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Comparative Evaluation of Shear Bond Strength of Three Different Reinforced Glass Ionomer Restorative Cements to TheraCal LC: An In Vitro Study

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Abstract

Aim: To evaluate and compare the shear bond strength of GC fuji IX, Equia forte and secure Core Z to TheraCal LC.

Methodology: A total of 30 acrylic blocks, each containing a cylindrical hole in the centre with a depth of 2mm and an internal diameter of 5mm, was prepared from self-cure acrylic resin. These 30 samples were randomly divided into three groups and restored viz Group A – TheraCal LC+ GC fuji IX, Group B – TheraCal LC + Equia Forte, Group C – TheraCal LC + Secure Core Z. All the specimens were stored in artificial saliva at 37°C for 24 hours before testing. The statistical tests used for the analysis of the result were: One way ANOVA, Tukey Multiple Comparison Test and Chi square test. The software used in the analysis were SPSS 24.0 and Graph Pad Prism 7.0 version and $p<0.05$ is considered as level of significance.

Results: Group B (TheraCal LC + Equia Forte) showed highest shear bond strength followed by Group C (TheraCal LC + Secure Core Z) while Group A (TheraCal LC + GC Fuji IX) showed lowest shear bond strength.

Conclusion: Equia Forte can be the restorative material of choice when TheraCal LC is used as base materials for better clinical efficacy.
Keywords: TheraCal LC, Vital pulp therapy, GC Fuji IX, Reinforced GIC, Equia Forte

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Introduction: The primary objective of restorative dentistry is to preserve pulpal health of vital teeth. Currently, there is no single pulp protection protocol for clinicians to follow. A direct pulp capping is a procedure in which the exposed vital pulp is treated with a therapeutic material, followed by a base and restoration, to promote healing, to maintain pulp vitality, and to protect the pulp from thermal, chemical, and noxious stimuli.[1] In recent years, vital pulp therapy (VPT) has received considerable attention in dentistry, especially in endodontics. Historically, this treatment was carried out using calcium hydroxide but was not widely accepted due to unpredictable results.[2] It has several disadvantages, namely, unsatisfactory adherence to dentin, dissolution over time and multiple tunnel defects in dentine bridge.[3]

Calcium Silicate materials like MTA and Biodentin are bioactive materials which release ions needed to stimulate dentin bridging and superior to calcium hydroxide cements. But MTA exhibits many drawbacks like difficult handling, long setting time.[1] Whereas Biodentin showed weak micromechanical bonding to the restoration due to its water-based chemistry. To overcome this limitation, a light-curable resin modified tricalcium silicate cement TheraCal LC (Bisco, Inc., Schaumburg, IL, U.S.A.) introduced as a pulp capping material.[4]

Introduction of novel dental biomaterials, supported by acceptable scientific evidence, has led to increased application of VPT technique in recent years.[2] Extensive research has been taking place in generating bioactive restorative materials with a potential for remineralization.[5] TheraCal LC is a new light-curing, resin-modified, tri-calcium silicate-based material designed for use as direct and indirect pulp capping as a protective base/liner under composites, amalgams, cements, and other base materials. As opposed to other tricalcium silicate-based materials, TheraCal LC contains polymerizable methacrylate monomers, included in order to achieve a bond to composite resins and dentin.[6] After light-cure of TheraCal LC, the material's high physical properties and low solubility permit immediate placement of the final restorative material (Scientific Catalogue of TheraCal LC, 2012).[7]

The quality and durability of the bond between pulp capping material and restorative material is of clinical significance in terms of longevity and predictability of final restoration.[6] Resin Composites and Glass Ionomer Cements are very popular in restorative materials in dentistry. Many previous studies demonstrated good bond strength of composite over GIC. But curing shrinkage of overlying composite can cause stresses in the bond strength between liner and composite.[8] The bonding of conventional glass ionomers to teeth is usually made through ionized structure whereas RMGI is bonded to tooth by ion exchanging and micromechanical interlocking.[9]

Conventional GICs have certain properties that make them useful as a restorative material of choice. However, some deficiencies like attack by moisture during the initial setting period, short working time, long setting and maturation time, have low fracture toughness, and exhibit lower wear resistance have limited their use to areas which are not subjected to masticatory stresses.[10] The physical and mechanical properties of GIC improved by various manufactures by incorporating various modifications in basic formulation of GIC cement.

Newer generation of glass ionomer, GC Fuji IX, was developed especially for Geriatric and Pediatric patients and was introduced to clinical practice in late 1990s. It is very popular material in general Dentistry practice due to its high strength, wear resistance, a chemical adhesion to tooth structure, fluoride release, radio-opacity, and less technique sensitivity to saliva. In addition, it is highly viscous, condensable, and has better esthetics. This improvement was due to reduction in the size of the glass particles in the matrix, allowing a faster speed of reaction between the silica particles and polyacrylic acid.[10]

Equia Forte (GC, Tokyo, Japan) was released as a new restorative material based on glass hybrid technology where a glass filler matrix combines fillers of different sizes. It consists of microlaminated Equia Forte Fil with a nano-filled coat (Equia Forte Coat, GC, Tokyo, Japan). In the Equia Forte Coat, nanofiller particles are dispersed in the liquid. Additionally, the Equia Forte Coat contains a multifunctional monomer that, as the manufacturer claims, improves surface hardness and wears resistance.[11]

Secure Core Z is a newer class of Zirconia reinforced, chemically bonding restorative material, that offers outstanding strength and durability. It incorporates homogenously dispersed fine zirconium particles, offering high tolerance to occlusal loads and improved

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abrasion resistance making it ideal for permanent posterior restorations where strong structural cores are needed. It is highly biocompatible and offer sustained fluoride release that helps reduce caries incidence. Although many previous studies have evaluated the bond strength of Calcium Silicate material over Composite and Glass Ionomer Cements. But there is limited data available regarding the bond strength of TheraCal LC to various Reinforced Glass Ionomer restorative material. Therefore, the aim of the present study is to evaluate Shear Bond Strength of different reinforced GIC restorative materials like Strontium based GIC (GC IX), Glass hybrid technology based GIC (Equia Forte) and Zirconia Reinforced GIC (Secure Core Z) to Resin Modified Calcium Silicate Material (TheraCal LC).

Methodology: A total of 30 acrylic blocks, each containing a cylindrical hole in the centre with a depth of 2mm and an internal diameter of 5mm, was prepared from self-cure acrylic resin (fig. 1). TheraCal LC was dispensed from syringe into the blocks in the increments of 1mm. Each 1mm increment was then light cured with a Light Emmiting Diode Curing lamp (Elipar Freelight S10, Woodpecker, China) for 20 sec. After second increment, a glass slab was placed on top of the block to obtain standardization of the sample surface and then light cured with a Light Emmiting Diode Curing lamp for 20 seconds (fig. 2). These 30 samples were randomly divided into three groups viz Group A – TheraCal LC+ GC fuji IX, Group B – TheraCal LC + Equia Forte, Group C – TheraCal LC + Secure Core Z.

Technique for placement of restorative material: GC Fuji IX and Secure Core Z are available in powder and liquid form while Equia Forte is available in Capsule form. They were mixed according to manufacturer's instructions. The plastic cylinder was placed over the TheraCal LC in the acrylic block. Cement was transferred to the plastic cylinder using suitable instrument (fig. 3). For Equia Forte, the mixed restorative cement was Immediately dispensed within 10 sec into plastic cylinder placed on each specimen Light curing was done for 20 seconds. After the setting of material, plastic cylinder was removed carefully. All the specimens were stored in artificial saliva (Wet Mouth, ICPA health products ltd, Mumbai, India) at 37°C for 24 hours before testing.

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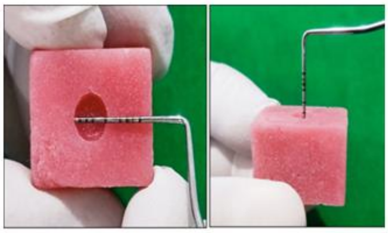

Fig.1 - Acrylic block with hole in the centre

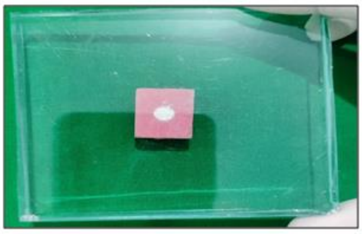

Fig. 2 - Placement of glass slab for standardization of the sample surface

Fig 3- Placement of cement into plastic cylinder

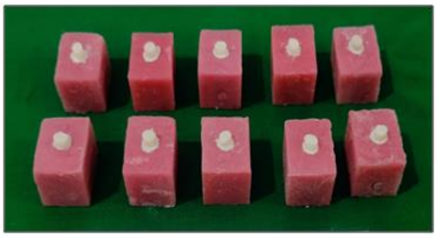

Fig. 4 – Final set material

Measurement of Shear bond strength: Each specimen was mounted in a universal testing machine and subjected to a shearing force using a knife-edge blade at a crosshead speed of 1mm/min (Fig.5). The load at failure was recorded in newtons (N), and the bond strength was calculated in megapascals (MPa) by dividing the load at failure by the adhesive surface area (mm^2).

Failure Modes was evaluated by single operator under a Stereomicroscope at 10X magnification and classified as follows:

- Adhesive failure (failure within the bonding interface of TheraCal LC & the restorative materials)
- Cohesive failure (failure within TheraCal LC or restorative material)
- Mixed failure (a combination of adhesive & cohesive failure of TheraCal LC or restorative material.)

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Fig 5. - Shear bond strength testing using universal testing machine

Statistical analysis: Analysis of the data was done by using descriptive and inferential statistics both. The statistical tests used for the analysis of the result were: One way ANOVA, Tukey Multiple Comparison Test and Chi square test. The software used in the analysis were SPSS 24.0 and Graph Pad Prism 7.0 version and $p<0.05$ is considered as level of significance.

Results: Table 1 shows the mean shear bond strength value of all the 3 groups. Group B (TheraCal LC + Equia Forte) showed highest shear bond strength followed by Group C (TheraCal LC + Secure Core Z) while Group A (TheraCal LC + GC Fuji IX) showed lowest shear bond strength.

Table 1: Comparison of Shear Bond Strength among samples of three groups

Group	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Group A	10	0.98	0.51	0.16	0.61	1.35	0.05	1.86
Group B	10	8.25	4.67	1.47	4.90	11.60	1.00	15.53
Group C	10	6.80	4.69	1.48	3.44	10.16	1.68	17.49

Std – Standard Deviation

Table 2 shows the comparison of modes of failure among the three groups. Maximum adhesive failure was noticed in Group A (TheraCal LC + GC Fuji IX) while maximum mixed type of failure was observed in Group B (TheraCal LC + Equia Forte). Group A showed no cohesive failure.

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Table 2: Comparison of Mode of failure among three groups using Chi-square Test

Mode of failure	Group A	Group B	Group C	χ^2-value
Adhesive	5(50%)	2(20%)	4(40%)	17.82 P=0.022, S
Mixed	5(50%)	6(60%)	4(40%)	
Cohesive	0(0%)	2(20%)	2(20%)	
Total	10(100%)	10(100%)	10(100%)	

S: Significant; NS: Non- Significant

Discussion: Therapeutic strategies focussed on the pulp preservation, are important when managing vital teeth with deep caries and an exposed pulp. Vital pulp treatments (VPTs); however, are not new, with indirect and direct pulp capping procedures being described as a therapy for carious teeth for over a century.[12]

A direct pulp capping is described as a procedure in which the exposed vital pulp is treated with a therapeutic material, followed by a base and restoration, to promote healing, to maintain pulp vitality, and to protect the pulp from thermal, chemical, and noxious stimuli.[13] Traditionally, Calcium hydroxide has been used as the pulp capping material of choice for pulpal exposures in permanent teeth. However, the major disadvantages of calcium hydroxide are insufficient adherence to dentinal walls, its poor sealing ability and high solubility which leads to the disappearance of the material and the defect formation in reparative dentin.[14]

Calcium silicate-based materials (CSMs) like MTA and Biodentin are bioactive materials capable of forming apatite by using calcium silicates or calcium aluminates.[15] But MTA exhibits many drawbacks like difficult handling, long setting time, induction of tooth discoloration, and incompatibility with other dental materials when layered. Biodentin also show some drawbacks like weak micromechanical bonding to the restoration due to its water-based chemistry and decrease in radio-opacity with time. To overcome this limitation, a light curable resin modified tricalcium silicate cement TheraCal LC (Bisco, Inc., Schaumburg, IL, U.S.A.) introduced as a pulp capping material. After light-cure of TheraCal LC, the material's high physical properties and low solubility permit immediate placement of the final restorative material. [16]

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

In this study, group D (TheraCal LC + Equia Forte) showed highest shear bond strength among all the experimental groups. A thorough search of litreatures and electronic databases revealed no other published study evaluating the SBS of Equia forte to TheraCal LC. 87 Hence, the results of the present study could not be compared, and therefore provide important information about the bond strength of Equia Forte to TheraCal LC.

In this study, statistically significant difference was found in Shear bond strength between group A (TheraCal LC +GC IX) and group B (TheraCal LC + Equia Forte) (p=0.0001). The results are in accordance with the study conducted by Francois P et al. which showed significantly higher shear bond strength of Equia Forte when compared to Type IX GIC.[17] They observed that for indirect restorations, Equia Forte can be used in synergy with the immediate dentin sealing technique to provide high bond strength values and low post-operative sensitivity and avoid bacterial contamination during the temporization phase. This finding is in accordance with Kunte S et al., in which Equia forte showed higher bond strength than GC Fuji IX and the results were statistically non-significant.[18]

In present study, statistically significant difference was not found between group B (TheraCal LC + Equia Forte) and C (TheraCal LC + Secure Core Z). Literature search was done and to the best of our knowledge no literature is available on comparison of shear bond strength of Equia Forte and Secure core Z to TheraCal LC.

In present study, Group A (TheraCal LC + GC type IX) showed 50% of adhesive failure and 50 % of mixed failure. In contrast to the present study results, Cengiz E and Ulusoy N 7 found that GC IX and TheraCal LC showed high frequency of adhesive failures.[6]

This study was performed with an effort to simulate the clinical conditions and achieve standardization. However, in vitro conditions do not completely reflect in-vivo conditions. Yet, in vitro experimental studies provide a more easily reproducible and reliable means for comparison of Shear bond strength and modes of failures of different reinforced GIC to TheraCal LC. Moreover, different study protocols and testing methods, amount of force applied by the universal testing machine and the time duration for which it is applied

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may account for this variability in reported values. Consequently, it would be difficult to accurately compare results. Therefore, further investigations using comparable methodology should be done to be able to directly compare results.

Limitations of this Study were that only 10 samples were tested in each group, therefore a greater number of samples should be tested in further studies to increase the power of the study. Forces applied intraorally vary in magnitude, speed of application as well as direction, whereas the forces applied to the teeth in this study were at constant speed and direction and increased continuously till fracture.

Conclusion: Within the limitations of this study the results exhibited that TheraCal LC with Equia Forte had highest shear bond strength and lowest with TheraCal LC and GC Fuji IX. Failure mode was predominantly adhesive failure in all the experimental GIC with TheraCal LC. Present study suggests that Equia Forte can be the restorative material of choice when TheraCal LC is used as base materials for better clinical efficacy.

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