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An In-Vitro Comparative Stereomicroscopic Evaluation of Micro leakage in Class II Restorations Using Three Different Restorative Materials

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Abstract: The interface between the restoration and dental hard tissue is an area of clinical concern as insufficient sealing can result in marginal discoloration, secondary caries, and pulpitis. Microleakage is defined as the clinically undetectable passage of bacteria, fluids, molecules or ions between tooth and the restorative or filling material. This leakage may not be clinically detectable but plays a vital role in the long-term success of the restoration. Hence adequate sealing is essential for the optimal clinical performance of any restoration. In this *invitro* study we tried to compare the microleakage levels in three different restorative materials namely, Nano composite, Glass Ionomer Cement and a novel restorative material Zirconomer. The study was conducted using a dye penetration method, which is one of the oldest and economical method of detecting microleakage. The restorative materials were used to restore class II box only cavities and the microleakage occurring at the gingival margins were examined. In this study Composite restorations presented the least amount of microleakage compared to the Glass Ionomer group and Zirconomer group, which was found to be statistically significant. The Zirconomer group showed the maximum amount of microleakage and the leakage results when compared to the Glass Ionomer group was statistically insignificant. From this study it was inferred that Composite restorations have better ability in sealing the tooth restoration interface and that Zirconomer, even though considered to be a stronger material, fails to seal the tooth restoration interface properly, which will affect its prognosis as a good restorative material.

Keywords: 1. Microleakage, 2. Nano composite, 3. Glass Ionomer Cement, 4. Zirconomer, 5. Class II restorations

Introduction

The major goal of a clinician in restoring a tooth is to maintain its normal healthy, form, function and aesthetics. For any restoration to sustain in the oral environment it should be having proper bonding to the tooth structure, resist dimensional changes and thus prevent microleakage.

Microleakage is a phenomenon in operative dentistry resulting from diffusion of bacteria, fluids, food debris, other ions and molecules along the tooth-restoration interfaces.[1]Microleakage in the class II restoration have always been a matter of concern for the clinician. Studies have shown that the gingival floor is more prone to microleakage, compared to the occlusal walls.[2][3][4]Hence any breach in the gingival wall restoration interface will affectthe integrity and longevity of restorations with deleterious effects on pulpal health.[2] In the past decade significant advancements have been made in the field of restorative materials which has improved their strength as well as bonding to the tooth structure thus markedly reducing the factor of microleakage.

Composites and Glass ionomer cements are well known for their bonding ability to the tooth structure. Composites bond to the tooth structure through a mechanism known as micromechanical bonding. In this mechanism, acid etching is done to produce micro porosities followed by resin tag formation to form a hybrid layer which will be formed atthe tooth restoration interface.[5] Glass Ionomer cements, which is an acid base cement hasPolyacrylic acid as its liquid component. This cement makes a chemical bond to the tooth structure which involves chelation reaction between the carboxyl groups of the polyacrylic acid and the calcium in the hydroxyapatite crystals of the tooth.[6] Glass ionomer cements also have the added advantage of fluoride release which will act as an anticariogenic factor thus reducing the chances of secondary caries.[6] Recently, Zirconia Reinforced Glass Ionomer (Zirconomer) cements were introduced that defines a new class of restorative material that promises the strength and durability of amalgam with the protective benefits of Glass Ionomer cement while completely eliminating the hazard of mercury.[7]

Even though many comparative microleakage studies have been performed, no studies have focused on comparing the marginal integrity of restorations at the gingival margin among Nano Composite, Conventional Glass Ionomer Cement & Zirconomer, when used as a Class II restorative material. Hence to address the gap in literature, this study aimed to compare the microleakage in three different restorative materials Nano Composite, Conventional Glass Ionomer Cement & Zirconomer, when used as a Class II restoration.

Aims & objectives

1. To compare and evaluate the amount of microleakage that occur, at the tooth restoration interface in the gingival seat of class II cavities, restored with Nanohybrid composite, Glass ionomer cement and Zirconomer.

2.To compare the restorative efficiency of Zirconomer with that of Nanohy brid Composite and Conventional Glass Ionomer Cement.

Materials & methods

Si No	Materials	Type	Manufacturer
1.	Samples	45 extracted maxillary premolars	
2.	Handpieces	Airotor straight handpiece	NSK, Nakanishi Inc, Japan
		Contra angle micro motor hand piece	NSK, Nakanishi Inc, Japan
3	Burs For cavity preparation	245 carbide burs SF 41SC diamond bur	Mani Inc, Japan
4.	Restorative materials used	Nano hybrid composite	Tetric N-Ceram; **Ivoclar; Germany**
		Type II Glass Ionomer Cement	**GC Gold label; GC; Japan**
		Zirconomer cement	**Zirconomer; Shofu; Japan**
		Etchant-37% phosphoric acid	Best Etch; Waldent; India
		Bonding agent	Tetric N Bond Universal Ivoclar; Germany
5	Staining	0.5% methylene blue dye	Research- Lab Fine Chem Industries; India
6	Microscopic Examination	Stereo Microscope	EuromexDZseries

Ethical Clearance:

The necessary ethical clearance for the conduct of study was obtained from the Institutional ethics committee, prior to the start of the study.

Study site:

1. Thermocycling procedure was done at Sree Chitra Tirunal Institute for Medical Sciences and Technology, Bio Medical Technology wing. Trivandrum

2. Stereo Microscopic study was done at Cochin University of Science & Technology

In this study 45 extracted, intact maxillary premolars were selected. The teeth were checked for any caries or defects, and those found to be faulty were discarded. All the teeth were then scaled to remove the adhering soft tissue and calculus and were stored under physiologic saline at room temperature until used as test specimens.

Sample preparation:

Standard Class II box only cavity preparations were prepared in all teeth, using a High- speed Airotor handpiece with adequate water coolant. The dimensions for all cavities were maintained in a standardised manner such that the axial wall height is 3mm, width of the cavity is 3mm and depth of gingival seat is 2mm.

Group I- Composite group

After tooth preparation the cavities were cleaned and dried and then etched with 37% phosphoric acid (Best Etch; Waldent; India) for 20 seconds. The cavities were then rinsed with water for 1 minute using a three-way syringe and then air dried. Subsequently a bonding agent was applied (Tetric N Bond Universal; Ivoclar; Germany) and cured using a light- emitting diode (LED) (WOODPECKER) at 850mW/cm^2 for 20 seconds. The cavities were then restored with a nano hybrid composite (Tetric N-Ceram**;**Ivoclar; Germany) using an incremental technique. The material was then cured for 40 seconds according to the manufacturer's instruction. The restorations were then finished and polished.

Group II – Glass Ionomer group

The prepared cavities were cleaned and dried and they were restored with Type II Glass Ionomer Cement (GC Gold label; GC; Japan). The manipulation of cement was done according to the manufacture's instruction. The final restoration was then finished and polished.

Group III – Zirconomer group

The cavities were cleaned and dried and then restored with Zirconomer cement (Zirconomer; Shofu; Japan). The manipulation of cement was done according to the manufacture's instruction and the final restoration was later finished and polished. The specimens were then stored under normal physiologic saline.

All the specimens were then thermocycled to simulate the oral environment and aging. Thermocycling was done for 500 cycles between 5±2°C and 55±2°C with a dwell time of 30 seconds in each bath and 20 seconds interval between baths at ambient air. After the thermocycling process the root apex of each tooth was completely sealed with sticky wax, so that dye penetration through apical foramen can be avoided. Following this each sample was sealed with two coats of nail varnish, leaving a 1 mm window around the cavity margins. The varnish coated teeth were then immersed in 0.5% methylene blue dye for 48 h.

The teeth were then sectioned mesio-distally and the samples were examined using a stereo microscope. The maximum degree of dye penetration was noted for individual specimen, and dye penetration was scored on a nonparametric scale.

The following scoring criteria were used to assess the extent of dye penetration at the tooth restoration interface, by the criteria described by Jessudaset al. [8]

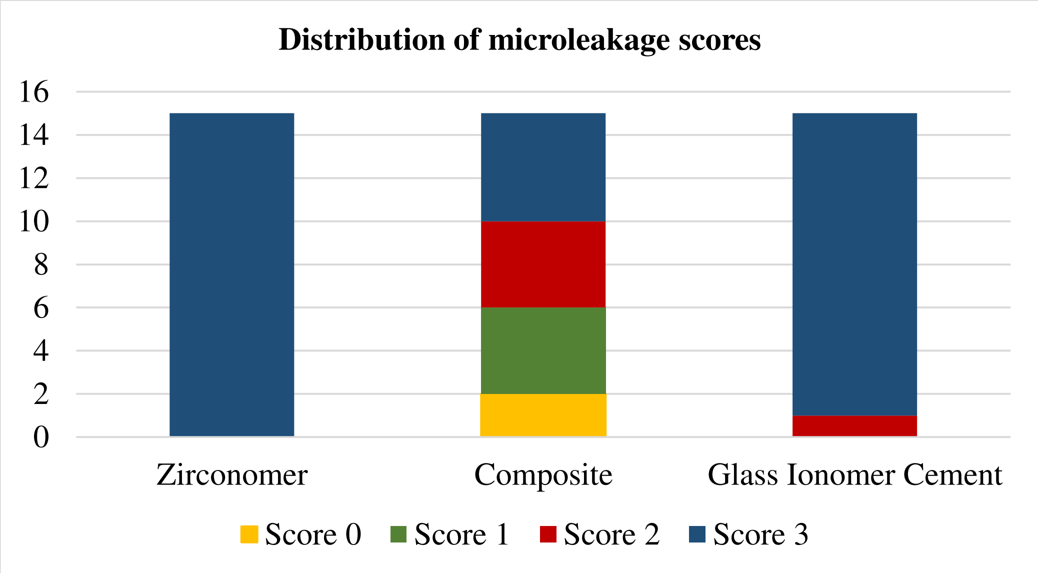
Score 0: No evidence of dye penetration.
Score 1: Dye penetrates to less than half the cavity depth.
Score 2: Dye penetration to full cavity depth.
Score 3: Dye penetration to axial wall and beyond.

The data collected by experiments were computerizedand analyzed using Statistical Package for SocialSciences (SPSS) version 23.0 (IBM SPSS, Chicago).

Observations and Results

The distribution of microleakage scores has been presented in the Table/Fig 2. The range of scores obtained for each type of restoration is given in Table/Fig 3. The ANOVA test revealed significant differences (p<0.001) in mean microleakage scores among the groups [Table/Fig 4]. The Composite group showed lesser amount of microleakage compared to the Glass Ionomer group and Zirconomer group, and this result was found to be statistically significant. The Zirconomer group showed more microleakage compared to the Glass Ionomer Cement group, which was statistically insignificant (*p*= 0.317).

Table /Fig 2



Table/Fig3 summarizes the range of scores obtained for each type of restoration

Type of restoration	**Total number of samples**	**Range of scores obtained**
Zirconomer	15	3
Composite	15	0-3
Glass ionomer cement	15	2-3

Table/Fig 4: Distribution of study samples based on micro leakage scores

Type of restoration	**Code**	**Score 0 n(%)**	**Score 1 n(%)**	**Score 2 n(%)**	**Score 3 n(%)**	**Kruskal Wallis ANOVA**	***Mann Whitney U test***
Zirconomer	1	0 (0)	0(0)	0(0)	15(100)	$\chi2$ =21.78 *p*<0.001	1>2 *p*= <0.001 2<3
Composite	2	2(13.3)	4(26.6)	4(26.6)	5(33.33)		
Glass ionomer cement	3	0(0)	0(0)	1(6.66)	14(93.33)		

Total	**2(4.44)**	**4(8.88)**	**5(11.11)**	**34 (75.55)**		*p*= 0.001 1=3 *p*= 0.317

One stereomicroscopic image pertaining to each sample group are provided in Fig :5, Fig:6 and Fig:7

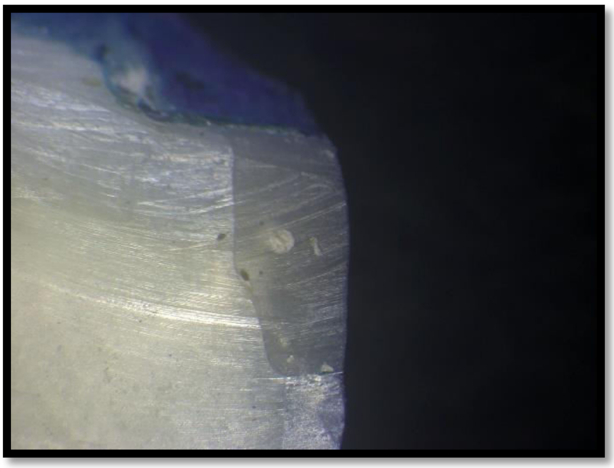


Fig:5 Composite restoration

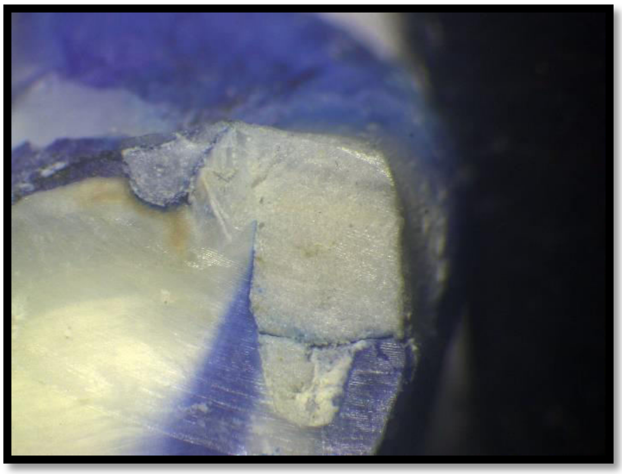


Fig:6 Glass Ionomer Cement Restoration

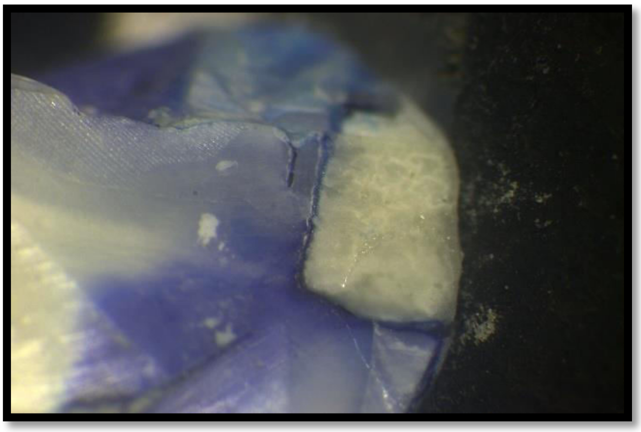


Fig:7 Zirconomer Restoration

Discussion

Ever since the beginning of dentistry, scientists and researchers have always been in a race to develop biomaterials that can be used as the best replacement to the tooth structure. Restorative dentistry focuses on removing caries and restoring a tooth, so that its normal form, function and aesthetics can be retained.

Clinical success of any restorative material depends on two main factors, its ability to withstand the occlusal loading forces inside the oral cavity and the ability of the material to adapt or bond to the tooth structure so that there is no or minimal microleakage at the restoration tooth interface. Good adhesion of restorative material provides better marginal integrity thereby increasing the clinical longevity.

This study was undertaken to compare the marginal integrity in three different restorative materials, namely Nano composite, Glass Ionomer Cement and a novel restorative material Zirconomer.

This study made use of the commonly used dye penetration method to assess the micro leakage, which is a simple, economical and effective technique. The diameter of the dye molecule is smaller compared to the diameter of the dentinal tubule, which makes it to easily penetrate and stain the tissues.[1]

The restorative materials used in the oral cavity are always subjected to a wide degree of temperature changes, owing to the different types of food a person have. The restorations are also exposed to a moisture filled environment because of the presence of saliva. Thermocycling the restorative materials in an invitro study, to an extent, is helpful in mimicking the oral environment. This exposes the material to various dimensional changes caused by the variant temperature and damp environment.[9] Thermocycling was done in this study, prior to the dye staining procedure.

Several studies have shown that more microleakage occurs at the gingival margin when compared to the occlusal margins.[2] Hence this study mainly focused on the marginal integrity of restorations at the gingival margin, and accordingly the study was conducted in Class II box only cavities.

In this study least microleakage was found in nano composites compared to Glass ionomer cement and Zirconomer and the results were statistically significant. Composites bond to the tooth structure through a mechanism known as micro mechanical bonding. Acid etching using 37% phosphoric acid will effectively create microporosities in tooth structure, that help in the formation of resin tags, as the resin penetrates into these porosities.[5] Our results were similar to the results published by Heintze et al. They in their systematic review, have found that Posterior resin composite restorations, placed with the Enamel etch technique showed the best clinical performance.[10] They also found that the longevity was not significantly influenced by the filler type or viscosity of resin composite material. This clearly indicates that it is the micro mechanical bonding that is favouring the success of composite restorations rather than its filler type.

Conventional Glass Ionomer cement (GC fuji II) used in our study has been successfully used as a dental restorative material following its invention by Wilson and Kent in the early 1970s.[6] The ability of these materials to chemically bond to the tooth structure, their fluoride releasing property and their pulp friendly nature have given them wide popularity as a restorative material. These materials bond to the tooth structure using an ionic bond mechanism. In our study the Glass Ionomer cement group showed greater microleakage compared to the composite group, and the values were statistically significant. However, the microleakage levels shown were slightly better than Zirconomer but the results were not statistically significant. Our results were similar to the results obtained by Diwanji et al. and Mali et al. [11][12] In both these studies conventional Glass Ionomer Cements had shown greater levels of microleakage. Heintze et al in their systematic review has clearly mentioned regarding the lower clinical success rate of conventional glass ionomer cement restorations with respect to Composite restorations.[10]

In this study we had also compared a novel restorative material Zirconomer. Zirconomer was introduced into the field of dentistry with the claim of having physical properties similar to amalgam with the additional benefits of fluoride release and chemical bonding of glass ionomer cements. In our study, the maximum levels of microleakage were seen in the Zirconomer group and the results were statistically significant, with respect to composite. The results were similar to studies done by Patel et al. [13] In their study they had compared Zirconomer with Amalgam and Composite and found that maximum microleakage was with Zirconomer. The results were also similar to the study done by Kumari et al. [14] They had compared Zirconomer with Glass Ionomer

cement and Cention N, and found that Zirconomer and GIC showed greater microleakage levels with respect to Cention N. The greater microleakage shown in Zirconomer might be due to the larger zirconia particles, that forms the major filler content in this material. It is possiblethat the zirconia fillers would cause interference in thechelating reaction between the calcium ions of tooth structure and carboxylic group of poly acrylic acid.[15]
Based on the present invitro study, it is clear that the bonding mechanism and adaptability of Composite restoration is much better than the conventional Glass Ionomer cement and Zirconomer. Zirconomer which is a newly introduced restorative material lacks a proper bonding mechanism, which might affect its clinical longevity and success.

Limitation of the study: Since this study is conducted as invitro, the performance of these restorations in clinical aspect, must be assessed separately.

Conclusion:

Within the limitations of this *invitro* study, it was found that all the three groups showed microleakage. Composite restorations showed the least amount of microleakage followed by Glass Ionomer Cement and Zirconomer and this was statistically significant. Microleakage in Glass Ionomer cement was greater than Composite but less than that of Zirconomer. Zirconomer showed the maximum amount of microleakage. The microleakage shown by Zirconomer and Glass Ionomer cements were statistically insignificant.

Composite and Glass Ionomer restorations already have a good clinical track record, in the field of dentistry. Zirconomer being a recently introduced material is yet to prove its clinical potential to be a good restorative material. However, the results obtained from this invitro study questions the ability of this material in providing a proper seal at the tooth restoration interface, which will compromise the restoration due to microleakage. In the light of this study Composite still proves to be a better restorative material and a clear winner in posterior class II restorations when compared to the newer materials like Zirconomer.

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