (4.55Mpa) inspite of the same bonding technique. MDP monomer of the universal adhesive used in the current study was supposed to bind chemically to Biodentine. However, the bond strength of Biodentine group was lower than that of TLC and SDR, which could be due to its non-resinous composition.

Studies have also shown that the bond strength of Biodentine varies depending on the passage of time between the placement of Biodentine and the composite layering . Biodentine's usual setting time is 12 minutes, as specified by the manufacturer. Biodentine was overlaid with resin composite in the present study after 24 hours of material placement. In 2013, Odabas et al analyzed the bond strength of a composite to Biodentine in two varying time periods of 12 min and 24 hours and reported higher Shear Bond strength levels for Biodentine in the 24-hour time period.[11] On the otherhand, some studies have already shown that BD has gained maximum bond strength for overlying restoration, two weeks after its restoration. Bachoo et al stated in 2012, while Biodentine takes approximately 12 minutes for its initial set, only after 2 weeks the product is fully set. This maturation is necessary, as the setting reaction of Biodentine can impair the strength of the bond between Biodentine and the overlying restorative material.[12] They recommended placing overlying resin composite as a final restoration after 2 weeks to allow complete internal maturation of Biodentine to withstand contraction forces of resin composite. So in the present study, the poor bond strength can also be ascribed to Biodentine's low cohesive strength in its early setting phase.

Group III TLC showed considerably higher shear bond strength, i.e. 2.87Mpa than Biodentine, which could be due to the presence of HEMA monomer that have enhanced the resin composite bonding. This research is in favour with Gaddalay et al's 2018 report. They evaluated TLC, biodentine, and MTA's shear bond strengths to composite resin and observed TLC showing significantly higher bond strength than Biodentine and MTA.[13] At the same time, in our analysis, bond strength of TLC Group was inferior than the SDR group. TLC with a composition based on resin was expected to show shear bond strength similar to that of SDR. The self-etching adhesives based on MDP used in the study were also expected to bind chemically to the calcium silicate element of TLC and maximize its bonding ability. Nevertheless, against our belief, the lower values achieved for TLC could be due to the mild pH of self-etching adhesives, i.e. 2.7, which could have been buffered by the alkalinity of

cement containing calcium.[14] This would have led to an incorrect etching pattern, resulting in reduced bond strength. Previous etching of these alkaline cements with phosphoric acid with a pH of 0.1-0.4 may strengthen the bond.[15] This was established in the report by Karadas et al, who tested TLC's bond strength with resin composite using several adhesive systems. They stated that when a 3-step adhesive containing HEMA was used in the base and adhesive TLC displayed the highest shear bond strength as compared to a single step and two-step adhesive.[16] The one-step adhesive system used in our study may have affected micromechanical bonding and favored chemical bonding alone.

Group I SDR gave the best shear bond strength value i.e. 4.55Mpa in comparison to Group II and Group III. This can be due to the SDR's solely resin-based structure, making it a more compatible substrate for layering composite.

Although the bond strength was lower for calcium silicate cements than resin-based dentin substitutes, they are definitely a better alternative from a biological point of view because of their bioactive nature. Biodentine and TLC's shear bond strength surpasses the values acquired by other silicate-based cement such as MTA. For the clinical use of these dentin replacement products, more improvement in the mechanical properties is necessary to make it more successful than resin-based cements.

The present study drawbacks were that a static load was used to measure the shear bond strength that is entirely different from the clinical scenario. It is recommended that bond strength analysis be carried out under dynamic conditions to support the above findings. The in-vitro test results can not be correlated directly with in-vivo instances. In order to ascertain the above results, further clinical research should be carried out.

CONCLUSION

SDR showed high shear bond strength with composite than Biodentine and TLC's. Biodentine demonstrated the lower value of the shear bond strength. TLC yielded better bond strength than Biodentine but less than SDR. A separate etching step might enhance the bonding ability between TLC and the composite resin. In order to have durability of dentin replacement material, further upgrades in the properties of calcium silicate cements are needed.

CONFLICTS OF INTEREST

The authors declare they have no potential conflict of interests regarding this article.

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