AN INVITRO COMPARATIVE EVALUATION OF MARGINAL ADAPTATION IN LARGE CLASS II CAVITIES USING VARIOUS LINERS IN OPEN SANDWICH TECHNIQUE

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In partial fulfilment for the Degree of

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BRANCH - IV

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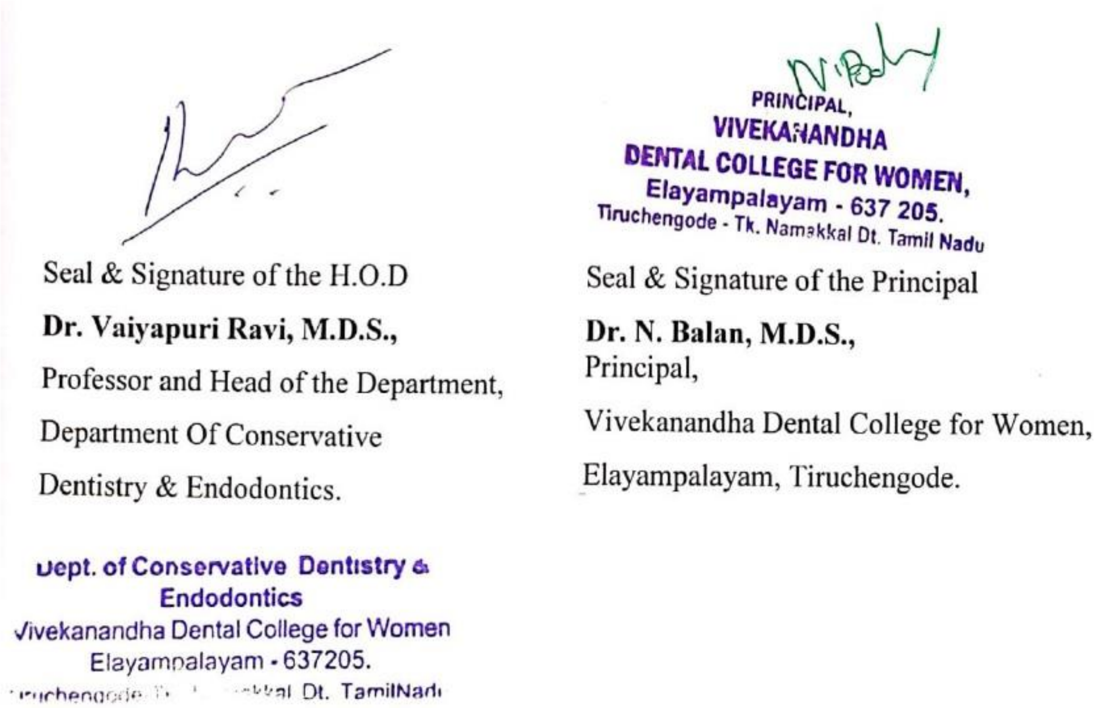

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58

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CONTENTS

INTRODUCTION

INTRODUCTION

The ultimate aim of operative dentistry is to restore the form and function of the tooth. One of the requisites of a restorative material is to adapt itself to the cavity walls. Among the various materials commonly used, and inspite of the tremendous improvements in means and technologies, none of the material could actually join chemically with the tooth structure. The gap left between the cavity walls and restorative material plays an important role in the prognosis of the restorative treatments. In the past, pulpal reactions to dental procedures were thought to be induced by mechanical irritation like heat, vibration, galvanism etc., and/or chemical irritation by the restorative material and its components. Research by various authors demonstrated that probably bacterial leakage was a greater threat to the pulp than toxicity of the restorative materials. Since then the concept of microleakage has drawn wide spread attention, especially so, in the clinical dentistry.

The performance of dental restorations is being influenced by various factors, including restorative materials used, the clinician's level of experience, the type of tooth, the tooth's position in the dental arch, restoration's design, the restoration's size, the number of surfaces restored, and the age of the patient.[1]

Amalgam was the material of choice worldwide for Class I and Class II restorations for more than a century.[2] However, rising demand for the use of esthetic materials in posterior teeth has increased dramatically over the past two decades, leaving silver amalgam at a disadvantage.[3]

Composites are gaining popularity over amalgam as posterior esthetic restorative material because of the following reasons: Scientific advances in the development of superior alternative restorative materials,[4]esthetic reasons, cavity preparation is both less invasive and less extensive, placing amalgam restorations without a dentin bonding agent fails to seal the margins,[4] and last but not the least is mercury toxicity.[5]

Microleakage is one of the most frequently encountered problem for posterior composite restorations, in particular, at the gingival margins of class II cavities extending onto the root.[6] Microleakage as a phenomenon has been cited in literature since 1912.

According to E.A.M Kidd, microleakage is defined as “The clinically undetectable passage of bacteria and bacterial products, fluids, molecules or ions from the oral environment along the various gaps present in the cavity restoration interface”. [7]

Direct class II restorations have been known to show more leakage than indirect restorations around enamel and dentin margins. Lamentably, when using composite, multiple factors account for marginal microleakage. The enamel surrounding the proximal box is often totally absent or of less quality. There were a few reports that showed some voids at the gingival margin and within the materials. Clinical success and adequate polymerisation of the material depends on clinical factors, such as the incremental technique, distance from the light source,[8] the type of curing unit, blood and salivary contaminations and the factors that are related to the material itself, such as the type of monomer or its shade. As a whole, class II restorations are mostly dependant on the operator skill.[9]

Difficulties with class II restorations have led to the development of open-sandwich restorations: a resin modified glass ionomer cement (RMGIC) or a glass ionomer cement (GIC) placed between the dentin gingival margins and occlusal composite restorations. GIC has two intriguing features in restorations by releasing fluoride and bonding spontaneously to dentin. These sandwich restorations are less sensitive to technique than composite restorations and show a high percentage of gap-free interfacial adaptation to dentin.[10] Since, there are conflicting views regarding the clinical performance of open sandwich restorations, this study attempts to highlight the intricate details about this technique and critically evaluates the literature regarding clinical performance of the restorations.

THE OPEN SANDWICH TECHNIQUE FOR RESTORATIONS

In 1977, McLean and Wilson were the first to describe the open sandwich technique, introducing it as a method to improve adhesion of resin composite restorations. To reduce the disadvantages of posterior composite restorations, particularly their lack of permanent adhesion to dentine, which could result in microleakage and post operative sensitivity, this technique was developed. To protect the surrounding tooth structure, Mount[11] advocated the use of Glass-Ionomer (GI) at the cervical margin be left exposed to allow fluoride release. This became to be popularly known as the Open-Sandwich Technique. This “Sandwich” of glass ionomer, dental adhesive and composite resin was proposed as an effective technique for both anterior and posterior resin based restorations by several clinicians as a means for pulpal protection from the acid-etch technique as well as a method for sealing the cavity in the absence of good dentin adhesion available with the materials of the time.[11]

The Open-Sandwich technique for a Class II posterior composite restoration has all the layers of restorative material exposed to the oral cavity at the proximal margins, which are areas of primary concern for long-term clinical success. A self or dual-cured composite resin material, glass ionomer, or resin-modified glass ionomer is used as a base that covers the entire proximal box including all the dentin and cervical margin up to about one-third to one-half the height of the matrix band. After a primary polymerization period of this base layer, a top layer of a light-cured composite resin is added to finish the restoration to a full anatomic form and function.

The open-sandwich technique was unsuccessful clinically mainly because of a continuous loss of material when conventional GI's were used to restore the cervical margins of Class II restorations. Consequently, the conventional GIC were replaced by the newly developed Resin Modified Glass Ionomer Cements (RMGIC). Resin added in the Glass Ionomer formulation allowed these newer materials to polymerise upon light activation. The resin also reinforces the chemical bond that Glass Ionomer achieves with tooth structure by bonding micro-mechanically. This double adhesion mechanism is the main determinant of the marginal sealing capacity of the material and retention. It has been reported that higher bond strengths were achieved with Resin Modified Glass Ionomer Cement than with conventional Glass Ionomer cement.[12,13,14]

It has been assumed that better sealing produced by RMGIC is a result of the formation of resin tags into dentinal tubules along with the ion exchange process present in the interface between dentin and RMGIC. The use of RMGIC as base material in Open Sandwich restoration reduces considerably the bulk resin composite used, improving the marginal adaptation and decreasing the polymerization shrinkage.

Another advantage of the sandwich technique is that the GIC releases fluoride, which is considered to have some inhibitory effect on caries progression and formation around the restoration.

To improve the marginal sealing, various incremental techniques, curing techniques and lining materials have been designed.[15] Flowable composites are non-sticky and injectable due to lower filler content.[16]The use of flowable composite as a liner reduced the microleakage. Recently a contemporary technique was introduced where a thin layer of flowable composite is applied to cavity floor which is immediately followed by packable composite increment and light curing which offers the advantage of intimate adaptation of filling.[17]

Of late, Septodont's research group has developed a dental material named Biodentine which could conciliate high mechanical properties with excellent biocompatibility as well as a bioactive behaviour. Biodentine is the first of its kind all-in-one biocompatible and bioactive dentine substitute based on unique Active Biosilicate Technology and designed to treat damaged dentine both for endodontic and restorative purposes.

The major shortcoming of visible light cure composites is the polymerization contraction that results in gap formation, particularly at the dentin interface. The shrinkage of resin-based restorations coupled with masticatory forces generates stresses within the adhesive layer that must be resisted to retain the restoration and maintain marginal integrity. [18]

Thermocycling is the in vitro process of subjecting a restoration and tooth to temperature limits similar to those experienced in the oral cavity, which can produce potential negative effects due to dissimilar coefficients of thermal expansion between the tooth and the restorative material.[19] Thermocyling increases the stresses between resin and the tooth, and it may affect bond strength, depending on the adhesive system.

The marginal adaptation was evaluated in terms of "continuous margin" at the gingival margin. [20]

Although new materials are subjected to extensive testing by the manufacturers, there is always a need for independent in vitro and in vivo research. The information obtained will also be useful for comparative assessment of the different materials and for drawing up clinical guidelines for the usage of these materials in the clinics.

Therefore, this study aimed at evaluating and comparing the marginal adaptation in large class II cavities using various liners in open sandwich technique.

AIM AND OBJECTIVES

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AIM OF THE STUDY

To evaluate the marginal adaptation of Biodentine, Resin Modified Glass Ionomer Cement (RMGIC) & Flowable composite as cavity liners under large Class II composite restoration using open sandwich technique.

OBJECTIVES OF THE STUDY

To compare the marginal adaptation of Biodentine, Resin Modified Glass Ionomer Cement (RMGIC) and Flowable composite using dye penetration.

To select a suitable cavity liner that can act as a dentin substitute, in large Class II composite restorations by Open sandwich technique

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Loss of marginal adaptation is always an issue at the cavosurface margin of the proximal box in Class II restorations. Much of the current literature on composites deals with the resolution of the microleakage problem.

Brannstrom et al (1971), proposed a possible cause of pulpal irritation by demonstrating the occurrence of microbial leakage around dental restorations, proving that its prevention would eliminate the inflammation. The ingress of bacteria at the tooth restoration interface is responsible for pulpal irritation. [21]

Cox et al (1987), demonstrated that chemical toxic factors such as acid and components of the restorative materials per se are less significant in causing pulpal injury than bacterial leakage around the restoration margins. [22]

Chapman et al (1994), stated that, composite resin restorations have become a popular alternative to the amalgam restoration in posterior teeth. When composite resins are used in Class II restorations of posterior permanent teeth, it is essential that they have an enduring quality. The major disadvantages of restoring posterior teeth with traditional composite resins are lack of adaptation of the composite to tooth structure, particularly at the gingival margin and the marginal failure which produces microleakage. [23]

Ehaideb et al (2001), evaluated the marginal sealing ability of five fifth generation one bottle adhesive resins. Bond 1, Single Bond, Tenure Quick, Onestep and Prime & Bond NT and compared their sealing ability with a fourth generation adhesive Tenure All surface bonding. They observed no statistical difference in the marginal sealing ability between the fourth and fifth generation adhesive agents. [24]

Bardwell et al (2002) stated that, polymerization shrinkage is one of the factors responsible for the formation of gap between the resin composite and the cavity wall. This gap may vary from 1.67 to 5.68 percent of the total volume of the restoration, and it may be filled with oral fluids. To reduce the stress from polymerization shrinkage, efforts have been directed toward improving composite and material formulation, placement techniques, and curing methods. [25]

Gagliardi et al (2002), assessed microleakage in vitro using various bonding agents. Compared to traditional acid-etching techniques, self-etching adhesives achieve similar marginal integrity in dentin. The advantage of self-etching systems is their simple application. [26]

Civelek et al (2003), evaluated the polymerization shrinkage in Class II cavities of various resin composites. They concluded in their study that microleakage at dentin cannot be eliminated with any adhesive restoration. Restorative materials differ in their microleakage scores at dentin. Ormocer and bonding-flowable-hybrid composite restorations show less microleakage than ion released and hybrid composite lined only with bonding agent at the cementoenamel margin in class II cavities.[27]

Perdigao et al (2003), compared the postoperative sensitivity and enamel marginal integrity in patients with Class I and Class II cavities restored with a proprietary hybrid resin based composite indicated for posterior restorations where total etch and self etch adhesives were used. They concluded that the self etch adhesive did not differ from total etch adhesive in regard to marginal discoloration and sensitivity. [28]

Bala O et al (2003), evaluated the microleakage in Class II cavities restored with five packable resin-based composites. All the test groups established that leakage of gingival/dentin margins were greater when compared with leakage of occlusal/enamel margins. At the occlusal/enamel margins, there were no significant differences between the materials that were used[29].

Sandwich technique, which was introduced by Mclean, is primarily indicated in large class I, II III, IV and V direct composite restorations. It can either be open or closed. Both types of sandwich techniques contradicts as in open method all restorative materials are exposed to oral cavity at the proximal margins as compared to the closed variant. The chief reason for failure of open sandwich technique was the continuous loss of base material (primarily GIC).

Microleakage invitro studies by **Tredwin et al (2005)** quoted that Flowable composites are recommended to enhance the adaptation of more viscous resin composites, particularly in proximal boxes of Class II preparations. The presumption is that use of these less viscous results in less leakage and post-operative sensitivity. It has also been suggested that flowable liners may act as a flexible intermediate layer, which helps relieve stresses during polymerization shrinkage of the restorative resin.[30]

Kasraei et al (2011) suggested the use of resin-modified glass ionomers as cavity liners in the closed-sandwich technique reduced microleakage in Class II composite restorations. [31]

Anne Raskin et al (2012) - Two directions in research have been taken to improve the quality of marginal sealing and reduce the stress:

1) The development of adhesive systems to reduce or eliminate marginal gaps and

2) The development of resin composites with low polymerization shrinkage.

To date, no restorative system has been able to completely prevent microleakage at the dentin/resin composite restoration interface, and no reliable “shrinkage-free” resin composite has appeared on the market. [32]

Claudio Poggio et al (2013) evaluated the microleakage in “deep” Class II composite restorations with gingival cavosurface margin below the CEJ (Cemento-enamel junction) and restored with different techniques and found that none of the restorative techniques tested completely eliminated microleakage dye penetration in dentin margins. [33]

Malkondu et al (2014) reviewed Biodentine as a Calcium silicate based materials which gained popularity in recent years due to their resemblance to mineral trioxide aggregate (MTA) and their applicability in cases where MTA is indicated. Though various calcium silicate based products are being launched to the market recently, one of these has especially beenthe topic of a variety of investigations and the focus of attention. This material is the “Biodentine” calcium silicate based product which became commercially available in 2009 brought an enormous range of applications including endodontic repair, root perforations, apexification, resorptive lesions, and retrograde filling material in periapical surgery and pulp capping and could be used as a dentine replacement material in restorative dentistry. The material is manufactured using the MTA-based cement technology and the improvement of some properties of these types of cements, such as handling and physical qualities. [34]

Hitesh ChandarGyanani et al (2016) evaluated microleakage in subgingival class II restorations using two different liners in open sandwich technique and concluded that recently introduced hybrid ionomers with good anti-cariogenic effect alike giomer may prove to be an effective alternative for the long term success of the highly technique sensitive class II composite restorations. [35]

Rajasekharan et al (2017), did a 3year literature review and update on Biodentine, material characteristics and clinical applications. The aggrandized physical and biologic properties of biodentine could be attributed to the presence of finer particle size, use of zirconium oxide as radiopacifier, purity of tricalcium silicate, absence of dicalcium silicate and the addition of calcium chloride and hydrosoluble polymer. [36]

REVIEW OF THERMAL CYCLING

Thermocycling is the in vitro process of subjecting a restoration and tooth to temperature extremes that conform to those found in the oral cavity.

Nelsen et al (1952), found that the thermal tolerances to be 4°C for the lower thermal tolerance and 60°C for the upper thermal tolerance, among five test subjects in the study. [37]

Evaluating microleakage must include thermocycling so that it simulates intraoral conditions. The coefficient of thermal expansion of the tooth varies widely from that of composite (**Jensen and Chan, 1985**)

Rossomando et al, **(1995)** determined that, the need for thermocycling is dependent on the restorative material's ability to conduct heat in relation to its mass. [38]

Thermocycling is widely used in dental research, particularly when testing the performance of adhesive materials.

Versluis et al (1996) used strain gauges to determine the thermal expansion by measuring the instantaneous strain along the temperature change. Thermally induced loads, introduced into restored teeth by the mismatch in the thermal co-efficient of expansion between the restoration and tooth structure, may be related to microleakage and wear problems. [39]

Gale et al (1999) demonstrated that, thermal stresses can be pathologic in two ways. Firstly, differential thermal changes draw in mechanical stresses that can cause crack propagation through the bonded interface. Secondly, gap volume changes associated with changing gap dimensions pump pathogenic oral fluids in and out of the gaps with possible pulpal complications. **[40]**

Mathew et al (2001) stated that, in vitro microleakage studies using thermocycling provide a more appropriate representation of the adhesive behaviour of the composite in clinical situations. [41]

Wahab et al (2003) stated that, thermocycling of resin composite restorations have significant effect on microleakage, especially when the gingival margins of the preparations are located in dentin. [42]

Y Korkmaz et al (2010) stated the performance of an adhesive system may differ according to the dentin substrate and thermocyling. [43]

VaghareddinAkhavan-Zanjani et al (2016) discussed in his study that physical and chemical properties of restorative resin materials such as the size of filler particles and type of monomer can affect the microleakage even under thermocycling conditions. [44]

REVIEW OF IN VITRO MICROLEAKAGE EVALUATION METHODS

Pashley et al (1990), stated that, in vitro tests should be regarded assetting a theoretical maximum amount of leakage that may or may not occurred in vivo. [45]

Taylor et al (1992), stated that, a large variety of methods have been used to evaluate the microleakage of restorative materials. These microleakage tests include color producing micro- organisms, radioactive isotopes including ^{45}Ca, ^{131}I, ^{35}S, ^{22}Na, air pressure method, neutron activation analysis, electrochemical studies, scanning electron microscopy, thermal and mechanical cycling, chemical tracers and dye penetration studies. [46]

Dejou et al (1996), stated that, in vitro studies help in the selection of restorative materials and techniques and are essential for research and developmental purposes. [47]

REVIEW OF DYE PENETRATION STUDIES

Tsuchiya et al (1986), described, a technique that involved examination of the restoration margin under magnification following exposure to a dye substance. The proportion of the margin that exhibited leakage was measured. The disadvantage of this technique is that it did not give an idea about the behaviour of the material in the section of the interface below the restoration margin, where large unrecordable gaps may have existed. [46]

Spangberg et al (1989), Goldberg et al (1989), have shown that if specimens were placed in a vacuum before immersion in the dye solution, it would result in the removal of any entrapped air from within the system. Vacuum dye delivery resulted in complete filling of the voids. [48] This would significantly increase the dye penetration along the marginal defects.

Taylor et al (1992), stated that, different techniques using different dye solutions have been reported in the literature**.** Dyes used in dental research have been provided as either solutions or particle suspensions of differing particle size dependent upon manufacturer and individual behaviour of the dye. The literature reveals that the choice of dyes used continues to be based on an apparent ad hoc basis with little attention given to the different size of dye molecules/particles and their behaviour.

Dyes that could bind to tooth substance or to the restorative materials are a potential source of error in leakage studies because penetration studies in dentine also exhibit some dentine staining that should be distinguished from the actual gap between the cavity wall and the restorative material**.** [46]

Dejou et al (1996), demonstrated that, a dye penetration measurement on sections through restored teeth is one of the most common techniques used for microleakage evaluation because it is simple and fast.

In vitro evaluation of dye penetration is frequently used to test the sealing efficiency of restorative adhesive systems.

1) The results should be considered as comparative tests of the maximum leakage which might be theoretically expected in vivo.
2) The results depend on the experimental design and particularly on the restorative materials: there is a relationship between the relative ranking of adhesive restorative systems and the inorganic filler volume percentage of restorative materials.
3) The maximum dye penetration measured on each tooth seems to be the best evaluation criteria. [47]

Kadar et al (2016) explained why Methylene blue was used for dye penetration. It was inexpensive, lucid and does not require complex laboratory procedure. The use of methylene blue dye makes the visualisation of the prepared cavity in a much better way, providing the evaluators with a clear reference point from which to score. The dye also provides an excellent contrast with the surrounding environment. [49]

REVIEW OF MICROLEAKAGE AND NUMBER OF TOOTH SECTIONS

Microleakage may be defined as the passage of bacteria, fluids, molecules or ions between a cavity wall and the restorative material applied to it (**Kidd, 1976**). [46]

(Going et al 1972, Taylor et al 1992, Alani et al 1997), have extensively reviewed the in vitro microleakage detection around dental restorations in the literature. [50,46,51]

Dejou et al (1996), stated that, dye penetration measurements on sections of restored teeth remain the most common method to determine microleakage due to its simplicity and cost effectiveness. [47]

Federlin et al (2002), stated that, the most commonly applied method is the use of dyes and a single midline section through the restoration in the tooth. Microleakage is assessed on an ordinal score and is expressed as linear leakage length, or a percentage of leakage length related to the total length of the measured surface line. [52]

Rajasekharan et al (2018), reviewed Biodentine, and concluded saying that using the dye penetration technique, Biodentine exhibited significantly lesser microleakage than MTA. [36]

MATERIALS AND METHODS

MATERIALS AND METHODS

ARMAMENTARIUM (Fig:1)

- ✓ William’s graduated periodontal probe
- ✓ Metal scale
- ✓ Straight probe
- ✓ Enamel hatchet
- ✓ 245 and 169 L bur
- ✓ Airotar handpiece
- ✓ Straight micromotor hand piece **(NSK)**
- ✓ Tofflemire matrix band retainer
- ✓ Universal metal matrix band
- ✓ Teflon coated composite placing instruments **(GDC)**
- ✓ LED curing unit
- ✓ B.P. blade No.15
- ✓ Thermocycling unit
- ✓ Sticky wax
- ✓ Nail polish
- ✓ Diamond disc with mandrel
- ✓ Stereomicroscope
- ✓ Camera connected to stereomicroscope

MATERIALS USED (Fig: 2)

- Biodentine (Septodont)
- Resin Modified Glass Ionomer Cement Light-cured Universal restorative – (GC) Gold Label
- Filtek Z 350 XT Flowable restorative - 3M ESPE - A3 shade
- Single Bond Universal Adhesive - 3 M ESPE
- Filtek Z 350 XT composite Body Refill - 3M ESPE – A3 shade
- 2 % Methylene blue dye solution

COMPOSITION OF THE MATERIALS USED IN THIS STUDY

BIODENTINE

Biodentine is available in the form of a capsule in a predetermined ratio of powder and liquid.

POWDER	LIQUID
Tricalcium silicate ($3CaO.SiO_2$) Dicalcium silicate ($2CaO.SiO_2$) Calcium carbonate ($CaCO_2$) Zirconium dioxide (ZrO_2) Iron oxide	Calcium chloride ($CaCl_2.2H_2O$) Water reducing agent Water

Properties of the different components:

• Tricalcium silicate ($3CaO.SiO_2$): It is the principal component of the powder. It regulates the setting reaction.

• Dicalcium silicate ($2CaO.SiO_2$): It is the second main core material.

- Calcium carbonate ($CaCO_3$): It acts as filler.
- Zirconium dioxide (ZrO_2): It has been added to provide the radio-opacity to the cement.
- Calcium chloride ($CaCl_2.2H_2O$): It is an accelerator.

Setting Reaction

The reaction between the powder and the liquid leads to the hardening and setting of the cement. The hydration of the tricalcium silicate leads to the development of a calcium hydroxide and hydrated calcium silicate gel (CSH gel). The cement impregnated in inter-grain areas has a high level of calcite ($CaCO_3$) content.

The hydration of the tricalcium silicate is accomplished by precipitation of calcium silicate hydrate and dissolution of tricalcium silicate. Usually, it is designated by chemists as C-S-H (C=CaO, S=SiO_2, H=H_2O). The calcium hydroxide is formed from the liquid phase. C-S-H gel layers formation is got after nucleation and growth on the tricalcium silicate surface. The unreacted tricalcium silicate grains are covered by layers of calcium silicate hydrated gel, which are relatively non - permeable to water; thereby slowing down the effects of further reactions. The C-S-H gel formation is because of the permanent hydration of the tricalcium silicate, which gradually fills in the spaces between the tricalcium silicate grains. The complete hydration reaction is epitomized by the following formula

$$\underbrace{2(3CaO.SiO_2)}_{\mathbf{C_3S}} + 6H_2O \rightarrow \underbrace{3CaO.2SiO_2.3H_2O}_{\mathbf{CSH}} + 3Ca(OH)_2$$

Setting time

The working time of Biodentine is around 6 minutes with a final set at around 10-12 minutes. This represents a great improvement compared to the other calcium silicate dental materials (ProRoot MTA), which set in more than 2 hours. [53]

Material	Initial setting time	Final setting time
MTA	70 mins	175 mins
BIODENTINE	6 mins	10.1 mins

RESIN MODIFIED GLASS IONOMER CEMENT

Glass ionomers (GI), which were introduced in 1972 by **Wilson and Kent**, set *via* an acid-base reaction between polymers of polyacrylic acid and fluoroaluminosilicate bases. In addition to fluoride release, their main advantage is the unique ability to bond chemically to tooth structure. Disadvantages include reduced early strength and moisture sensitivity during setting.

Resin-modified glass ionomers (RMGI) were invented in an attempt to improve mechanical properties, attenuate moisture sensitivity and decrease setting time. Simplistically, RMGIs are a hybrid of glass ionomers and composite resin, and thus contain acid-base and polymerizable components. RMGIs are usually formulated from fluoroaluminosilicate glasses, photo-initiators, water, polyacrylic acid and a water soluble methacrylate monomer, such as hydroxyethyl methacrylate (HEMA), which may or may not be grafted onto the polyacrylic acid.[54]

FLOWABLE COMPOSITE

Flowable resin-based composites are similar to conventional composites with the filler loading reduced to 37%-53% (volume) compared to 50%-70% (volume) for conventional minifilled hybrids. This amended filler loading modifies the viscosity of these materials. Most of the manufacturers package flowable composites in small syringes that allow for easy dispensing with very small gauge needles. This makes them suitable for use in small preparations that would be difficult to fill otherwise. Flowable resin composites ranged in radiopacity from dentin equivalence to greater than that of enamel, making the product selection an important consideration for achieving adequate diagnostic contrast. [55]

SINGLE BOND UNIVERSAL ADHESIVE - 3 M

Single Bond Universal Adhesive is an exclusive dental adhesive built on a trusted 3M ESPE bonding legacy.

It has become the single-bottle solution for all surfaces, and can be used reliably in total-etch, self-etch or selective-etch mode for both direct and indirect restorations. It provides the flexibility for the clinician to choose one adhesive to use independent of their preference of technique. It bonds to the various types of methacrylate-based restoratives, cement and sealant materials to dentin, enamel, glass ionomer and various indirect restorative substrates (metals, glass ceramics, alumina and zirconia) without an extra primer step. The principal use is with light-cured materials, however, when used in conjunction with a separate activation solution, Single Bond Universal Dual Cure Activator, it has the capability to bond to self or dual-cure composite and cement materials that depend on self-cure polymerization.

Single Bond Universal adhesives have very unique set of properties that include:

- Combined total-etch and self-etch bonding capability
- Uncompromising and consistent bond strengths
- High moisture resistance to allow consistent bonding to both moist- and dry-etched dentin
- Technically no post-op sensitivity in both total-etch and self-etch modes
- Combined primer/adhesive capacity to bond to indirect substrates like metals, zirconia, alumina and glass ceramics without a separate primer
- No refrigeration required—2-year shelf life
- Dual-cure capability with separate dual-cure activation solution

Single Bond Universal adhesive provides a strong bond to seal the dentin if used in the self-etch or total-etch mode and protects the dentin from open tubules and potential sensitivity, or as a method for reducing sensitivity for patients that are already symptomatic.

The Single Bond vial now comes with a new “flip-top” cap design which allows the user to open and dispense with one hand. Contradictory to the standard black, opaque vial used for most adhesives that shields the photo initiator from all ambient light, the Single Bond Universal adhesive vial has a unique translucent orange color that gives us a visual inspection of the remaining contents but yet protects the adhesive by shielding the visible light absorbed by the photoinitiator. [56]

Filtek Z350 XT Universal Restorative

3M ESPE Filtek Z350 XT Universal Restorative is a great visible light-activated composite designed for use in anterior and posterior restorations. This resin system is mildly modified from the original Filtek Z250 Universal Restorative and Filtek Supreme Universal Restorative resin.

The resin contains bis-GMA, UDMA, TEGDMA, and bis-EMA resins. To reduce the shrinkage, PEGDMA has been substituted for a portion of the TEGDMA resin in Filtek Supreme XT restorative. The fillers are a mixture of non-agglomerated/non-aggregated 4 to 11 nm zirconia filler, of non-agglomerated/non-aggregated 20 nm silica filler and aggregated zirconia/silica cluster filler (comprised of 20 nm silica and 4 to 11 nm zirconia particles). The Dentin, Enamel and Body (DEB) 3 shades have a cluster particle size of 0.6 to 10 microns. The Translucent (T) 4 shades have an average cluster particle size of 0.6 to 20 microns. The inorganic filler loading is about 72.5% by weight (55.6% by volume) for the Translucent shades and 78.5% by weight (63.3% by volume) for all other shades. [57]

Inclusion criteria:

Non-restored, non-cavitated human Mandibular molars with nearly similar coronal dimensions were included in this study.

Exclusion criteria:

Restored, cavitated and teeth with fractured crown were excluded from the study.

PROCEDURE

CAVITY PREPARATION:

60 non-carious human extracted human mandibular molars were collected (Fig:3), cleaned from debris with ultrasonic scaler (Fig:4) and was stored in distilled water. Proximal slot preparations were made on the mesial side of all the samples under water coolant. The isthmus was prepared with an approximate dimension of 3.25 ± 0.25 mm. Pulpal depth maintained to 2 mm. The gingival floor prepared was 4 ± 0.25 mm wide and kept 1mm below the cement-enamel junction to keep the gingival margin of the cavity in the dentin (Fig:5).

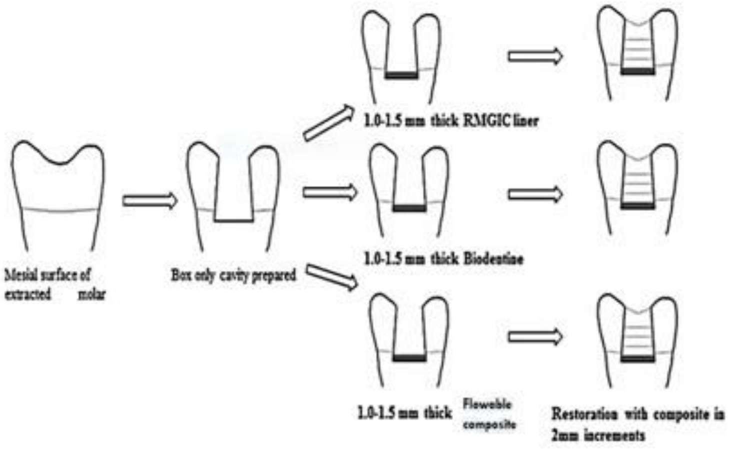
The samples were divided in to four experimental groups of 15 samples each (Fig:6).

Group I – Biodentine

Group II– Resin Modified Glass Ionomer Cement

Group III – Flowable composite

Group IV – Direct composite without cavity liner (CONTROL)



Schematic representation of methodology

A William’s graduated periodontal probe was used to gauge the depths of all cavities. Buccal and lingual walls of the preparation were parallel and connected to the gingival wall with rounded line angles. All the margins were kept approximately to a 90-degree cavo-surface angle. All the cavities were prepared by a single operator and evaluated by another operator. Burs were replaced after every five preparations.

RESTORATION PROCEDURE:

Following cavity preparation, the teeth were stored in distilled water till the next procedure. The teeth were randomly divided into four groups with fifteen teeth each and restored according to manufacturer’s instructions.

A universal metal matrix band with tofflemire matrix band retainer was tightened around the tooth and held by finger pressure against the gingival margin of the cavity so that the preparation will not be overfilled at the gingival margin. This also permitted the light to be directed only in the apical direction while curing the composite. [58] Group I, II, materials were mixed as per manufacturer's instructions and placed in the gingival margin for about 1 mm thick. Group III dispensed directly through the syringe and light cured for about 20 seconds (Fig:7).

Next, Bonding agent 3M single bond Universal adhesive was applied and gently air dried. A second layer was applied, gently air dried again and light cured for 10 seconds. Filtek 350 XT 3 M universal restorative composite was then placed in increments of 2mm. Each increment was light cured for 40 seconds (Fig:8). After restoring, surface finishing was done and then they were stored in distilled water for 24 hours before the next procedure.

THERMAL CYCLING

The restored samples were subjected to thermocycling regimen of 2500 thermal cycles by alternating immersion in water at +5±8ºC and +55±8ºC with a dwell time of 2 min and transfer time of 5s in each bath (Fig:9).

DYE PENETRATION

The teeth were superficially dried after thermocycling. Then, apices of all the teeth were sealed with sticky wax (Fig: 10). Two coats of nail polish were applied all over the teeth except 1mm around the restoration (Fig:11). Then the teeth were inverted and immersed in 2% buffered methylene blue dye for 48 hours under vacuum (Fig:12,13).

STEREOMICROSCOPIC EVALUATION

After 48 hours of dye penetration, the teeth were washed in running water, and the nail varnish coating was removed with BP blade. The teeth were sectioned longitudinally in the mesio-distal direction using diamond disc (Fig:14). The tooth sections were examined at the gingival margins along the tooth-liner interface with a stereomicroscope under 40X, images were captured by the camera and the scoring was done (Fig:15).

SCORING CRITERIA:

Staining along the tooth-liner interface were recorded according to the following criteria (Fig:16)

Score 0 - No dye penetration

Score 1 - Dye penetration less than 1/3 rd of the cavity depth

Score 2 - Dye penetration less than 2/3 rd of the cavity depth

Score 3 - Dye penetration into the entire cavity depth

STATISTICAL ANALYSIS:

The obtained results were statistically analysed using SPSS version 18.0. Cavity liners and percentage of micro leakage were analysed using one-way ANOVA test and Post-hoc test for multiple comparison of the mean values of different groups of cavity liners. The differences were considered statistically significant for $P<0.05$.

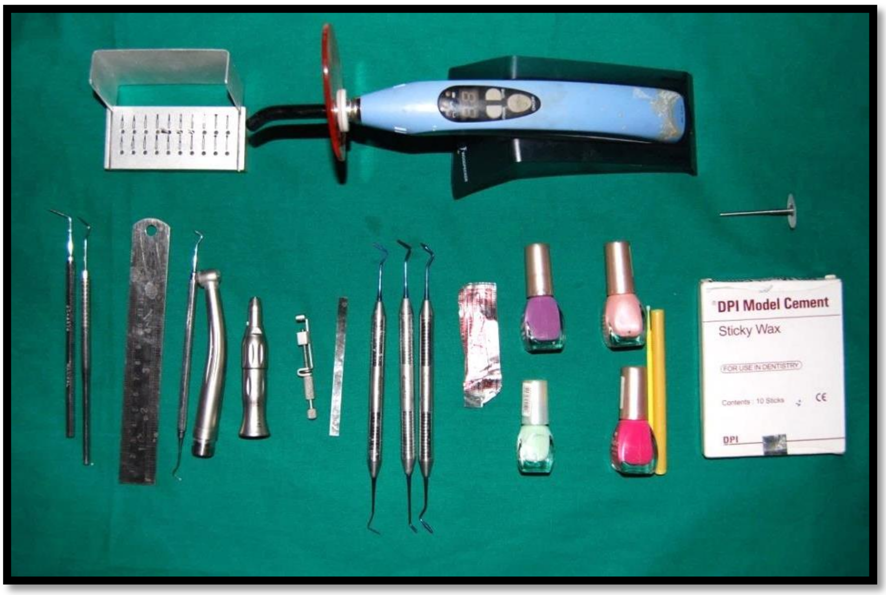


FIG: 1 - ARMAMENTARIUM

FIG: 2 - MATERIALS USED

FIG: 3 - 60 EXTRACTED HUMAN MANDIBULAR MOLARS

FIG: 4 - TOOTH SURFACE DEBRIDEMENT

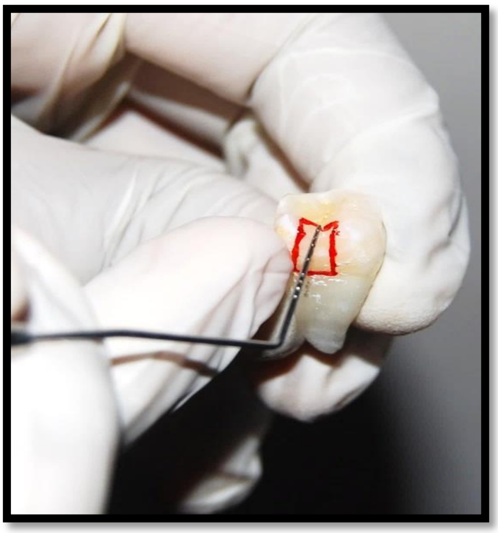
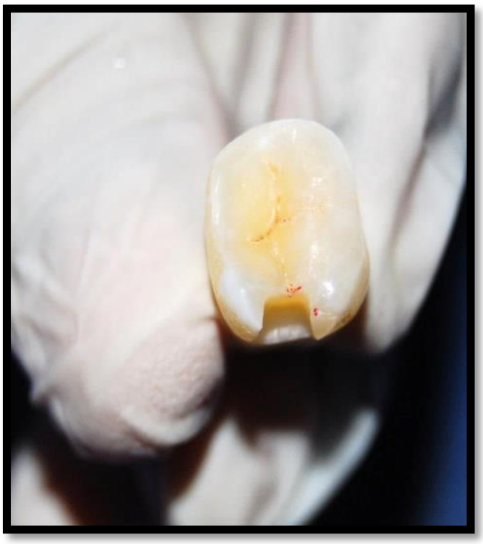
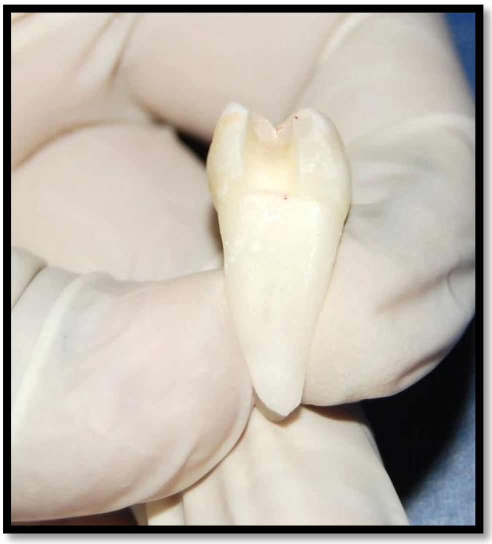


FIG: 5 - CAVITY OUTLINE AND PREPARATION



OCCLUSAL VIEW



MESIAL VIEW

FIG: 6 - DISTRIBUTION OF SAMPLES (Each group contains 15 samples)

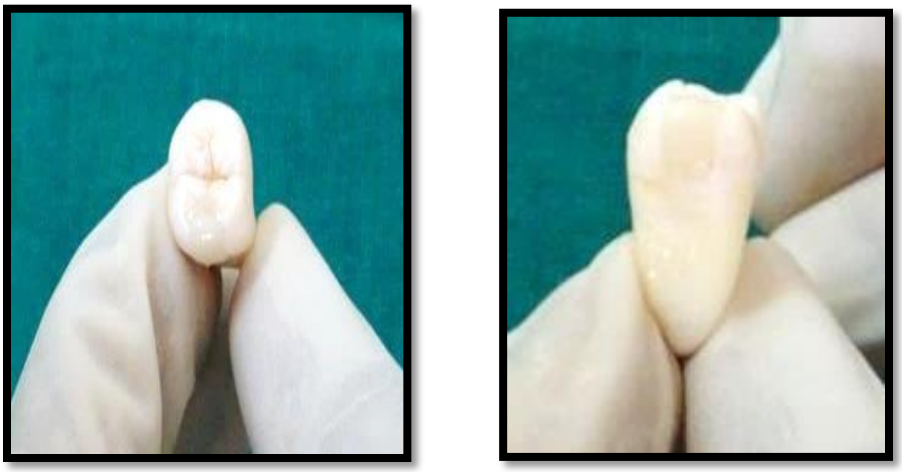
GROUP I	BIODENTINE
GROUP II	RESIN MODIFIED GLASS IONOMER CEMENT
GROUP III	FLOWABLE COMPOSITE
GROUP IV	DIRECT COMPOSITE WITHOUT LINER(CONTROL)

GROUPING OF THE SAMPLES

FIG: 7 - PLACEMENT OF CAVITY LINER

LINERS OF STUDY GROUPS

FIG: 8 - RESTORED SAMPLE



OCCLUSAL VIEW **MESIAL VIEW**

FIG: 9 - THERMOCYCLING UNIT

FIG: 10 - APICES SEALED WITH STICKY WAX

FIG: 11 - APPLICATION OF NAIL POLISH

FIG: 12 - IMMERSION OF SAMPLES IN THE DYE

FIG: 13 - SAMPLES UNDER VACCUM FOR 48 HOURS

FIG: 14 - SECTIONED SAMPLES

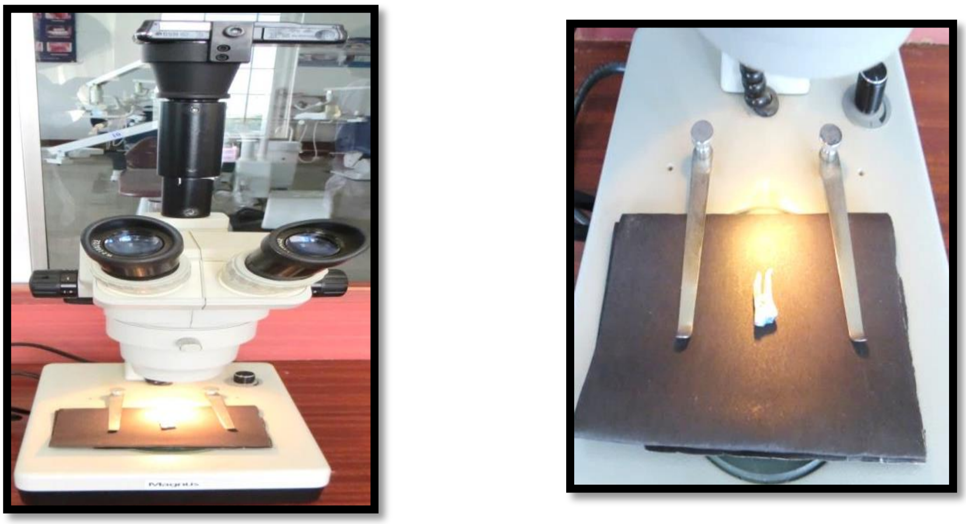
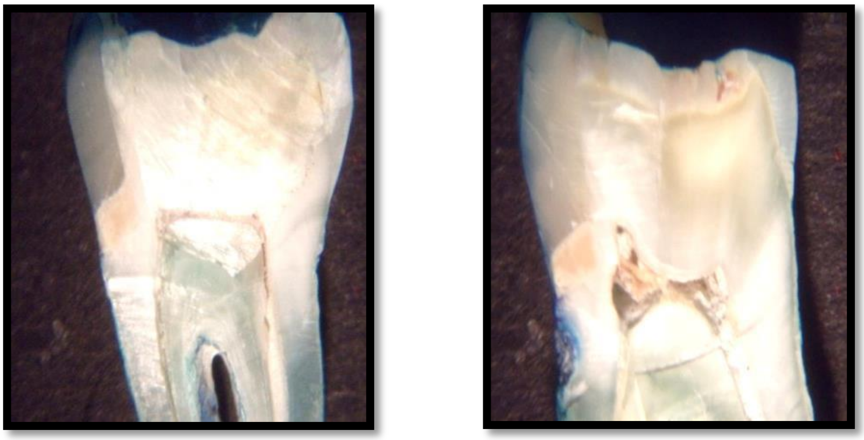
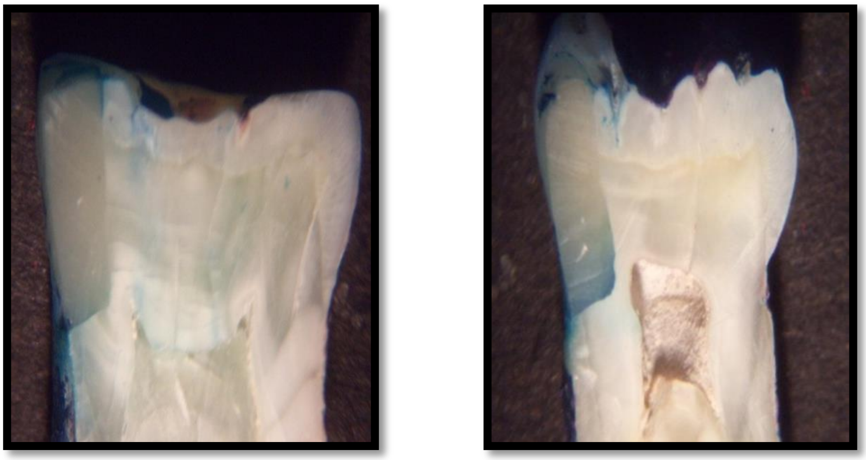


FIG: 15 - STEREOMICROSCOPIC EVALUATION

FIG: 16 - SCORING OF DYE PENETRATION



SCORE - 0 **SCORE - 1**



SCORE - 2 **SCORE - 3**

RESULTS

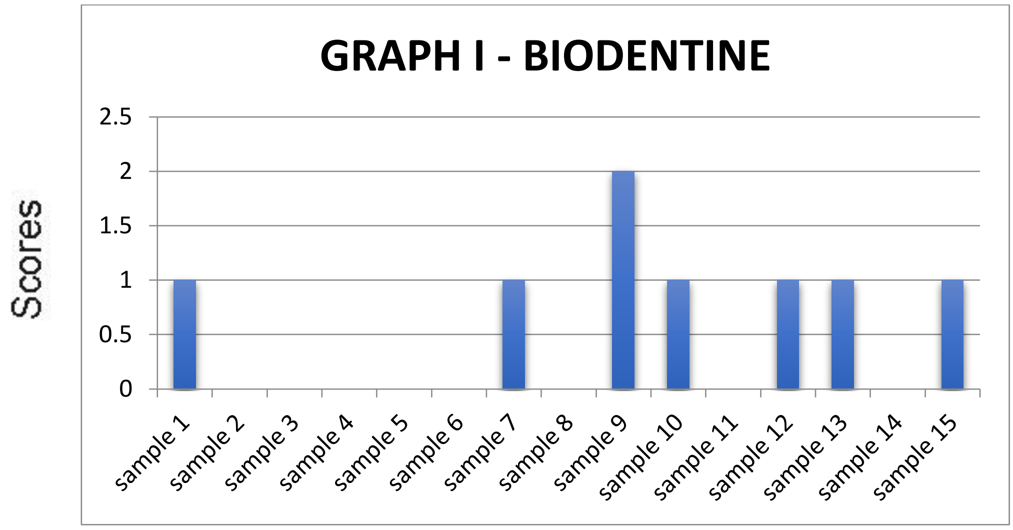
RESULTS

In the present study, 15 samples of Biodentine, RMGIC, flowable composite and control group (without liner) were evaluated for marginal adaptation – [Table 1]

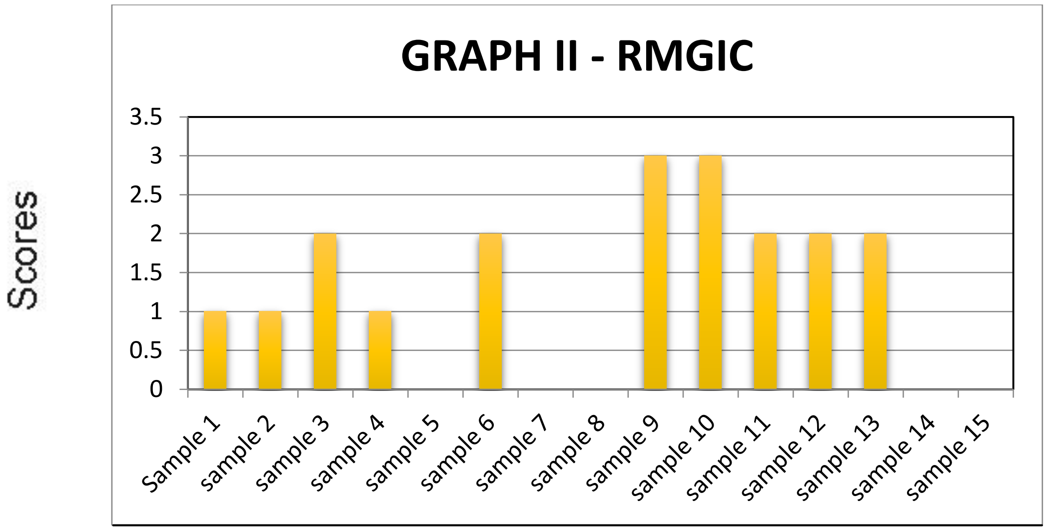
Table 1 - Evaluation of marginal adaptation of the study samples (scores)

SAMPLE	BIODENTINE	RMGIC	FLOWABLE COMPOSITE	CONTROL
I	1	1	3	3
II	0	1	3	3
III	0	2	3	3
IV	0	1	3	3
V	0	0	3	3
VI	0	2	3	3
VII	1	0	3	3
VIII	0	0	3	3
IX	2	3	3	3
X	1	3	3	3
XI	0	2	3	3
XII	1	2	3	3
XIII	1	2	3	3
XIV	0	0	3	3
XV	1	0	3	3

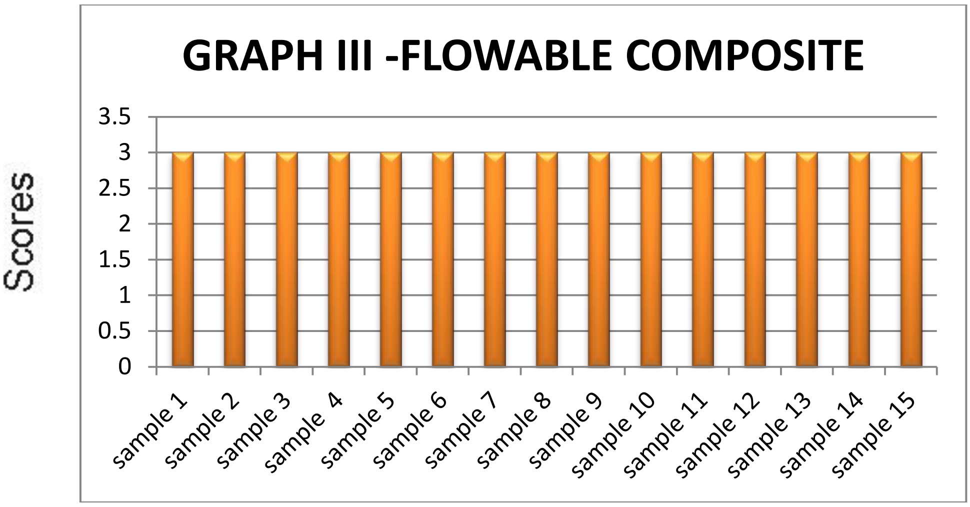
GRAPH I - MEAN SCORE OF BIODENTINE



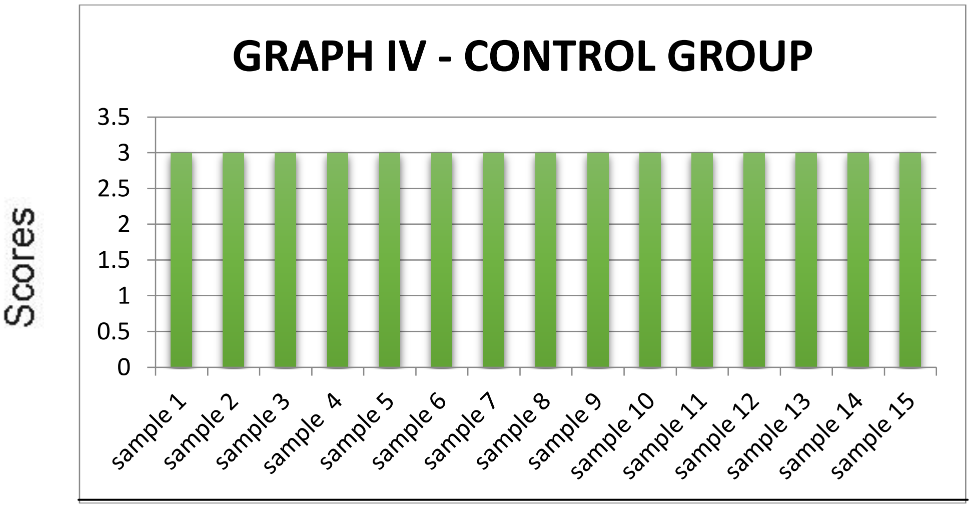
GRAPH II -MEAN SCORE OF RMGIC



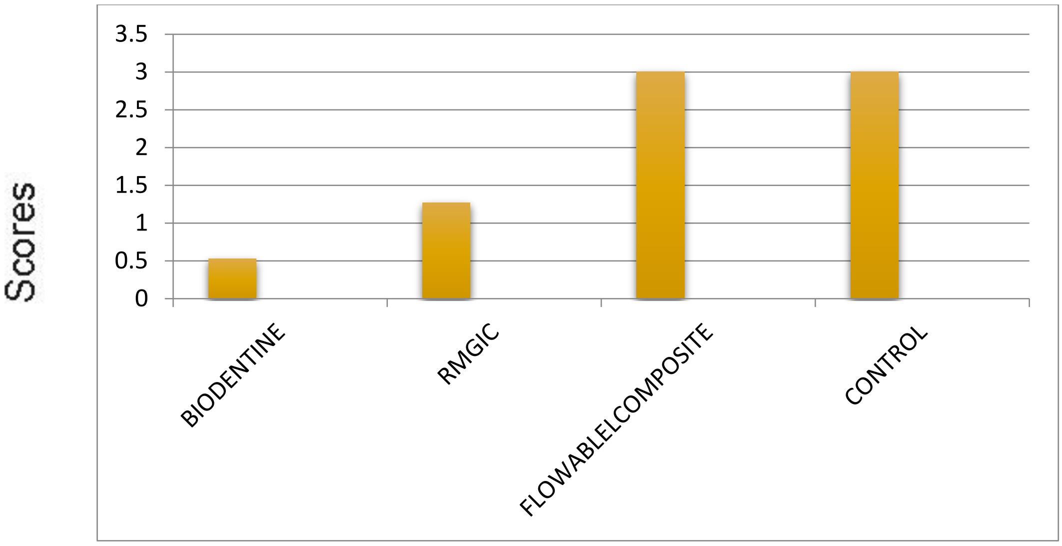
GRAPH III - MEAN SCORE OF FLOWABLE COMPOSITE



GRAPH IV - MEAN SCORE OF CONTROL GROUP



GRAPH V - MEAN SCORE OF INDIVIDUAL GROUP:



The marginal adaption of the Biodentine, RMGIC, Flowable composite and the control group were illustrated with Graph I, II, III, IV and V respectively.

Table 2: Comparison between the groups using one way ANOVA

	Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Between groups	70.183	3	23.94	57.798	0.000
Within Groups	22.667	56	0.405		
Total	92.850	59			

GROUP 1 – BIODENTINE

GROUP II – RESIN MODIFIED GIC

GROUP III – FLOWABLE COMPOSITE

GROUP IV – CONTROL

Multiple comparison between the study groups and within the groups was done using one way Anova. (Table 2). Statistically significant ($p<0.05$) difference was achieved pertaining to the marginal adaptation using stereomicroscope.

To assess the difference between individual groups, Post hoc analysis using Tukey test was done [Table 3]

Table 3: Post hoc comparison of four different groups

GROUPS	Std.error	95% Confidence interval		Sig P value
		Lower limit	Upper limit	
GR 1 vs GR 2	0.232	-1.35	-.12	0.013*
GR1 vs GR 3	0.232	-3.08	-1.85	0.000*
GR 1 vs GR 4	0.232	-3.08	-1.85	0.000*
GR2 vs GR 1	0.232	0.12	1.35	0.013*
GR2 vs GR 3	0.232	-2.35	-1.12	0.000*
GR2 vs GR4	0.232	-2.35	-1.12	0.000*
GR3 vs GR 1	0.232	1.85	3.08	0.000*
GR3 vs GR 2	0.232	1.12	2.35	0.000*
GR3 vs GR4	0.232	-0.62	0.62	1.000
GR4 vs GR1	0.232	1.85	3.08	0.000*
GR4 vs GR2	0.232	1.12	2.35	0.000*
GR4 vs GR3	0.232	-0.62	0.62	1.000

*P value < .05 significant

Group I (Biodentine)

Group I demonstrated statistically significant difference when compared with Group II, III, IV.

Group II (RMGIC)

Group II showed statistically significant difference when compared with Group III and Group IV.

Group III (Flowable composite)

Group III demonstrated statistically significant difference between group I and group II and there was no significant difference when compared with group IV.

Group IV (Control)

Group IV showed significant difference with Group I and Group II.

In this study, Biodentine exhibited higher marginal adaptation than other cavity liner materials. Followed by biodentine, RMGIC showed good marginal adaptation compared to flowable composite and control group.

DISCUSSION

DISCUSSION

One of the important goals of adhesive dentistry is to restore the peripheral seal of dentine that is interrupted when enamel is lost as a result of developmental sequelae, caries, trauma or operative intervention such as preparatory excision. For coronal carious lesions the exposed strata is bounded by enamel, dentine or both.

Manufacturers work very hard on resin formulations that will restore this peripheral seal with absolute durability and operative ease. The perplexity of Class II restorations led to the development of open-sandwich restorations. These sandwich restorations are relatively less sensitive to technique than composite restorations and show a high percentage of gap-free interfacial adaptation to dentin. [11]

Failure of a restorative procedure occurs when a restoration reaches a level of degradation that precludes proper performance either for esthetic or functional reasons or because of inability to prevent new disease. Failure of dental restorations is of a sizable concern in dental practice. It is estimated that replacement of failed restorations constitutes about 60% of all operative work. Failure and survival rates have always been used as measures of clinical performance. The reason behind the failure is also critical, because it points to a specific weakness of the restoration-tooth system. [1]

The lack of marginal integrity of restorations and microleakage has been implicated in secondary caries formation, dentinal sensitivity, corrosion or dissolution of dental materials, discoloration of dental materials and surrounding tooth structure and percolation of fluid. The fact that restorations exhibit leakage at marginal interfaces with tooth structure comes as no surprise to practicing dentists. It has been described as the movement of oral fluids between the tooth and restoration interface.

That fluid may contain bacteria and other noxious substances that may affect the tooth/pulp biologic unit. [59]

Preservation and protection of the dental pulp in developing teeth promote root maturation and extend tooth survivability by postponing or even avoiding more complex endodontic and restorative care. Early intervention with the help of hydraulic calcium silicate cements such as mineral trioxide aggregate (MTA) stimulates pulpal cell recruitment and differentiation, up-regulates transformation factors (gene expression), and promotes dentinogenesis. MTA and new hydraulic calcium silicate cements provide biocompatible environments that predictably promote reparative dentin bridge formation when placed under properly bonded and sealed composite restorations.[60]

Hydraulic calcium silicate cements are considered to be bioactive materials showing a dynamic interaction with dentine and pulp tissue interface. Improved knowledge at both cellular and biomaterial level has led to the development and modification of many new dental cements to achieve the aforementioned goals.[61]

Biodentine (Septodont Ltd., Saint Maur des Fausse´s, France) is a new tricalcium silicate (Ca_3SiO_5) based inorganic restorative commercial cement and advertised as ‘bioactive dentine substitute’. The material is claimed to possess better physical and biological properties compared to other tricalcium silicate cements such as mineral trioxide aggregate (MTA) and Bioaggregate (Bioaggregate).[61]

Biodentine has been tuned by the use of known selected additives to enhance the material properties. This demonstrates that using pure tricalcium silicate instead of specific clinker can be beneficial in order to produce dental cements.[62]

Synthetic tricalcium silicate does not contain heavy metals contrary to purified natural tricalcium silicate. This has been proved by the analysis of acid extracts and leached species of Biodentine which demonstrated absence of heavy element contamination.[63]

Although tricalcium silicate appears to be a common ingredient in both MTA and Biodentine, X-ray diffractometry of unhydrated cements conceded that Biodentine consisted of triclinic form of tricalcium silicate while MTA consisted of the monoclinic form. Another difference is the finer particle size of tricalcium silicate in Biodentine as shown by the greater value of specific surface area of Biodentine (2.811 m2/g) when compared to that ofMTA (1.0335 m2/g). [62]

The mixing of Biodentine powder and liquid resultsin a gel structure, allowing ionic exchanges and polymerization over time to form a solid network. The reaction product consists of a radiopacifier phase comprising of zirconium oxide, a cementitious phase containing tricalcium silicate and the authors claim that calcium carbonate acts as a nucleation site which allows the formation of reaction rims around it, therefore enhancing the hydration and producing a denser microstructure. Setting of Biodentine is at least partially due to polymerization of the silicate phase to a Q2 chain-like structure, similar to that present in Portland cement but the setting kinetics are faster (12 min) in Biodentine. [62,63]

The compressive strength of Biodentine amounts to 10.6 ± 2, 57.1 ± 12 and 72.6 ± 8 MPa after 35 min, 24 h and 28 days, respectively. [61] The greater strength of Biodentine in comparison to other tricalcium silicate cements is attributed to the low water/cement ratio made possible by the water soluble polymer in the liquid. [64]

The physical properties of Biodentine such as flexural strength (34 MPa), elastic modulus (22,000 MPa) and Vickers hardness (60 HV) are higher than those of MTA but similar to dentine. [61] Biodentine is reported to be more dense and less porous when compared to MTA.[62]

The mean porosity percentage for Biodentine is 7.09 ± 1.87 while that of MTA is 6.65 ± 1.93. [65]

The radiopacity of Biodentine after immersion in Hanks' balanced salt solution (HBSS) was 4.1/mm Al and 3.3/mm Al after 1 and 28 days, respectively, which is lower than that of Bioaggregate and IRM. [64]

Microleakage in open sandwich restorations showed that glucose diffusion at the interface between Biodentine and dentine walls is similar to that of resin modified glass ionomer cement. [66]

1 % methylene blue was used as a tracer which resulted in significantly less leakage for Biodentine (0.13 ± 0.006 mm) when compared to MTA (0.73 ± 0.13 mm) and Glass Ionomer Cement (1.49 ± 0.23 mm). [67] These results are substantiated by a study of Raskin et al. who concluded that Biodentine provides adequate marginal seal at the interface of enamel, dentine and dentin bonding agents. [68]

When a composite resin has to be bonded to Biodentine, self-etch adhesive systems showed better shear bond strength compared to etch and rinse adhesive systems, and the highest bond strength value was obtained for two-step self-etch adhesive at a 24-hour period.[69]

The colour stability of Biodentine over time independent of oxygen and light irradiation thereby proving that the material is suitable for use under light-cured restorative materials in esthetically sensitive areas.[70]

The use of Biodentine in treatment modalities such as deep carious lesion (4 months)[71] direct pulp capping after iatrogenic pulp exposure (6 months) [72,73] and external cervical and apical external root resorption and obturation of root canal (15 months) [74] showed successful healing without any clinical or radiological symptoms. There have also been isolated reports published in short communications regarding the clinical applications of Biodentine. These include deep cavity restorations, pulp chamber floor perforations pulp therapy, root perforations, invasive external root resorption, apexification, apexogenesis, full canal obturation and root-end filling. The wide range of documented use in pulp therapy involves direct as well as indirect pulp capping and pulpotomy in both carious as well as traumatized teeth. [61]

Use of Biodentineas a dentine substitute under a composite restoration

According to the manufacturer, Biodentine material can be used in class II fillings as a temporary dentine substitute and as permanent substitute in large carious lesions. A Study has been done by Septodont to compare the Biodentine with Filtek Z100 as posterior restorative material showed that Biodentine has excellent anatomic form, easy handling, very good marginal adaption and establishes a very good interproximal contact.

Advantages of Biodentine Over MTA

- Biodentine consistency is better adapted to the clinical use than MTA.
- Biodentine presentation provides a better handling and safety than MTA.
- Biodentine exhibits better mechanical properties than MTA.
- Biodentine does not need a two-step restoration procedure as in the case of MTA.
- As the setting is faster, there is a lower risk of bacterial contamination than with MTA. [53]

Because of these advantages over MTA, Biodentine was chosen in our study as one of the cavity liners.

Resin modified glass ionomers are materials that fall within the Glass-Ionomer family in that they contain basic glass, water and an acidic polymer and are capable of setting by an acid–base reaction. [75] They also contain a resin component (i.e., a monomer) and the ingredients necessary to cause these to undergo polymerization.

An essential feature of genuine Resin modified Glass Ionomers is that they undergo some sort of acid–base reaction and therefore will set in the dark. Such setting must be caused only be the acid–base reaction, not by a two-part polymerization process analogous to those which occur in two-paste composite resins. Where an acid–base reaction occurs, it is slower than the light-initiated reaction and results in a cement with inferior mechanical properties. Dark-curing on its own is not sufficient to confirm that a material is a resin-modified glass-ionomer, but failure to set in the dark is proof that the material is not any sort of Glass-Ionomer cement. [75]

The ability of Resin modified Glass Ionomers to release fluoride was reported in one of the earliest accounts of these materials, [76] and it is considered one of their key clinical advantages. [77] The fluoride release behaviour is found to be similar between resin-modified and conventional glass-ionomers in that release is greatest in the first day, and declines from the second day, finally stabilizing to a steady release by about 7 days. [78,79,80,81] This involves early wash-out of readily available soluble fluoride, followed by steady low levels of fluoride released more slowly by a diffusion process as fluoride ions move gradually through the cement and out through pores and cracks. [82] There is some evidence that resin-modified glass-ionomers may release more fluoride than conventional glass-ionomers. [83] Resin-modified glass-ionomers show good inherent adhesion to freshly cut tooth surfaces. [84]

This property was reported early on, when Mitra observed shear bond strengths of the first commercial material, Vitremer liner/base to bovine dentine of 12 ± 3 MPa after 24 h in distilled water. [85]

Good bonding by resin-modified glass-ionomers is partly a function of the fact that they contain a polymeric acid such as poly (acrylic acid), which as we have seen is capable of interacting strongly with the mineral phase of the tooth. [86] In addition, they contain HEMA, a substance that is also currently used as a component of dentine bonding agents. [87] The effect of this combination is not known for certain, but is likely to result in high bond strengths and durable bonding to the tooth surface. Due to the HEMA content, the resin modified GI bond more strongly to the dentine than the conventional GIC. [88]

The bonding of resin-modified glass-ionomer cements is associated with the formation of a gel phase at the interface between the material and the tooth surface. [89] This phase is said to originate from the acid–base part of the formulation, as it consists substantially of calcium polyacrylate, a substance that forms as the cement sets. However, the gel phase is more substantial in these materials than in conventional glass-ionomers, so that its occurrence owes something to the overall composition of resin-modified glass-ionomers. [90] Since the earliest report on the adhesion of resin-modified glass-ionomers, a variety of studies have been reported.

Findings have been inconclusive for the comparisons that have been made with conventional glass-ionomers. This could be because both materials might often fail cohesively, so that results of bond testing turn out to be strongly influenced by the strength (either shear or tensile) of the specific materials used. There is some evidence that these materials do show definite differences in bond strength [90] where the resin-modified glass-ionomer.

Fuji II LC exhibited significantly higher micro-tensile bond strength than the conventional glass-ionomer Fiji IX. Against that, it showed no significant difference when bonded to enamel or dentine. Attempts have been made to improve the bond strengths of resin-modified glass-ionomers to dentine by using them in association with dentine bonding agents. [91,92] However, using shear bond testing, such bonding agents have been found to make no significant difference to the measured bond strength, [92] a result that a more recent study confirms.

Microleakage of resin-modified glass-ionomers has been reported as being better than that of conventional glass-ionomer. [93] This is consistent with findings about the quality of the interface and its resistance to permeability, [94] and probably results from improved wetting of the tooth surface caused by the presence of HEMA.

A relatively new development of resin-modified glass-ionomers is to have them presented as a paste-liquid system. [95] Such a presentation makes the material easier to mix at the chair-side than the conventional powder-liquid system, though there are difficulties in producing stable systems of this type. This material contains a modified polyacid, which is a methacrylated copolymer, [95] and it also contains what have been described as ‘nano-fillers’. However, the exact state of division of these fillers has not been reported in the scientific literature, and there is evidence that such fillers are in fact of larger size than the nanometre scale and consist of clusters of nanoparticles or even nanocrystallites within more conventionally sized particles. Properties of this material have been reported. It has been found to bond to enamel and dentine, and to do so reliably and with good durability. Results from X-ray photoelectron spectroscopy(XPS) and Fourier-transform infrared spectroscopy(FTIR) show that this bonding is the same as for conventional glass-ionomers and involves the formation of chemical bonds to calcium in the mineral phase of the tooth.

There is also evidence of micromechanical adhesion in this material. Fluoride release and recharge have been reported as well. Release follows the same kinetics as for other types of resin-modified glass-ionomer, namely an early burst followed by a steady release based on diffusion which has a square root of time dependency.

The new type of resin-modified glass-ionomer showed similar recharge behaviour to other types of resin-modified glass-ionomer and was able to take up and release reasonable amounts of fluoride after ageing for 3 months. Surprising, coating the material with its proprietary primer did not alter the fluoride release rate significantly. Overall, the results show that the material presented as a paste-liquid system has satisfactory in vitro properties. Further work is necessary to determine how it performs clinically over reasonable periods of time. [96]

“Packable” Composites were brought in to market place as an alternative to amalgam. Packables have higher filler loadings (>80% by weight). These stiffer materials might not competently adapt to internal areas and cavosurface margins at the cervical joint. Flowable resin composites used as liners in areas of difficult access have been suggested to address this concern.[2]

Introduced in the late 1996, flowable composites were created by retaining the same particle sizes of traditional hybrid composites but reducing the filler content and allowing the increased resin to reduce the viscosity of the mixture. [97]

Flowable composite liner, beneath composite restorations has several advantages. First, the flowable composites are used in a syringe and can flow easily into the preparation, resulting in greater ease of placement and allowing the dentist to cover the entire preparation. This reduces the presence of voids at the interface.

Second, the flowable composite liner might be able to act as a flexible intermediate layer, which helps in relieving stresses during polymerization shrinkage of the restorative resin. [98,99] This could be due to the low young’s modulus of the flowable composites in comparison to the other hybrids. This would dissipate of contraction stresses during polymerization.

Use for flowable composites is in conjunction with placement of viscous packable composites. Leevailoj et al., studied packable composite resin placement with and without a flowable composite and found that there was significantly less microleakage in teeth restored with the flowable composite resin as the first increment in the proximal box. [100]

The use of a flowable composite liner with microhybrid or packable composites is highly recommended in restoring deep class II cavities to reduce the marginal microleakage and problems associated with it.[2]

Use of 1mm of flowable composite intermediate layer improved the sealing ability of packable composites than the resin modified glass ionomer.[101]

In contrast to the above mentioned studies, our study revealed that the RMGIC was better than the flowable composite when used as a 1mm thick liner beneath the packable composite.

Our study results were similar to that of study conducted by Belli et al in 2001 which proved though flowable composites were recommended for gap-free resin dentin interface, it did not produce gap-free resin margins. [102]

The magnitude and kinetics of polymerization shrinkage, together with elastic modulus, may be potential predictors of bond failure of adhesive restorations. [103] The authors came to a conclusion that, flowable composites generally showed higher shrinkage than traditional non-flowable composites.

The elastic moduli of hybrid composites exhibited the highest values, while the flowable composites were in the low-medium range and the microfilled the lowest. The higher shrinkage of flowable composites than that of hybrids may show a potential for higher interfacial stresses. However, their lower rigidity could be a counteracting factor. From literature it can be concluded that there a huge amount of factors might have an influence on the volumetric shrinkage of a material i.e., filler content, filler size, type of monomers, monomer content, organic matrix type, organic matrix conversion factors, power intensity of the curing unit, thickness of the material/depth of the cavity and technique of placement of the material.[104]

The clinically undetectable passage of bacteria, fluids, molecules, or ions between the cavity wall and the applied restorative material, known as microleakage, is an important concern in restorative dentistry because of its clinical damages, such as secondary caries lesions, pulpal pathologies, postoperative pain and sensitivity and, consequently, the failure of the restorative procedure. [105]

Gingival wall microleakage was evaluated in packable and microhybrid composite restorations with and without a flowable composite liner and found all restorations with margins in cementum/dentin leaked significantly more than those with margins in enamel, which was in accordance to our present study which exhibited leakage when placing flowable composite as a liner. [30] Therefore, the marginal integrity of flowable composites is still questionable and more clinical trials need to be conducted to confirm their performance.An evaluation was done whether the intermediate layers of flowable resin composite and Resin Modified Glass Ionomer Cement used prior to packable composite resin restoration would eliminate or cardinally decrease microleakage at the gingival floor and which is the most suitable intermediate layer under packable composite resin restoration.

He concluded that flowable resin composite when used as a 1 mm thick liner under a packable resin composite at the gingival margins showed overall less microleakage than the other two groups to some extent. [106] Results of this study infer that leakage scores are not affected when a packable composite was used alone to when an intermediate layer was used. [101]

Flowable composites which are being less viscous, improves the wettability by flowing onto all prepared surfaces creating an intimate union with the microstructural defects in the floor and the walls of the cavity preparation.[101] Resin Modified Glass Ionomer Cement has molecular bonding to dentin and enamel, bacteriostatic action, thermal expansion similar to that of enamel and dentin and a slow setting reaction with a low setting shrinkage.

The gingival floor of class II cavity preparations yields the greatest distance to the source of light, which could decrease the degree of polymerization, leading to greater leakage values. The use of material with which curing is not dependent on light may be beneficial in deep cavity areas, far from the light source. A layer of chemically cured resin composite for the gingival floor of a proximal cavity solves this problem improving marginal adaptation. [107]

Flowable resin composites dispensed from syringe and can flow into the preparation, allow to cover the entire preparation and reduces the possibility of voids at the interface and acting as a flexible intermediate liner helps to relieve stresses during polymerization shrinkage of the restorative resin. Since it has less filler content, the coefficient of thermal expansion of flowable composite is close to that of the tooth structure and this further increased the marginal adaptation when the specimens are thermocycled. [108]

The long term quality of a dentin adhesive interface appears to be maintained when a resin-modified glass-ionomer liner is used. [109]

This result is in contrast with our study, in which Biodentine and RMGIC group placed as a 1mm thick liner under the packable composite performed better than the Flowable composite and the control group.

RMGIC has been successfully used as a liner in sandwich technique since many years because of its definite advantages like it bonds well to the tooth, its coefficient of thermal expansion is similar todentin with the property to command set. It shows superior mechanical properties, less dissolution rate and good sealing ability as compared to conventional GIC. One of the main disadvantage of RMGIC was again shrinkage, due to resin component and technique sensitivity. Also, the monomers that leach out of RMGIC are said to have noxious effects on the pulp. [110]

In deep carious lesion, liners which can promote dentin deposition are preferred. These materials should serve the purpose of a liner as well as an indirect pulp capping agent. Some of the materials used as liners under restorations in deep cavities include calcium hydroxide, mineral trioxide aggregate, Biodentine and Theracal LC.

A calcium silicate cement (MTA) introduced by Dr. Mahmoud Torabinejad has been used as a material for pulp capping, because of its good sealing ability preventing bacterial leakage and the ability to stimulate cementum, bone and dentin. These properties have helped MTA unsurp the position of a gold standard in pulp capping, previously held by calcium hydroxide. However, it has some disadvantages, like long setting time (2 hours 45 minutes), low compressive strength, staining of teeth etc., which lead to the development of Biodentine. [111,112]

Biodentine, could overcome most disadvantages of MTA. It has a shorter setting time of 12 minutes. Its mechanical properties such as compressive strength and modulus of elasticity is similar to natural dentine and has sufficient strength to withstand occlusal loading. Hence, Biodentine is used as one of the cavity liners in our study excluding MTA for its disadvantages.

Higher mean microleakage was recorded in Group 1 (no liner) followed by Group 2 (RMGIC), Group 4 (Theracal LC) and Group 3 (Biodentine) respectively. [110] This study is similar to our study in which Biodentine showed least microleakage compared to the other three groups.

Among the groups RMGIC showed statistically significant higher leakage values as compared to Theracal LC and Biodentine when used as a liner beneath closed sandwich restorations. According to a few researchers, RMGIC bonds get distrupted with dentin, mainly in the initial stages of GIC maturation due to contraction forces which occur within polymerising composite resin. So, the polymerisation stress leads to pulling away of RMGIC from dentin and cementum during polymerisation of composite resin layer. [113]

Good marginal integrity of sandwich restorations filled with Biodentine and Theracal LC is also likely due to the ability of the calcium silicate materials to form hydroxyapatite crystals at the surface, when formed at the interface between the restorative material and the dentin walls, these crystals may contribute to the sealing efficiency of the material. [34] This explains the reason for lower leakage values seen beneath Biodentine and Theracal LC in Class II closed sandwich restoration in this study. Biodentine performs better even when margins are located in cementum.

Biodentine forms tag like structures at the interface which is an advantageous property over RMGIC which is sensitive to moisture.[114]

Hence Biodentine was selected in our study, since the cavity margins were in the cementum and to check its efficacy in open sandwich restorations where isolation being challenged. RMGIC was selected for its sustained fluoride release in patients with high caries index and Flowable composite which is known for its property of low viscosity and helps to relieve stresses during polymerization shrinkage of the restorative resin.

The inference of comparison between the four groups regarding complete elimination of microleakage and better marginal adaptation suggests that first group, using Biodentine as a liner acted superlatively better than the other three groups with maximum number of specimens having no microleakage at all.

There was no significant difference between flowable composite group and control group in which there was no liner placed.

SUMMARY & CONCLUSION

SUMMARY

Obtaining a durable bond between composite resin and dentin substrate often poses a challenge for the clinician. The inherent moisture content of the dentin restricts the bonding with hydrophobic resin monomers. This attenuated bonding, along with polymerization shrinkage stresses, can lead to formation of marginal gaps at the restoration-tooth interface, which in turn can lead to postoperative sensitivity, marginal fracture, secondary caries and eventual bond failure.

Open sandwich technique i.e., placing a liner upto the cavity margin, has been advocated in the past to negate the effect of shrinkage stresses at the gingival margin. This technique is especially beneficial in cases with caries extending onto the root surface or in patients at high caries risk. Resin modified Glass Ionomer cement has mechanical properties comparable with dentin and is widely used as the dentin substitute under restorations. Flowable composite being characterized by low viscosity unfilled resin which can reduce the polymerization shrinkage stress under composite restoration. Recently, Calcium silicate materials like Biodentine with short setting time been used which forms resin tags with the tooth surface further promoting the marginal adaptation of tooth-liner interface.

In our study, while comparing the marginal adaptation in large class II cavities using various liners such as RMGIC, Flowable composite and Biodentine, the better marginal adaptation was achieved by the groups where biodentine was placed as a liner. However with the various limitations of the study, further in-vivo and long term follow up studies required to substantiate our in-vitro results.

LIMITATIONS OF THE STUDY

1. In our study, only vertical sectioning was performed in the mesial-distal direction. It has been suggested that a more accurate way to evaluate the total leakage is to completely remove the restoration and evaluate the total amount of leakage as this can vary from various sections.
2. Mechanical loading was also not done to simulate the intra oral conditions.
3. Present study utilized only materials from one manufacturer which would be difficult to follow in all clinical scenario. Since greater variability exists in the material composition from one manufacturer to the other, the results cannot be generalized to include other combinations.

Further, In vivo long term follow up studies are mandatory to evaluate the better marginal adaptation material in a open sandwich restorations.

CONCLUSION

Within the limitations of the methodology, followed and procedures performed, the following conclusion can be drawn.

There is significant difference between the groups. None of the groups was able to provide good marginal adaptation. Biodentine, when used as a 1 mm thick liner under the composite at the gingival margins, showed overall better marginal adaptation than the other groups.

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VIVEKANANDHA DENTAL COLLEGE FOR WOMEN
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Ethics Committee Registration No. ECR/784/Inv/TN/2015 issued under Rule 122 DD of the Drugs & Cometics Rule 1945.

No: VDCW/IEC/33/2016

Date: 05.11.2016

TO WHOMSOEVER IT MAY CONCERN

Principal Investigator: Dr. Chandrika.R.P.

Title: AN IN VITRO COMPARATIVE EVALUATION OF MARGINAL ADAPTATION IN LARGE CLASS II CAVITIES USING VARIOUS LINERS IN OPEN SANDWICH TECHNIQUE.

Institutional ethics committee thank you for your submission for approval of above proposal .It has been taken for discussion in the meeting held on 25 .10.16.The committee approves the project and it has no objection on the study being carried out in Vivekanandha Dental College For Women.

You are requested to submit the final report on completion of project. Any case of adverse reaction should be informed to the institutional ethics committee and action will be taken thereafter.

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