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Microleakage comparision in class V Cavities using different glass ionomer cements: An in-vitro study

Baljeet Singh Hora
Principal and Professor (Department of Conservative Dentistry and Endodontics, Rama Dental College Hospital and Research Centre, Kanpur, India)

Asheeh Sawhny
Professor and Head of Department (Department of Conservative Dentistry and Endodontics, Rama Dental College Hospital and Research Centre, Kanpur, India)

Virginia Vizo
Post Graduate Student (Department of Conservative Dentistry and Endodontics, Rama Dental College Hospital and Research Centre, Kanpur, India)

Mukta Bansal
Senior Lecturer (Department of Conservative Dentistry and Endodontics, Rama Dental College Hospital and Research Centre, Kanpur, India)

Rashmi Singh
Post Graduate Student (Department of Conservative Dentistry and Endodontics, Rama Dental College Hospital and Research Centre, Kanpur, India)

Debajit Sarkar
Post Graduate Student (Department of Conservative Dentistry and Endodontics, Rama Dental College Hospital and Research Centre, Kanpur, India)

***Abstract*---**Aim: The aim of this study was to compare the microleakage of Conventional Glass Ionomer Cement(CGIC),Resin Modified Glass Ionomer Cement (RMGIC)and Nano-Filled Resin Modified Glass Ionomer Cement (RMGIC). Materials and Methods: forty five sound extracted human molar teeth were selected. Teeth were randomly divided into three groups of 15 teeth each and restored as follows: Group 1-CGIC; Group 2-RMGIC; and Group 3-Nano-filled RMGIC. Datas were analyzed using Kruskal-Wallis and Wilcoxon tests. Results: There was no statistically significant differences in dye leakage between the three restorative materials for occlusal margins ($P = 0.465$).At the gingival margins, Group 3 showed significantly less microleakage than Groups 1 ($P = 0.008$) and 2 ($P = 0.041$). The degree

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of microleakage in the gingival margins of each group was higher than that found in occlusal margins. Conclusions: No material was able to completely eradicate microleakage at enamel, dentin, or cementum margin. Nano-filled RMGIC show significantly less microleakage as compared to other two cements at gingival margins.

Keywords---conventional GIC, resin modified GIC, nano-filled GIC, class V cavity, microleakage.

Introduction

Microleakage is the movement of bacteria, fluids,chemicals,ions, and even air between the prepared cavity walls and the applied restorative materials[1]. Microleakage is the major factor responsible for the failure of Class V restorations, as gingival margins are generally situated in dentin/cementum[2]. For many years,cervical lesions have been a restorative challenge for dentists. The main problem associated with the restoration of this kind of cavity is leakage at the gingival margin located in dentin[2]. Glass Ionomer Cements have undergone many modification since its invention by Wilson and Kent in 1970's4 .It has several advantages like ability to bond to dental hard tissues, fluoride release. The comparable coefficient of thermal expansion of Glass Ionomer Cement to tooth structure allows for improved marginal adaptation, minimal microleakage, and good restoration retention[7].However, it has certain drawbacks such as sensitivity to desiccation and moisture contact during the early setting stages4. Glass Ionomers are appropriate alternative materials to composites for the cervical lesions because of their chemical adhesion to tooth structure, fluoride release, biocompatibility, lower shrinkage values, reduced microleakage, and acceptable esthetics[5].

Resin Modified Glass Ionomer Cements (RMGIC) were introduced to overcome the drawbacks of conventional Glass Ionomer Cement, by possessing a prolonged working time, improved translucency, faster set and attainment of early strength9. Nano-filled Resin-Modified Glass Ionomer was developed that combines the benefits of a resin-modified light-cured glass ionomer and bonded nanofiller technology. Nano-filled Resin Modified Glass Ionomer contains fluoroaluminosilicate glass, together with nanomers and nanoclusters in the filler loading, which is approximately 69% by wt. The aim of this study was to evaluate the microleakage of CGIC, RMGIC, and Nano-filled RMGIC at the occlusal and gingival margins of Class V cavities.

Materials and Method

Forty-five extracted human molar teeth were used in this study.They were throughly cleaned with hand-scaling instrument,rubber cup and slurry of pumice, disinfected in 0.5% chloramine, and subsequently stored in distilled water at room temperature.Class V cavity preparation was done on the buccal surface of each tooth. Preparations were made with an 008-diamond bur (Diatech Dental AG) under air-water cooling. The dimensions of the preparations are 5 mm in length, 3 mm in width, and 2 mm in depth with the occlusal margin in enamel and the gingival margin in dentin. A William's periodontal probe (API) was used to gauge the dimensions of the cavity. Subsequently, teeth were randomly divided into three groups (n = 15).

- Group 1 - Restored with CGIC
- Group 2 - Restored with RMGIC
- Group 3 - Restored with Nano-filled RMGIC

Table 1
The commercial name, composition, and manufacturer of the materials used

Materials	Manufacturer	Composition
Conventional Glass Ionomer (Fuji II)	GC Corporation, Tokyo, Japan	Calcium fluroaluminosilicate glass, polyacrylic acid, iatonic acid, maleic acid, tartaric acid, water
Resin Modified Glass Ionomer (Ionolux)	Voco, Germany	Bis-GMA, polyacrylic acid, UDMA, HEMA, fluroaluminosilicate glass
Nano-Filled Resin Modified Glass Ionomer (Equia Coat)	GC Corporation, Tokyo, Japan	Methyl methacrylate, colloidal silica, camphorquinone, urethane methylacrylate, phosphoric ester monomer

All the three restorative groups were restored according to the manufacturer's instruction.A thermocycling regimen of 500 cycles between 4°C and 55°C water baths was used to simulate the oral environment. The dwell duration was 1 minute, while the transfer time between baths was 3 seconds. The specimens were coated with two layers of nail polish, leaving a 1 mm space around the cavity margins. Teeth were inverted and placed in a solution of 2% Rhodamine-B dye (Reachem Laboratory Chemical Pvt Ltd, Chennai, India) for 24 h at 37°C under vacuum. In order to prevent leakage through the root apices, only the coronal portion of teeth was covered with the dye. After removal of the specimens from the dye solution, the surface-adhered dye was rinsed in tap water and nail varnish was removed with a BP blade.A low speed diamond disc was used to section the teeth in a buccolingual direction through the centre of the restorations. The sections were scored according to the criteria, and the level of dye penetration at the occlusal and gingival margins was evaluated using a stereomicroscope at × 10 magnification[6].

Dye scoring criteria

The depth of dye penetration was analyzed according to a 0-3 scale scoring system as suggested by Silveira de Araïjo C[2].

- Score 0 = No evidence of dye penetration
- Score 1 = Dye penetration along the occlusal/gingival wall to less than half of the cavity depth

- Score 2 = Dye penetration along the occlusal/gingival wall to more than half of the cavity depth, but not extending on to the axial wall
- Score 3 = Dye penetration along the occlusal/gingival wall to the full cavity depth and extending on to the axial wall

All the above-mentioned dye scoring criteria for microleakage have been depicted in (Figure-4)

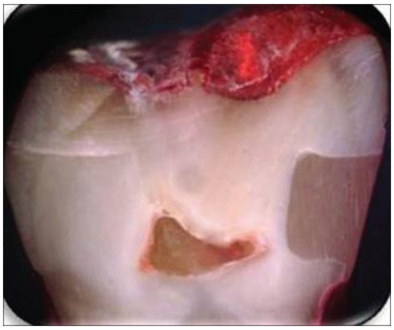

Figure 1. No evidence of dye penetration (score 0)

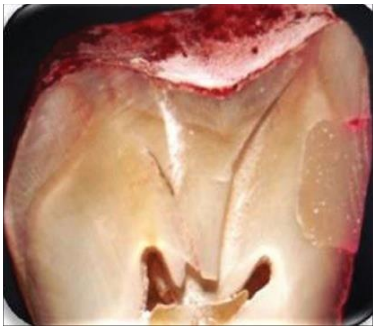

Figure 2. Dye penetration along the occlusal/gingival wall to less than half of the cavity depth (score 1)

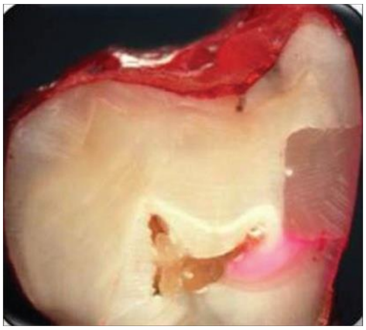

Figure 3. Dye penetration along the occlusal/gingival wall to more than half of the cavity depth, but not extending on to the axial wall (score 2)

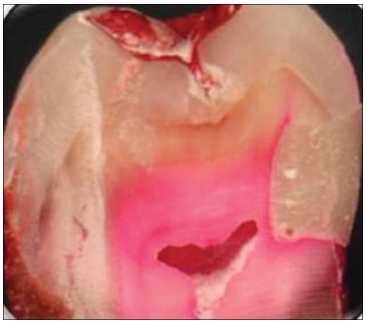

Figure 4. Dye penetration along the occlusal/gingival wall to the full cavity depth and extending on to the axial wall (score 3)

Statistical analysis

The Wilcoxon test was used to compare each matched pair of restorative materials. Occlusal and gingival scores for each set of restorations were compared using Kruskal-Wallis one-way analysis of variance (ANOVA) to see if there was any statistically significant difference between the materials. The significance was considered at the ≤0.05 level.

Results

Microleakage scores for the tested materials are presented in Table 2.

Intergroup comparison [Table 3]

Kruskal–Wallis one way ANOVA showed no statistically significant differences in dye leakage between all the restorative materials for occlusal margins ($P = 0.465$). However, there was a statistically significant difference ($P = 0.008$) at the gingival margins. Group 3 showed less leakage than groups 1 and 2 at gingival margins ($P = 0.008$ and $P = 0.041$). There was no significant difference between groups 1 and 2. (0.320).

Intragroup comparison

Wilcoxon test (used to compare occlusal and gingival scores of each materia) found that the occlusal and gingival scores for each matched pair of restorative materials showed statistically significant differences(for Group 1- $P < 0.001$,Group 2- $P < 0.001$,Group 3-$P < 0.006$).

Table 2
Mean Microleakage scores for the occlusal and gingival margins

Materials	Dye leakage score at occlusal margins				Dye leakage score at gingival margins			
	0	1	2	3	0	1	2	3
Group 1	12	2	0	1	0	0	0	15
Group 2	13	2	0	0	1	0	0	14
Group 3	10	5	0	0	3	2	0	10

Table 3
Intergroup Comparison

Groups	At occlusal margins	At gingival margins
Groups 1, Groups 2 and Groups 3	0.465	0.008*
Group 1 and Group 2	0.545	0.320
Group 2 and Group 3	0.205	0.041*
Group 1 and Group 3	0.595	0.007*

*significance was considered when P value ≤ 0.05

Discussion

Microleakage is a key factor in determining the success of any restorative material.This study examined the microleakage of different types of Glass Ionomer Cement in Class V cavities using a dye penetration test. Cervical lesions caused by caries, erosion, or abrasion provide a challenge to the dentist since the restorative material must adhere to various types of tooth tissues . Cervical restorations typically have enamel coronal borders and dentin or cementum cervical margins11. Polyacrylic acid attacks aluminosilicate glass particles in a complex acid-base setting reaction in GIC. The release of calcium and aluminium ions from the glass causes the cement to gel and solidify. Polyacrylic acid creates complexes with calcium ions on the tooth surface when the glass ionomer is applied to enamel or dentin, resulting in a chemical interaction between the substrate and cement.

RMGIC contains components similar to Conventional Glass Ionomer, but it also contains additional polymerizable resin monomers in liquid (HEMA), along with initiators and activators. When the powder and liquid are mixed, the acid-base reaction of the Conventional Glass Ionomer and the polymerization reaction of the resin components occur, resulting in the development of two distinct matrices, namely the metal polyacrylate matrix and the poly HEMA matrix7. Nano-filled RMGIC combines the benefits of a resin-modified light-cure glass ionomer and bonded nanofiller technology. Nano-filled RMGI is a true RMGI material that performs both glass ionomer and free radical reactions like other RMGI, according to infrared (IR) studies.

Microleakage can be detected using a variety of methods. Dyes, chemical tracers, and radioactive tracers, scanning electron microscopy, neutron activation analysis, and fluid filtration are some of the methods used13. The dye leakage method was used in this study because it is a simple, inexpensive, and quick method that does not involve the use of complicated laboratory equipment13.One of the most used ways for identifying microleakage is dye leakage tests14. Methylene blue, India ink, basic fuschin, crystal violet, and fluorescin have all been used in dye penetration studies13.However, Rhodamine-B dye was used in this study because its molecular size is as small as 1 nm, which is smaller than the diameter of a dentinal tubule and thus can penetrate through even the smallest of gaps between the restoration tooth interfaces15. It is an organic dye made from red-violet powder , classified as a xanthene dye and has a higher diffusion rate on human dentin than methylene blue16.

Because of the possible effect of entrapped air on ingress of dye solution , the validity of dye leakage tests has been questioned17.Spanberg et al. and Goldman et al. reported that when using passive dye penetration, entrapped air can inhibit dye penetration into the gap between filling materials and dentinal walls19. Dye penetration under vacuum was used in this study because vacuum pressure reduces the volume of entrapped air and allows full dye penetration18.Thermocycling was done to simulate temperature changes that take place in the oral environment20. The results obtained in this study showed that all three restorative materials had higher microleakage on the gingival margins than on the occlusal margins .No material, however, was able to completely prevent microleakage at the enamel, dentin, or cementum margins. This finding is in agreement with other studies which concluded that cavity preparations with enamel margin produce consistently stronger bonds21.

Unique challenges are encountered with dentin surface bonding due to enamel that is 92% inorganic hydroxyapatite and dentin that is 45% inorganic by volume22. There was no statistically significant difference in microleakage between groups 1 and 2 at both the occlusal and gingival edges in this investigation. This finding is in accordance with previous studies23.However, few studies have shown that the microleakage of these materials differs statistically significantly .This could be due to difference in experimental designs and testing methods used in these studies24. In this study the gingival margins of groups 1 and 2 showed high levels of dye penetration. It reached the full depth of the cavity as well as the axial wall. Earlier study found a similar result, but the dye penetrated to a lower amount27.The vacuum used in this study eliminates trapped air that can inhibit dye penetration, which may be the reason for the differenence in severity of dye penetration in this and previous studies.

Nanofilled RMGIC showed less gingival marginal leakage than CGIC and RMGIC. This may be due to the higher filler loading in nanofilled type which result in lower polymerization shrinkage and lower coefficient of thermal expansion, thus improving the long term bonding to tooth structure. Abd El Halim found that higher magnification of the bond interface of Nano filled RMGIC showed an indistinct interface between the margin of the tooth structure and the restoration, suggesting that a chemical bond had formed between the GIC and tooth28. The high leakage of CGIC and RMGIC may be due to the absence of primers, but Nano filled RMGIC have the advantage of using essentially acidic primers. The function of the primer is to modify the smear layer, properly wet the tooth surface and promote the adhesion of the material to the hard tissue.

Conclusion

Within the limitations of this study, it can be concluded that none of the three GIC were free from microleakage. The degree of microleakage at the gingival margin of each group was higher than at the occlusal margin. There was no statistically significant differences between all restorative materials at the occlusal margins. Nano-filled RMGIC showed less gingival marginal leakage than CGIC and RMGIC. Therefore, Nano-filled RMGIC may be a better choice of restorative material for Class V cavities.

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