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A comparative evaluation of shear bond strength of three different restorative materials to biodentine and TheraCal LC: An *in-vitro* study

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Abstract
Aim: The aim of this study was to evaluate and compare the shear bond strength of three different restorative materials to Biodentine and TheraCal LC respectively.
Materials and Methods: 60 acrylic blocks were prepared and divided into 2 groups of 30 samples each. Group I samples were filled with Biodentine and Group II with TheraCal LC. Each of these groups were further divided into 3 groups of 10 samples each in which restorative materials were packed over the Biodentine or TheraCal LC base as follows: Group IA- Biodentine-Composite, Group IIA- TheraCal LC-Composite, Group IB- Biodentine-Glass ionomer cement, Group IIB- TheraCal LC- Glass ionomer cement, Group IC- Biodentine- Resin modified GIC and Group IIC- TheraCal LC- Resin modified GIC. The samples were then tested for shear bond strength using the universal testing machine. The data were analysed using ANOVA test followed by Post hoc dunnett's test for multiple group comparison.
Results: On comparison of shear bond strength, statistically significant difference ($p<0.05$) was found between Group IA and IIA and that of Group IC and IIC. No statistical significant difference ($p>0.05$) was present between Group IB and IIB. A highly statistical significant difference ($p<0.001$) was present between the six groups in relation to shear bond strength.
Conclusion: The highest shear bond strength value was obtained with TheraCal LC and Composite and lowest value with Biodentine and GlC.

Keywords: Calcium silicate cements, restorative cement, shear bond strength

1. Introduction
Protective liners and bases are materials that are placed between dentin (and sometimes pulp) and the restoration to provide pulp protection [1].
The most popular agents for direct and indirect pulp capping are calcium hydroxide [$Ca(OH)_2$]-based and calcium oxide (CaO)-based materials, unfortunately they are soluble and raise local pH which forms a necrotic layer at the material–pulp interface [2]. As bioactive tricalcium silicate cements such as Biodentine and TheraCal LC have a potential for remineralisation, better mechanical properties, shorter setting time and easy application, it makes them suitable for their use as pulp capping agent and as a cavity base/ liner [3, 4].
The restorative materials used in vital pulp therapy should completely seal the involved dentin from the oral environment and preserve the tooth vitality [5].
Resin-based composites, Glass ionomer restorative materials and Resin modified glass ionomer cement are popularly used in Pediatric dentistry. It is because of their aesthetic quality and good adhesion with dentinal surfaces which resists the dislodging forces that act upon them [6, 7]. However, the strength with which the tricalcium silicate cements bond to these restorative materials is unclear.
As per our review of literature, we did not come across many studies which have been done to evaluate and compare the bonding ability of resin-based composite, glass ionomer restorative material and resin modified glass ionomer cement to tricalcium silicate cements like Biodentine and TheraCal LC together.
Therefore, the aim of this study was to evaluate and compare the shear bond strength of three different restorative materials namely Composite restorative material, Glass ionomer restorative cement and Resin modified glass ionomer cement to Biodentine and TheraCal LC respectively.

2. Materials and Methods

2.1 Sample preparation

The study was conducted in the Department of Pedodontics and Preventive Dentistry after obtaining approval by the Institutional Review Board. 60 acrylic blocks (N=60) having 2 mm depth and 5 mm diameter central holes were prepared from a stainless steel mould. The samples were then divided into two groups of 30 samples each: Group I samples comprised of Biodentine (Septodent). The Biodentine capsule was mixed in the amalgamator for 30 seconds and inserted completely into the holes of acrylic blocks and allowed to set for 12 minutes. Group II samples comprised of TheraCal LC (Bisco, Schaumburg, IL, USA). TheraCal LC was expelled in 2 increments of 1 mm each into the acrylic blocks and cured for 20 seconds. The samples for Group I and II were then divided into three subgroups of 10 samples each according to the restorative material that will be placed. (Fig. 1)

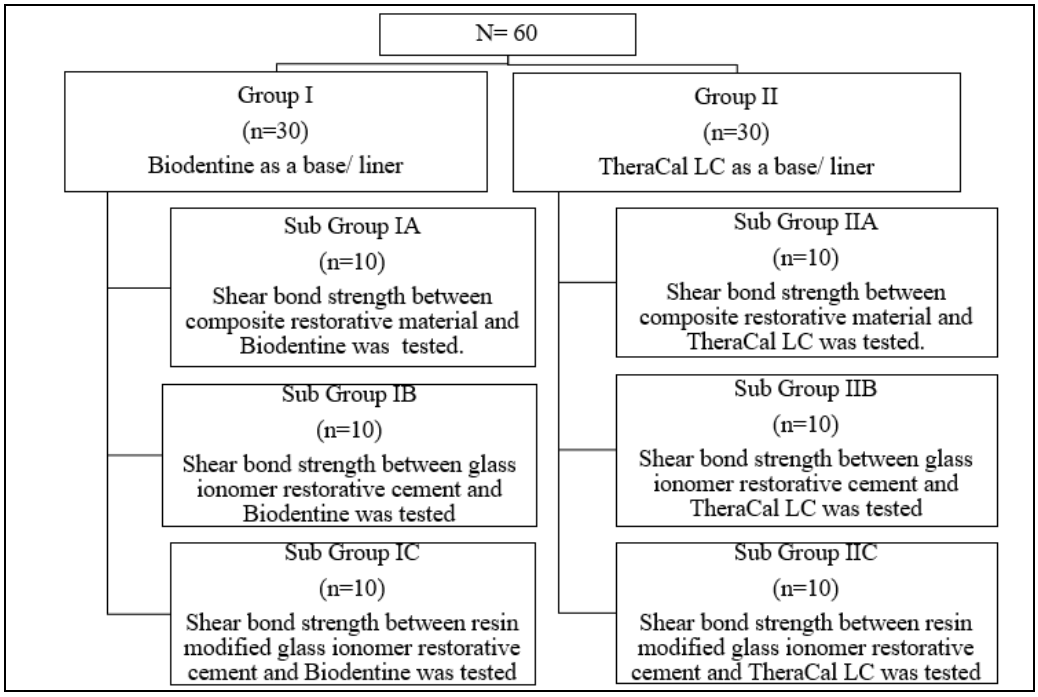

Fig 1: Groups for the study

2.2 Preparation of rubber moulds

A rubber mould with internal dimension of 3 mm x 3 mm was prepared using a stainless steel mould for packing of the restorative material.

2.3 Technique for placement of restorative material

The technique for placement of resin based composite material to Biodentine (Group IA) and TheraCal LC (Group IIA) was same. 37% phosphoric acid gel (Eco- Etch, Ivoclar Vivadent) was used to etch the surface of both Biodentine and TheraCal LC base area for 15 seconds. A 5th generation dentin adhesive system (Ivoclar, Vivadent) was applied on the etched surface and cured for 20 seconds. A nanohybrid packable composite material (3M ESPE, Filtek Z350 XT) was placed at the centre of the Biodentine and TheraCal LC surface by packing the material in 2 increments into the rubber mould and cured for 30 seconds. To standardize curing distance, tip of the curing unit was placed in contact with the surface of the rubber moulds.

The technique for placement of glass ionomer restorative cement (HS Posterior Extra, GC Gold Label) to Biodentine (Group IB) and TheraCal LC (Group IIB) was same. The surface of Biodentine and TheraCal LC were conditioned using a dentin conditioner (Pyrax) for 10 seconds. Glass ionomer restorative cement was manipulated and placed at the centre of Biodentine and TheraCal LC surface by the packing material into rubber mould and allowed to set for 10 minutes to ensure completion of setting reaction.

The technique for placement of resin modified glass ionomer restorative cement((Light-cured universal restorative, GC Gold Label) to Biodentine (Group IC) and TheraCal LC (Group IIC) was similar as Group IB and IIB, except that RMGIC was cure for 20 seconds.

For all the groups, after the polymerization or setting process, the rubber mould was removed carefully and the samples were stored at 37^{o} $\pm$ 2 ^{o}C in an incubator for 24 hours to simulate the oral cavity and encourage setting.

All the samples were prepared by a single investigator.

2.4 Measurement of Shear bond strength

For the shear bond strength test, each sample was secured in a universal testing machine. A chisel-edge plunger was mounted onto the movable crosshead of the testing machine and positioned so that the leading edge will be aimed at the Biodentine or the TheraCal LC base/ adhesive interface till bond failure occurs. The force required to remove the restorative material was measured in Newton's (N) and the shear bond strength was calculated by dividing the peak load values by the restorative material base area (3 x 3 mm^2).

Shear Bond Strength = 1MPa/ mm^2

2.5 Statistical analysis

The data was statistically analysed using SPSS for Windows, Version 16.0. Chicago, SPSS Inc. Released 2007. Power of the study was set at 80% with Beta error set at 20%. ANOVA F test was applied to shear bond strength of 6 groups. Post hoc data analysis which follows ANOVA was done by using Dunnett's multiple comparison test for multiple pair-wise

comparison among individual group. Probability $p<0.05$, considered as significant as alpha error set at 5% with confidence interval of 95% in the study.

3. Results & Discussion

Table 1 shows the mean shear bond strength value of all the 6 groups.

Table 1: mean shear bond strength of all 6 groups

Groups	Group Ia	Group Ib	Group Ic	Group Iia	Group Iib	Group Iic
Sr. No.	Biodentine + Composite	Biodentine + GIC	Biodentine + RMGIC	TheraCal LC + Composite	TheraCal LC + GIC	TheraCal LC + RMGIC
Mean Value	7.278 MPa/mm^2	2.174 MPa/mm^2	4.397 MPa/mm^2	8.805 MPa/mm^2	2.388 MPa/mm^2	5.715 MPa/mm^2

On comparison of shear bond strength of Group IA and IIA and that of Group IC and IIC using Independent 't' test, a statistically significant difference ($p<0.05$) was obtained. No statistically significant difference ($p>0.05$) was present between Group IB and IIB in relation to shear bond strength.

On comparison of shear bond strength of all three restorative materials to Biodentine and TheraCal LC base respectively, there existed a highly statistical significant difference ($p<0.001$) between the six groups in relation to shear bond strength.

Table 2 shows the comparative statistics of shear bond strength of all the 6 groups. The Post – hoc Dunnett's test was done to obtain pair –wise multiple comparisons. It was found that highly significant difference ($p<0.001$) was obtained in relation to comparison of shear bond strength of Group IA with Group IB, IC and Group IIB respectively. Significant difference ($p<0.05$) was found on comparison of Group IA with Group IIA, Group IIC respectively. On comparison of Group IB with other groups (IC, IIA, IIC), there was highly significant difference except with Group IIB where no statistical significant difference ($p>0.05$) was found. On comparison of Group IC with other groups (IIA, IIB), significant difference was found except with Group IIC where no significant difference was found. On comparison of Group IIA with other groups (IIB, IIC), highly significant difference was found in relation to comparison of shear bond strength ($p<0.001$). On comparison of Group IIB with other Group IIC, highly significant difference was found ($p<0.001$).

Table 2: Post – hoc Dunnett's test done to obtain individual pair –wise multiple comparisons

Groups	Comparison Group	Mean Difference	p value, Significance
Group Ia (Composite -Biodentine)	Group Ib (Gic -Biodentine)	5.10	$p<0.001$**
	Group Ic (Rmgic - Biodentine)	2.88	$p<0.001$**
	Group Ii A (Composite –Theracal Lc)	1.52	p = 0.023*
	Group Ii B (Gic – Theracal Lc)	4.89	$p<0.001$**
	Group Ii C (Rmgic – Theracal Lc)	1.56	p = 0.018*
Group Ib (Gic -Biodentine)	Group Ic (Rmgic - Biodentine)	2.22	$p<0.001$**
	Group Ii A (Composite – Theracal Lc)	6.63	$p<0.001$**
	Group Ii B (Gic – Theracal Lc)	0.21	p = 0.997
	Group Ii C (Rmgic – Theracal Lc)	3.54	$p<0.001$**
Group Ic (Rmgic - Biodentine)	Group Ii A (Composite – Theracal Lc)	4.40	$p<0.001$**
	Group Ii B (Gic – Theracal Lc)	2.00	p = 0.001*
	Group Ii C (Rmgic – Theracal Lc)	1.31	p = 0.071
Group Ii A (Composite- Theracal Lc)	Group Ii B (Gic – Theracal Lc)	6.41	$p<0.001$**
	Group Ii C (Rmgic – Theracal Lc)	3.08	$p<0.001$**
Group Ii B (Gic – Theracal Lc)	Group Iic (Rmgic-Theracal Lc)	3.32	$p<0.001$**

$p>0.05$ – not significant, $p<0.05$ – significant, $p<0.001$ – highly significant

Discussion

Many restorative materials provide excellent properties for the bulk of a dental restoration, but they may not protect the pulp during their setting reactions or during cyclic thermal or mechanical stressing. Liners and Bases are materials that are placed between dentin and the restorative material to provide pulp protection [8].

Calcium silicate-based materials are bioactive materials. They are also biointeractive, where they stimulate dentin bridge formation by releasing ions. Among the new calcium silicate materials that have appeared recently, Biodentine is advertised as 'bioactive dentine substitute'. It has demonstrated the ability to induce odontoblast differentiation from the pulp progenitor cells resulting in the formation of mineralized matrix similar to the molecules of dentin [9].

TheraCal LC is used as a protective liner and as a pulp capping agent under various base materials, restorative materials, or cements. TheraCal LC is a class 2 cement material "in which the setting reaction of the polymerizable component is light- activated." The material-induced bioavailability of calcium ions plays an important role in the proliferation and differentiation of dental pulp cells and the formation of new mineralized hard tissues [10].

Considering the properties of these materials and the less research that has been done to evaluate the shear bond strength of Biodentine and TheraCal LC with resin based composite material, glass ionomer restorative cement and resin modified glass ionomer cement, these materials were chosen as a base in this study to evaluate the shear bond strength.

In the groups IA and IIA the shear bond strength between TheraCal LC and composite was higher as compared to that of Biodentine and composite and there existed a statistical difference ($p<0.05$) among both the groups. The results were similar to a study done by Kenan Cantekin *et al.* in 2015 [11]. and Velagala Deepa *et al.* in 2016 [12].

In groups IB and IIB the shear bond strength of Biodentine and TheraCal LC to glass ionomer restorative cement was similar, thereby indicating that there existed no statistical significant difference ($p>0.05$) among both groups. The results were similar to a study done by Kenan Cantekin *et al.* in 2014 [7].

In groups IC and IIC the shear bond strength of TheraCal LC with RMGIC was higher as compared to Biodentine and RMGIC, thereby indicating that there existed statistical significant difference ($p<0.05$) among both groups. This was in accordance with a study done by Esra Cengiz *et al.* in 2016 [13].

On comparison of shear bond strength of all three restorative material (IA, IB, IC) to Biodentine base respectively, it was found that there existed highly statistical significant difference ($p<0.001$) where the shear bond strength of Biodentine with composite was the highest, followed by RMGIC and least with GIC. Similar results were obtained with TheraCal LC.

Among all the groups tested in this study, TheraCal LC with composite presented higher shear bond strength value. The results were similar to a study done by Velagala Deepa *et al.* in 2016 [12]. This can be due to the presence of dimethacrylate monomer, which has known to promote a chemical adhesion between TheraCal LC and bonding adhesive [14].

The lowest shear bond strength values with TheraCal LC was found in GIC group which was in accordance to a study done by Muhammed Karadas *et al.* in 2016 [15].

Regarding the bond strength of Biodentine to restorative materials, the lowest shear bond strength values were demonstrated in the GIC group. This result was in agreement with a previous study done by Kenan Cantekin *et al.* in 2014. [7]

Compared to GIC and RMGIC, the significantly higher shear bond strength values of RMGIC may be related to its resin content, which consists of mainly 2- Hydroxy Ethyl Methacrylate (HEMA) [13].

Thus, the highest shear bond strength values were obtained with TheraCal LC and Composite followed by Biodentine with composite, followed by TheraCal LC with resin modified glass ionomer cement which was higher than Biodentine with resin modified glass ionomer cement. The lowest values were obtained with TheraCal LC and glass ionomer restoration followed by Biodentine with glass ionomer restoration.

The limitations of this study were that only 10 samples were tested in each group, therefore more number of samples should be tested in further studies to increase the power of the study. Hashem *et al.* [14] stated that Biodentine should be allowed to mature for 2 weeks to adequately before testing the shear bond strength to withstand the contraction forces of the composite resin, in our study the shear bond strength was tested after 24 hours to simulate clinical conditions.

4. Conclusion

Within the limitations of this study the results exhibited that TheraCal LC with composite had highest shear bond strength and lowest with Biodentine and glass ionomer restoration.

As the shear bond strength is low with glass ionomer restoration in both the cases of Biodentine and TheraCal LC and with the sensitive technique of placement of composite restoration especially in children, our study suggests that resin modified glass ionomer cement can be the restorative material of choice when TheraCal LC and Biodentine are used as base materials for better clinical efficacy.

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