Section A-Research paper

To evaluate and compare the shear bond strength of Biodentine, Light cure MTA, and TheraCal LC to resin composite using a universal adhesive

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ABSTRACT

Introduction: Preserving the dental pulp in a healthy state is essential for treating teeth with exposed vital pulp. Pulp capping biomaterials placed as a protective layer on exposed vital pulp possess bioproperties such as biocompatibility, biointeractivity, and bioactivity to promote pulp cell activity and the formation of new reparative dentin. New calcium silicate cements like biodentine, TheraCAL LC, Light cure MTA have been developed trying to preserve the biological benefits of MTA, while improving its physical-mechanical characteristics.

Aim: To evaluate and compare the shear bond strength of Biodentine, Light cure MTA, and TheraCal LC to resin composite using a universal adhesive.

Materials and methods: 84 acrylic blocks were prepared of 20mm height and 12mm diameter in dimension. After that a cavity was prepared of 2mm depth and 5mm diameter and samples were divided randomly into 3 groups A, B and C of 28 Samples each based on the liner that was condensed in the prepared cavity. A Universal dental adhesive was applied over the liner surface with a micro brush. The polyethylene tube of 2.5 mm diameter and 4mm height was placed over liner surface and filled with the resin composite and light cured with light emitting diode curing unit. The polyethylene tube was removed with a Bard parker handle and blade no 15 after the completion of the resin composite build up. All the samples were stored in water for 24 hours. The specimens were attached to the universal testing machine. A chisel with knife edge was gently held against the resin composite and liner respective interface and loaded at a cross- head at speed of 1.0mm/min until bond failure occurred.

Results and Conclusion: The mean difference between shear bond strengthat pair wise comparison there was statistically highly significant difference among Light cure MTA and Biodentine; Biodentine and Theracal LC; and there was statistically significant difference among Light cure MTA and Theracal LC.

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Key Words: Shear bond strength, Biodentine, Theracal LC, Light cure MTA

INTRODUCTION

Restorative dentistry aims to restore and preserve dental health by protecting pulp and restoring function.(1)

Preserving the dental pulp or part of it in a healthy state is essential for treating teeth with exposed vital pulp, particularly in those where root formation has not yet been completed. This is due to injuries or impact, cracked, fractured, chipped teeth, aggressive tooth brushing, malocclusion, grinding teeth, and other causes.

Direct pulp capping is a long-standing treatment option that involves covering exposed pulp with a protective wound dressing or base. Ideally, the pulp heals with a mineralized tissue barrier known as dentine bridge.(2)

Pulp capping biomaterials placed as a protective layer on exposed vital pulp possess bioproperties such as biocompatibility, biointeractivity, and bioactivity to promote pulp cell activity and the formation of new reparative dentin. (2)

Calcium hydroxide is a widely used pulp protection material, but it does not adhere to dentine and lacks the ability to seal. To overcome these drawbacks, calcium silicate-based liner materials have been introduced which are biologically well tolerated by pulp tissue.(3, 4, 5,6)

New calcium silicate cements have been developed trying to preserve the biological benefits of MTA, while improving its physical-mechanical characteristics.

MTA forms thicker bridges and has an odontoblastic layer, but has drawbacks such as long setting time, difficult handling, induction of tooth discoloration, and no interaction with other materials. Light cure MTA has been introduced which has command setting time and prolonged release of calcium ions.(6,7)

Tricalcium silicate is found as the main cementitious component in Biodentine.Tricalcium silicate-based materials with quicker setting times have been introduced. In order to combine the great biocompatibility and bioactivity of calcium silicates with improved features such as short setting time and high strength, biodentine has been developed.

TheraCal LC is a new resin-modified, light-cured calcium silicate-based material that is easy to handle and accurate to apply. When compared to MTA and Dycal, TheraCal LC exhibits better sealing ability, less interfacial microleakage, less solubility, and a larger release of calcium ions. TheraCal LC's advantage of allowing quick placement of the final restorative material after light-curing, as opposed to other calcium silicate cements, is appealing. TheraCal LC might be a better option for pulp capping than MTA and Dycal because of the stated qualities.

The advent of bonded restorations is a relatively recent breakthrough in the development of restorations. In 1955, Buonocore developed the idea of acid etching of enamel, which created the groundwork for adhesive dentistry. Since 2011, the universal bonding agent has been a well-liked and reliable method of bonding. The universal adhasive has a single step application and has bonding properties equivalent to other modern dental bonding agents. (8)

Bonding develops an adhesive between the restoration and the tooth surface, which reduces or eliminates the need for macro-mechanical retention and for more conservative cavity preparation. Bonding increases the inherent tooth strength and resistance to fracture. Bonding

improves the marginal seal, lowering the likelihood of pulpal and dentine contamination as well as the occurrence of secondary caries. (9)

Composite apart from being bonded restoration has predictable esthetic properties.

Nanohybrid composites are those that contain milled glass fillers and discrete nanoparticles (40–50 nm) as dispersed phase**.** They have been found to provide better mechanical strength and surface finish than microhybrid composites.This material is suitable for so-called bulk-fill restorations with a maximum curing depth of 2mm. (10)

The most common method to evaluate adhesive properties of adhesive restorative material is by evaluating bond strength of material.The success of these laminate restorations depends on the bond strength of liner to the dentin and also on the quality of the bond between liner and overlying composite. (6)

The shear strength of a material is defined as its ability to resist forces that cause the material's internal structure to slide against itself. Since the masticatory process is more of a shearing phenomenon, shear bond strength indicates the adhesive strength of the restorative material at the pulp protection material –restoration interface.

This in vitro study was conducted to evaluate and compare the shear bond strength (SBS) of resin composite bonded to three different calcium silicate-based liners: Biodentine, Light cure MTA, and TheraCal LC using a universal adhesive with the help of universal testing machine.

MATERIALS AND METHODS

Sample size estimation

The sample size estimation was done using GPower software (version 3.0). The sample size was estimated for F test and ANOVA. A minimum total sample size of 84 was found to be sufficient.

Sample preparation

A total of 84 acrylic blocks were prepared. Each block was prepared 20mm height and 12mm diameter in dimension.

After that a cavity was prepared of 2mm depth and 5mm diameter with the help of 330 Standard Carbide bur and confirmed with a digital vernier caliper.

Further these samples were divided randomly into 3 groups A, B and C of 28 Samples each based on the liner that was condensed in the prepared cavity.

After the respective liner material sets, a Universal dental adhesive was applied over the liner surface with a micro brush for 20 seconds, followed by gentle air drying for approximately 5 seconds and then light cured for 10 seconds.

The polyethylene tube of 2.5 mm diameter and 4mm height was placed over liner surface and filled with the resin composite and light cured with light emitting diode curing unit. The polyethylene tube was removed with a Bard parker handle and blade no 15 after the completion of the resin composite build up.

All the samples were stored in water for 24 hours. The specimens were attached to the universal testing machine. A chisel with knife edge was gently held against the resin

composite and liner respective interface and loaded at a cross- head at speed of 1.0mm/min until bond failure occurred.
The load at failure was recorded in Newtons
Shear bond strength = load (N) / Area (mm sq).
If other than shear bond failure occurs, samples were replaced with new samples.

RESULTS

Table 1 and 2: Shear bond strength (MPa) of samples of three study groups.

Group	Minimum-maximum	Mean±SD
Group A (Light Cure MTA)	1.8 to 2.6 MPa	2.178 Mpa
Group B (TheraCal LC)	2.17 to 5.08MPa	3.573 MPa
Group C (Biodentine)	0.59 to 0.9MPa	0.76 MPa

Group	Comparison group	Mean difference	p value, significance
Group A(Light Cure MTA)	Group B (TheraCal LC)	1.395	P< 0.001
Group A(Light Cure MTA)	Group C (Biodentine)	1.481	P< 0.001
Group B (TheraCal LC)	Group C (Biodentine)	2.813	P< 0.001

In group A where light cure MTA was condensed in prepared cavity, the mean shear bond strength was found to be 2.178 MPa.
In group B where Theracal LC was condensed in prepared cavity, the mean shear bond strength was found to be 3.573 MPa.
In group C where Biodentine was condensed in prepared cavity, the mean shear bond strength was found to be 0.76 MPa.
The mean difference between shear bond strength of Light cure MTA and Theracal LC is 1.395 MPa. The mean difference between shear bond strength of Light cure MTA and Biodentine is 1.418 MPa. The mean difference between shear bond strength of Theracal LC and Biodentine is 2.183 MPa.
At pair wise comparison there was statistically highly significant difference among Light cure MTA and Biodentine; Biodentine and Theracal LC; and there was statistically significant difference among Light cure MTA and Theracal LC.

DISCUSSION

A dental restoration is used to restore the strength and functional component of the tooth following the removal of the carious portions. Any dental restoration must be able to resist masticatory forces and also be esthetic at the same time. The resin composite is one such material.[5]
Some of the composite resins today have hybrid fillers, that is a combination of nano, micro or mini fillers. Filler particles can be of glass, zirconia, silicon or a combination of these

materials.[5, 9]The rapid progress in dental adhesive technology has extensively influenced modern restorative dentistry. Despite the vast advances made in adhesive technology during the last 50 years, the bonded interface itself remains as a weakest point of an adhesive restoration.[10]

Bond strength of pulp capping materials to restorative materials is important for the success of restorations and can be measured by bond strength testing.[1] Longevity of a restoration is predicted to some extent by its adhesive ability, and this in turn can be measured by bond strength testing. Over the years, clinicians have relied upon laboratory evaluations to choose the adhesive systems to use in their daily practice. [11,12]

Shear and tensile bond strengths refer to the resistance of the composite resin to masticatory forces when it is bonded to the tooth. Shear strength of a material is calculated to check the shear strength between two surfaces. Shearing action is present in the posterior teeth during chewing, and therefore, the SBS test would represent the performance assessment of the restorative material under clinical condition.[13]

Intermediate restorative materials are materials that are placed between a restoration and the dentine with a primary function of protecting the pulp. Dental liners, bases and cavity varnishes are used for this purpose.[14]

A dental liner is a material that is usually placed in a thin layer over exposed dentine within a cavity preparation. Its functions are dentinal sealing, pulpal protection, thermal insulation and stimulation of the formation of irregular secondary (tertiary) dentine.[11]

Resin composite is a poor thermal conductor. Application of cavity liner under a resin composite restorations are done to fulfill either a physical barrier role or a therapeutic role, and thus have a maximum thickness of the order of 0.5mm. Typical examples are quick-setting calcium hydroxide. Cavity bases fulfil a dentine replacement role and are therefore typically >O.5mm in thickness.[14]

Calcium hydroxide, initially proposed in 1930 as a “remineralizing agent” in direct pulp capping, plays a key role in the biological events of reparative dentinogenesis when in close proximity to pulp tissues, due to the release of calcium (Ca) and hydroxyl (OH) ions. [2]

Calcium silicate–based materials, belong to a category of hydraulic self-setting materials, mainly composed of dicalcium and tricalcium silicates. They are hydrophilic radiopaque materials which form a sticky self-setting calcium-silicate-hydrate. The father of the family of calcium silicate cements was Gray Portland cement innovatively introduced as tooth-fillingmaterial by Dr. Torabinejad in 1995 as gray ProRoot MTA. This cement was initially proposed for root therapies and revolutionized operative dentistry. [1]

Calcium silicate–based cements seem to have intrinsic properties tailored for their clinical use (apicectomy, root perforation and apexification) such as good sealing correlated to expansion, and the ability to set in the presence of fluids, bioactivity, the release of ions acting as epigenetic signals and good biological properties. Therefore, new calcium silicate cements such as light cure MTA , TheraCal and Biodentine have recently been introduced . [7]

In this vitro study planned, we have evaluated and compared the shear bond strength (SBS) of resin composite bonded to three different calcium silicate-based liners: Biodentine, light cure MTA, and TheraCal LC using a universal adhesive with the help of universal testing machine.

In this study, the strength between the liner material and composite is calculated in a universal testing machine, and force was applied by the machine on each specimen at a crosshead speed of 1 mm/min. A chisel-edge plunger was secured onto a vertically movable crosshead in the testing machine and adjusted its position to ensure that the leading edge was aimed at the liner/composite interface force was continuously applied until the failure took place.This method was thus chosen for testing the bond strength, as our goal was to find the bond strengths of three pulp capping materials with the overlying restorative composite resin.(1)

The 7thgeneration bonding agents are easy to handle and apply. Therefore, the bonding system was expected to show lower failure rates in clinical applications.(12)

In this study, the mean SBS values ranged between 0.76 MPa and 3.5 MPa. The mean SBS was found to be 2.178 MPa of Group A (light cure MTA) specimens, 3.573 MPa of Group B (TheraCal LC) specimens, and 0.76 MPa of Group C (Biodentine) specimens.At pair wise comparison there was statistically highly significant difference among Light cure MTA and Biodentine ; Biodentine and Theracal LC ; and there was statistically significant difference among Light cure MTA and Theracal LC.

Light cure MTA and TheraCal LC are calcium silicate cements introduced in 2010 with formulations quite different from the Biodentine tested. Biodentine is a tricalcium silicate based material composed of a powder packaged in capsules (0.7 g) to be mixed with a liquid phase (0.18 mL) containing calcium chloride. Biodentine has the drawback of requiring an amalgam vibrator for its preparation and that prevents the clinician from adjusting the fluidity of the paste by regulating the amount of mixing liquid. In the previous SEM analyses of fresh Biodentine have showed a surface strongly different from that of the other calcium silicate materials, with particles appearing suspended in a matrix. The low SBS of the Biodentine seemed to be owing to the low initial strength of the material and other studies also argued the same . Biodentine being a porous material requires minimum two weeks to fully crystallize and to reach the required bulk strength, which can resist the stress caused by polymerization. In the present study, the bonding was applied to the Biodentine after 24 hours. This could explain the relatively low bond strength.(12) In this study, only 24 hours was permitted to set the Biodentine with resin composites and this might be responsible for the overall poor strength.

TheraCal is a light-curable resin-based MTA-like material containing calcium silicate particles marketed as a ready-to-use paste. According to ISO 9917-2017 part 2 clause 4.1, TheraCal LC is a class 2 cement material in which the setting reaction of the polymerizable component is light activated. TheraCal LC is set following applied light-cure for 20 s with a cure-depth of 1.7 to 2 mm, allowing rapid attainment of its physical properties (Gandolfi et al., 2012). TheraCal showed low solubility (2.75%) compared with the other materials, likely related to the presence of a light-curable resin, and the ability to release a moderate but rather constant amount of calcium.This new material has been reported to have a shorter setting time, lower solubility and higher flowability compared with conventional MTA.(13)

One-step self-etch adhesives, also called “all-in-one” adhesives, contain acid, primer, and adhesive components in one solution, allowing one-step application. Over the last few years, these adhesives have become increasingly popular. In this respect, TheraCal LC may be

preferable to conventional MTA for direct pulp capping. TheraCal LC may be attributed to the presence of dimethacrylate monomer that promotes chemical adhesion between the TheraCal LC and bonding adhesive. Universal adhesive contains 10-metacryloxydecyl dihydrogen phosphate (MDP), which has been reported to chemically bond to calcium within the TheraCal (Yoshida et al., 2004). Theoretically, it could be assumed that the 10-MDP monomer may bind chemically to the calcium in TheraCal LC, thereby promoting chemical adhesion in addition to micromechanical interlocking.[13]

Bond strength between Light cure MTA liners and composite depends on their physicochemical properties, nature of the bond between liner and composite, and the types of adhesive used. In the present study, methacryloyloxydecyl dihydrogen phosphate (MDP)-based, universal adhesive with silanes was selected. This self-etch 10-MDP-based adhesive shows chemical bonding to Ca ions, and Al and zirconium oxides. The bifunctional silane molecule bonds chemically to silica-containing materials and has methacrylate functionality that allows chemical union with resinous substrate. Silanes also act as adhesion promoters by enhancing the wetting ability of the adhesive system. This adhesive was selected in our study, aiming for additional chemical bonding with Ca releasing bio active liners. Hydroxyethyl methacrylate (HEMA) incorporated into the Light cure MTA forms a chemical bond with the resin of the composite. Additional chemical union is due to copolymerization of unreacted methacrylate groups present in the oxygen-inhibited layer of Light cure MTA with those of composite resin.[15, 16 17]

Groups A and B (TLC and Light cure MTA) showed statistically similar SBS , and were adequate to withstand contraction stresses of composite . This could be due to similar resin chemistry promoting chemical adhesion with composite. Nano-hybride composites offer a favorable choice of material to produce a monolithic reconstruction and a microleakage-free restoration when used on Light cure MTA and TheraCAL LC with universal bonding agent as compared to Biodentie.

CONCLUSION

This in vitro study was conducted to evaluate and compare the shear bond strength (SBS) of resin composite bonded to three different calcium silicate-based liners: Biodentine, Light cure MTA, and TheraCal LC using a universal adhesive with the help of universal testing machine.

- In group A where light cure MTA was condensed in prepared cavity, the mean shear bond strength was found to be 2.178 MPa.
- In group B where Theracal LC was condensed in prepared cavity, the mean shear bond strength was found to be 3.573 MPa.
- In group C where Biodentine was condensed in prepared cavity, the mean shear bond strength was found to be 0.76 MPa.

The order of shear bond strength was as follows

Theracal LC > light cure MTA > Biodentine

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