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# THE OPEN SANDWICH TECHNIQUE WITH GLASS IONOMER CEMENT – A CRITICAL EVALUATION

**Dr. Vipin Arora<sup>1</sup>, Dr. Vineeta Nikhil<sup>2</sup>, Dr. Shefali Sawani<sup>3</sup>, Dr. Pooja Arora<sup>4</sup>**Professor, Department of Conservative Dentistry and Endodontics, Subharti Dental College, Meerut, U.P, India<sup>1</sup>Professor and HOD, Department of Conservative Dentistry and Endodontics, Subharti Dental College, Meerut, U.P,  
India<sup>2</sup>Post Graduate Student, Department of Conservative Dentistry and Endodontics, Subharti Dental College, Meerut, U.P,  
India<sup>3</sup>Associate Professor, Department of Prosthodontics, Subharti Dental College, Meerut, U.P, India<sup>4</sup>

**Abstract:** One of the critical 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, trauma, caries or operative intervention such as preparatory excision. For coronal lesions the exposed strata may be bounded by dentine, enamel or both. Manufacturers continue to work vigorously on resin formulations that will restore this peripheral seal with operative ease and absolute durability. Difficulties with Class II restorations led to the development of open-sandwich restorations: a glass ionomer cement (GIC) or a resin-modified glass ionomer cement (RMGIC) placed between the dentin gingival margins and occlusal composite restorations. GIC presents two interesting features in restorations by bonding spontaneously to dentin and releasing fluoride. These sandwich restorations are less sensitive to technique than composite restorations and show a high percentage of gap-free interfacial adaptation to dentin.

**Keywords:** Class II restorations, Open sandwich technique, sandwich restorations

## I. INTRODUCTION

With the increasing demand for esthetic treatment options in restorative dentistry, an interest in longevity and reliability of resin composite restorations has grown. Resin composites represent the material most commonly used as an alternative to amalgam for class II restorations. [1]

Microleakage is one of the most frequently encountered problems for posterior composite restorations, in particular, at the gingival margins of class II cavities extending onto the root. [2]

Direct class II restorations are known to show more leakage around enamel and dentin margins than indirect restorations. Unfortunately, several factors account for marginal microleakage when using composite. The enamel around the proximal box is often of poor quality or totally absent. [3] Furthermore, some voids within the materials and at the gingival margin have been reported. Adequate polymerization of the material and, therefore, clinical success, depends on the factors related to the material itself, such as the type of monomer or its shade, and on clinical factors, such as the incremental technique, distance from the light source,[4] the type of curing unit and blood and salivary contaminations. Together, this renders the class II restorations technique sensitive to operator skill. [5] Difficulties with class II restorations led to the development of open-sandwich restorations: a glass ionomer cement (GIC) or a resin-modified glass ionomer cement (RMGIC) placed between the dentin gingival margins and occlusal composite restorations. GIC presents two interesting features in restorations by bonding spontaneously to dentin and releasing

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fluoride. These sandwich restorations are less sensitive to technique than composite restorations and show a high percentage of gap-free interfacial adaptation to dentin. [6]

Since, there are conflicting views regarding the clinical performance of open sandwich restorations, this review attempts to highlight the intricate details about this technique and critically evaluates the literature regarding clinical performance of the restorations.

### II. THE OPEN SANDWICH TECHNIQUE FOR RESTORATIONS

McLean and Wilson first described the open sandwich technique in 1977, proposing it as a method to improve adhesion of resin composite restorations. The technique was developed to limit the shortcomings of posterior composite restorations, particularly their lack of permanent adhesion to dentine, which could result in microleakage and postoperative sensitivity. Mount [7] advocated that the glass-ionomer (GI) at the cervical margin be left exposed to allow release fluoride to protect the surrounding tooth structure. This became to be known as the Open-Sandwich Technique. This so-called “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 mechanism for sealing the cavity in the absence of good dentin adhesion available with the materials of the time. [8]

The Open-Sandwich Technique for placement of a Class II posterior composite restoration has all 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 placed 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 an initial polymerization period of this base, a top layer of a light-cured composite resin is placed to complete the restoration to full anatomic form and function. [9]

#### A. Clinical Technique for Open-Sandwich Restoration with Glass Ionomer Cement (GIC)

The Open Sandwich Technique involves layering of GIC and composite to obtain better results. After the removal of caries, isolate the tooth and place sectional matrix. After a 2 second, etch of the dentin with 37% phosphoric acid and then rinse. Apply glass ionomer cement in the proximal box areas to a point just apical to the contact area. Condense the first increment of composite resin to place using a non-serrated amalgam plunger. This increment extends from the flowable layer to the occlusal side of the proximal contact. Further, apply composite resin to facial and palatal enamel in increments and sculpt the desired occlusal anatomy. Then, smooth the resin layer prior to curing.

#### B. Modifications in the technique for Open-Sandwich Restoration

##### 1. Composite resin co cure technique

Bond a thin layer of a resin modified glass ionomer cement (RMGIC) bonding agent directly onto etched enamel and dentine. Next place a second layer of resin modified glass ionomer cement bonding agent followed immediately by the application of a composite resin prior to light curing.

The first layer of resin modified GIC bond cures all the HEMA and seals the cavity while the second layer acts as a polymerization stress release during photo initiation of the composite resin. For cavities over 2mm deep a further layer of resin modified glass ionomer cement bonding agent can be used as a stress breaker between layers of composite resin. [10]

##### 2. Glass ionomer cement co cure technique

Following cavity preparation and etching of dentine and enamel surfaces, an increment of auto cure glass ionomer cement is placed into the proximal box and over the floor of the cavity extending up to the dento-enamel junction around the perimeter of the preparation or just short of the cavo-margin at the base of the proximal box.

## International Journal of Innovative Research in Science, Engineering and Technology

(ISO 3297: 2007 Certified Organization)

**Vol. 2, Issue 8, August 2013**

Either prior to or at the immediate set of the auto cure glass ionomer cement, a layer of resin modified glass ionomer cement bonding agent is brushed over the auto cure glass ionomer cement and up to the outer perimeter of the preparation. [10]

An increment of composite resin is next placed over the auto cure glass ionomer cement to fill the cavity followed immediately by photo curing the preparation.

Upon photo initiation the composite resin cures and undergoes polymerization shrinkage before the resin modified glass ionomer bond has cured resulting in a stress free bond to tooth structure at the cavity perimeter. Resin modified glass ionomer cement chemically bonds composite resin to glass ionomer cement. The exothermic setting reaction of the composite resin heats the auto cure glass ionomer cement initiating a cascade setting reaction of the auto cure glass ionomer cement to occur between 20 to 40 seconds depending on the ambient temperature.[10]

### C. Rationale for Use of GIC

Given the advances in dentine-bonding agents and resin composites, one would think that the technique would by now have become obsolete. However, the clinical success of posterior composite restorations is still limited with respect to leakage and longevity [11],[12] and this has meant that the sandwich technique is still in use today. The restoration of deep approximal cavities also requires that several problems must be overcome, the difficulty of placement of a rubber dam, the time-consuming incremental packing technique, and the intricate handling required by some dentine bonding systems.[13]

It is therefore relevant to look at these relatively old materials with the aim of solving current problems in adhesive bonding because the GI family is naturally self-adhesive to tooth structure. [14]

The open-sandwich technique failed clinically when conventional GI's were used to restore the cervical margins of Class II restorations, mainly because of a continuous loss of material.

Consequently, the then newly developed resin-modified glass ionomers (RMGI) were used in place of conventional GI. The inclusion of resin in the GI formulation allowed these newer materials to polymerise upon light activation. The resin also supplemented the chemical bond that GI achieves with tooth structure by bonding micromechanically. This double adhesion mechanism is the main determinant of the retention and marginal sealing capacity of the material. It has been reported that higher bond strengths were achieved with RMGI than with conventional GI. [15],[16],[17]

It is assumed that better sealing produced by RMGIC is a result of the formation of resin tags into dentinal tubules allied to the ion exchange process present in the interface between dentin and RMGIC, as previously reported. [18] Although some studies do not testify the presence of these resin tags or even the formation of a hybrid layer, [19] this assumption stands to be the reason for the superior performance of the RMGIC. In addition, the presence of HEMA in the RMGIC is responsible for the increased bond strengths to resin composite. [20]

The use of RMGIC as base material in Open Sandwich restoration reduces considerably the bulk resin composite used, so, the amount of shrinkage polymerization of resin composite is decreased and the marginal adaptation may be improved. A further advantage of the sandwich technique is the fluoride releasing property of GIC, which is considered to have some inhibitory effect on caries formation and progression around the restoration. [21] GIC is still considered the only material that self-adhere to tooth tissue and it has been previously shown that GIC and resin composite can adhere effectively to each other, regardless the limitations concerning this system. [22]

Other authors suggest that the use of resin-modified glass ionomer could change the configuration factor to a more favourable internal shape, minimizing the polymerization contraction effects. [23],[24] The intrinsic porosity of this material, introduced by hand mixing, can increase the "within-material" free surface area, which also contributes to stress relief. Furthermore, the higher water sorption and hygroscopic expansion that occur with this kind of material may decrease the gaps developed in the bonding interface. [25] The low elasticity modulus of this material is also considered by some authors as another reason for the good seal it provides. Its relative "flexibility" can compensate the

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**(ISO 3297: 2007 Certified Organization)**

**Vol. 2, Issue 8, August 2013**

internal stress and the high stiffness of the composite resins after cure, preventing the adhesive interface from debonding. [26] This fact has been correlated with a better marginal adaptation.

Recently, Kleverlaan, Duinen V and Feilzer investigated the mechanical properties and compressive strength of GI's that were either chemically cured, ultrasonically activated or heat cured, and concluded that the mechanical properties of GI's significantly improved after ultrasound or heat curing. An ultrasonically cured GI demonstrated increased hardness, a decrease in the soft surface layer and negligible creep at a significantly shorter time after placement, suggesting that the curing process may be accelerated immediately after ultrasonic activation. [27]

### *D. Critical Analysis*

AUTHOR	PARAMETER STUDIED	REMARKS
S.Fragkou [28] 2013	Tensile bond characteristic between composite resin and RMGIC restoratives used in open sandwich technique.	The use of bonding agent improved the Composite resin/RMGIC bond by tensile strength and strain tests.
U.Kamath [29] 2012	The effect of delayed light polymerization of a dual-cured composite base material on the marginal adaptation of class II composite restoration.	Delayed light polymerization of the dual-cured composite base reduced the microleakage in class II open-sandwich restorations.
J.Fourie [30] 2011	The effect of thermocycling, cervical position and the use of different materials on the cervical microleakage of Class II open-sandwich restorations.	The use of an ultrasonically cured glass-ionomer in the open-sandwich resulted in the least microleakage (after thermocycling) when the cervical margins of Class II restorations were placed in dentine.
A.Fabianelli [31] 2010	Evaluated whether Class II restoration in a flowable resin composite has to be placed prior to (open-sandwich technique) or after (closed-sandwich technique) construction of the interproximal wall in the centripetal build-up technique in order to reduce microleakage.	The centripetal open-sandwich technique led to significantly lower dye penetration than the centripetal closed-sandwich technique.
A.D Bona [32] 2009	Evaluated the sealing ability of different glass ionomer cement (GIC) materials used for sandwich restorations and examine the influence of acid etching the GIC on microleakage of GIC-resin composite interface.	Acid etching the GIC prior the placement of resin composite do not improve the sealing ability of sandwich restorations. The RMGIC was more effective at preventing dye penetration at the GIC-resin composite-dentine interface.
M.Atieh [33] 2008	Investigated the clinical performance and survival of stainless steel crown (SSC) restoration and modified open-sandwich technique using resin-modified glass ionomer cement.	Modified open-sandwich restoration is an appropriate alternative to SSC in extensive restorations, particularly where aesthetic considerations are important.
LW.Stockton [34] 2007	evaluate various restorative procedures in terms of their ability to reduce microleakage in posterior composite restorations with gingival margins within dentin	Both Clearfil SE Bond and Vitrebond in a closed-sandwich technique were effective methods for reducing microleakage within dentin
A.Lindberg [35]	Evaluated durability of a polyacid-	Both restorative techniques showed good durability

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**(ISO 3297: 2007 Certified Organization)**

**Vol. 2, Issue 8, August 2013**

2007	modified resin composite/resin composite open sandwich restoration in a 9 years follow-up. A polyacid-modified resin composite (PMRC; compomer, Dyract) was placed as an intermediate layer and covered with resin composite (RC, Prisma TPH). A direct RC restoration was used as control.	during the 9-year period. No clinical advantage was observed for the sandwich technique.
Florita.Z [36] 2006	Assessed the microleakage between different restorative materials and the dentine cervical margin, as well as between these materials and a composite used in the open sandwich technique in class IIcavities.	The best adaptation at cervical and junction interfaces was obtained using the resin modified glass-ionomer - composite open-sandwich technique.
Alex Gary [37] 2005	Evaluated the use of Resin-Modified Glass Ionomer Liners Under Composite Resins to control Microleakage.	Long term bonding to phosphoric acid-etched enamel surfaces has proven to be very reliable and predictable; long-term bonding to dentin is not as predictable, regardless of the adhesive system used.
A.Sachdeo [38] 2004	Evaluated the wear and clinical performance of a control group of amalgam restorations compared with that of a group of posterior composite resin restorations fillings and a group of compomer/composite open sandwich restorations placed by a single general dental practitioner.	There was no statistically significant difference recorded between the groups at 6 months or 1 year. However, at the end of the 2-year study, there was a significantly lower rate of wear recorded for the control amalgam restorations compared with other two groups. There was no statistically significant difference in wear recorded between the two groups of tooth-coloured restorations. With regards to clinical performance of the restorations, occlusal and proximal contacts in each group of restoration remained satisfactory throughout the study.
R.Atash [39] 2003	Compared the marginal microleakage of Fuji II LC (A), composite resin Z250 (B), Fuji IX GP (C), and Dyract AP (F) in class V cavities and at the Fuji II LC/Z250 (D) and Fuji IX GP/composite resin Z250 (E) interfaces of an open sandwich technique on deciduous teeth	No leakage was seen at the junction between Fuji II LC and Z250, whereas a mean leakage of 184 microns between Fuji IX and Z250 was measured. In enamel the best seal was obtained with Dyract AP. Sealing was significantly worse with Z250. In cementum, the comparison between the grouped data Z250-Fuji II LC versus Fuji IX GP-Dyract AP was highly significant, while there was no detectable difference between Z250 and Fuji II LC.
C.Besnault [40] 2003	Investigated the influence of stimulated oral environment and microleakage of Class II composites and sandwich restorations.	In comparison with values obtained in ambient conditions, the simulation of extreme environmental conditions resulted in increased silver penetration percentages for direct resin composite restorations. On the contrary, the open sandwich technique, using resin-modified glass-ionomer cements, did not seem sensitive to excessive "temperature/relative humidity" parameters. Restorations made with resin-modified glass-ionomer cements used in the open sandwich technique appear to be more tolerant towards "temperature/relative humidity" parameters, which simulated intra-oral conditions, compared with modern adhesive systems.

## **International Journal of Innovative Research in Science, Engineering and Technology**

**(ISO 3297: 2007 Certified Organization)**

**Vol. 2, Issue 8, August 2013**

ML.Cannon [41] 2003	Evaluated the clinical efficacy of the "open sandwich" restoration for pediatric dental practice.	The "open sandwich" technique can be successfully used in a pediatric dental practice.
A.Lindberg [42] 2003	Evaluated the durability of a new open sandwich restoration with improved interfacial adaptation. A polyacid-modified resin-based composite (PMRC; compomer) was placed as an intermediate layer and covered with resin composite (RC). A direct RC restoration was used as control.	No significant differences were seen between the restoration techniques. For marginal adaptation a significant change occurred between baseline and 6 months in both groups. For marginal discoloration, a significant change was observed at 6 months in the sandwich group and at 36 months in the RC group. Color match of the resin composite material changed significantly in both groups at 36 months. Both techniques showed good durability during the 3-year follow up.
AD.Loguerici [43] 2002	Evaluated gingival microleakage in Class II total bond resin restorations in comparison to open sandwich technique restorations using different materials.	The use of Vitremer in the open sandwich technique present the lowest degree of microleakage among the treatments considered in this study.
IE. Wenckert- Andersson [44] 2002	Evaluated the interfacial adaptation to enamel and dentin of modified Class II open RMGIC/RCsandwich restorations and the influence of different light curing techniques and matrix bands.	The restorations showed a high percentage of gap-free interfacial adaptation <i>in vivo</i> . Interfacial adaptation to dentin and to cervical enamel was significantly better for RMGIC than for RC.
MS.Hagge [45] 2001	Evaluated the marginal sealing ability of four different intermediate materials applied before placement of a condensable composite.	The resin-modified glass ionomer cement demonstrated significantly less microleakage than the use of a dentin bonding agent alone or in combination with flowable composite, flowable compomer, or autopolymerizing composite. This study supports the use of the glass ionomer open sandwich technique in deep Class II indirect composite restorations.
Choi. K.k [46] 2000	Evaluated the effects of adhesive thickness on Polymerization Contraction Stress of Composite	Substantial reduction in stress was obtained by relatively thick layer of adhesive exceeding 100µm.
JW.Dijken [47] Van 1999	Evaluated the durability and cariostatic effect of a modified open-sandwich restoration utilizing a resin-modified glass-ionomer cement (RMGIC) in large cavities.	The three-year results indicated that the modified open-sandwich restoration is an appropriate alternative to amalgam including extensive restorations.
JS.Reid [48] 1994	Evaluated the microleakage and gap size of glass ionomer/composite resin "sandwich" restorations in primary teeth.	Microleakage scores were measured at the proximal box and were greatest for the closed sandwich group with the cavosurface margin on dentin/cementum. The best result was obtained for the open sandwich group with the cavosurface margin on enamel.
Gordon M [49] 1991	Evaluated the microleakage in three designs of glass ionomer under composite resin restorations.	The least dye penetration at the gingival margin was observed when Ketac bond glass ionomer covered the entire non-bevelled wall. No configuration entirely eliminated dye penetration at the gingival margin.

## International Journal of Innovative Research in Science, Engineering and Technology

(ISO 3297: 2007 Certified Organization)

Vol. 2, Issue 8, August 2013

### III. CONCLUSION

One of the many questions that is still debated in dentistry relates to the optimal current methods of restoring Class I and Class II restorations directly. There are many practitioners who adopt a resin only approach and there are others that follow a combination of glass ionomer/bonding regime. The latter approach employs the philosophy that in restoring teeth, one treats dentin and enamel as separate entities and with such an approach, maximizes different materials to achieve optimum long term success. In using the sandwich technique the operator selects a dentin substitute (glass ionomer) and an enamel analog (resin composite). Glass ionomers in this technique are utilized for dentin replacement and offer the following characteristics:

- Long term fluoride release that can create fluoro-appetite in replacement of damaged dentin and have long term caries inhibition effects.
- Similar thermal expansion properties as dentin.
- Insulation from the affects of higher temperature from curing lights.
- Insulation from the potential of uncured monomer from bonding agents that could seep into dentin tubules and create negative outcomes.
- Less shrinkage and stress than composites.
- A family of materials that have demonstrated less microleakage than adhesion products and thus ultimately creating better internal seals with dentin.
- Overall a far less technique sensitive procedure that eliminates the issues of hydrophilic and hydrophobic properties of adhesion materials. [50]

Previous studies have shown that the inability of conventional GICs to produce an effective seal depends on two factors: 1) the material's sensitivity to moisture during placement and early set; and 2) the dehydration after setting, resulting in crazing and cracking. Yet, it is assumed that the better sealing produced by RMGIC is a result of the formation of resin tags into the dentinal tubules allied to the ion exchange process present in the interface between dentin and RMGIC, as previously reported. [51] Although some studies do not testify the presence of these resin tags or even the formation of an hybrid layer [52],[53]. This assumption stands to be the reason for the superior performance of the RMGIC. In addition, the presence of HEMA in the RMGIC is responsible for the increased bond strengths to resin composite [54] and should contribute to prevent dye penetration through the interface of these materials.

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**(ISO 3297: 2007 Certified Organization)**

**Vol. 2, Issue 8, August 2013**

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**Vol. 2, Issue 8, August 2013**

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