Comparative Evaluation of Microleakage in Class V Cavities Restored with Giomer, Resin-Modified Glass Ionomer, Zirconomer and Nano-ionomer: An In vitro Study

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Aims and Objective: Clinically, microleakage is the major cause for the failure of restorations in Class V cavities which may cause postoperative sensitivity and secondary caries. The newer generation of glass ionomers has been introduced in market with superior characteristics compared to conventional glass ionomers. The aim of this study was to evaluate the adaptability of new novel restorative material Nano-ionomer with resin-modified glass ionomer, Zirconomer, Giomer to tooth surface by measuring the degree of microleakage at gingival and occlusal restorative margins of Class V cavities and compare the same among the groups using stereomicroscopic study. Methodology: A total of 60 Class V cavities were prepared with occlusal margin in enamel, and the cervical margin in dentin and cementum of sound extracted premolars. Restorations were randomly assigned to one of the four groups (n = 15) and were restored with various type of glass ionomers (resin-modified glass-ionomer cements [RMGIC], Zirconomer, Giomer, Nano-ionomer), respectively. Specimens were thermocycled, immersed in Methylene blue dye, sectioned longitudinally and analyzed for leakage at the occlusal and cervical interfaces. Analysis of variance test, followed by post hoc Bonferroni Test was used to determine the inter- and intra-group difference and Paired t-test was used to determine the significant difference at enamel and cementum margins. Results: The intergroup comparison of occlusal and gingival scores showed a significant difference between RMGIC and Giomer, Zirconomer and Nano-ionomer and Giomer and Nano-ionomer (P < 0.05). Conclusion: It was concluded that all the restorative materials tested shows microleakage to an extent. Nano-ionomer was better than the other three types of glass ionomers in reducing the microleakage.

Keywords: Cementum, dental restoration, dentin, enamel, giomer, glass ionomers, Nano-ionomers, Zirconomer

INTRODUCTION

The aim of restorative dentistry is to restore the tooth to its function and form. It has been given more importance to the retentive ability of a material and adhesion of dental restorative materials to the cavity walls to seal the cavity against passage of microorganisms and oral fluids.[1] The inability of the restorative materials to attain the complete marginal

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seal leads to the occurrence of micro gaps, in which the seepage of fluids, ions, and bacteria occurs, which causes secondary caries, hypersensitivity and pulpal infections. Microleakage is the major factor responsible for the failure of Class V restorations, as gingival margins of such restorations are generally situated in dentin/cementum and the bonding to dentin is less to be expected than enamel due to its lower mineral content and complex pattern.[2] Nowadays, restorative materials such as glass ionomers, hybrid ionomers, composite resins, and compomers are commonly used for restoration of Class V cavities.[3] The conventional glass-ionomer cements (GIC) were water-based materials which set by an acid and base reaction. Since these were brittle materials, attempts were made to improve the physical properties. Resin Modified GIC (RMGIC) was introduced (1990) to improve the drawbacks of conventional glass ionomers cements.[4] Recently, nano-filled resin-modified glass ionomers were developed that combines the benefits of bonded nanofiller technology and resin-modified light-cured glass ionomers.[5] Giomers are hybrid between resin composites and glass ionomers which uses pre-reacted glass filler technology. Another class of restorative glass ionomer that comprises the durability and strength of amalgam is developed as a recent restorative material called Zirconomer, which is also called as white amalgam. The aim this study is to evaluate and compare the adaptability of new novel restorative material Nano-ionomer with resin-modified glass ionomer, Zirconomer, and Giomer to tooth surface by measuring the degree of microleakage at gingival and occlusal margins of Class V cavities and comparing among this four restorative materials using stereomicroscopic study.

**Methodology**

Sixty noncarious freshly extracted human maxillary premolar teeth extracted for orthodontic purpose were included in this study. All teeth with previous cervical defects were excluded from the study. The procedure for cavity preparation and restoration were standardized for all groups and performed by a single operator to minimize experimental variables. On the buccal surface of each tooth a standardized Class V cavity preparation was done. The dimensions of the preparations measured 4 mm mesiodistally, 4 mm occlusogingivally, and 2 mm depth with the occlusal margin in enamel and the gingival margin in cementum/dentin. The teeth were then randomly divided into four experimental groups, each group containing 15 teeth. Group I was restored with RMGIC (GC gold label light cured universal restorative, Tokyo, Japan), Group II with Zirconomer (Zirconomer improved SHOFU INC, Kyoto, Japan), Group III Giomer (Beautifil II, Shofu, Kyoto, Japan.), and Group IV Nano-ionomer (Ketac N 100, 3M ESPE, St. Paul, MN, USA), respectively. All the restorative groups were restored according to the manufacturer’s instruction. To simulate the oral environment specimens were subjected to a thermocycling regimen of 500 cycles between 4°C and 55°C water baths. Dwell time was 1 min, with a 3 sec transfer time between baths. The specimens were coated with two layers of nail polish, leaving a 1 mm space around the cavity margins to avoid ingress of dye through other microfissures and cracks. Teeth were kept in methylene blue dye (Spectrum Reagents and Chemicals Pvt. Ltd.,) for 24 h. The teeth were then sectioned in a buccolingual direction through the center of the restorations using a low-speed diamond disc.

The specimens were scored according to the criteria and assessed with a stereomicroscope at ×10 magnification to evaluate the depth of dye penetration at the occlusal and gingival margins. The depth of dye penetration was assessed according to the criteria given by Wahab et al.[6]

**Statistics**

The data collected by experiments were computerized and analyzed using Statistical Package for Social Sciences (SPSS) version 23.0 (IBM SPSS, Chicago). The mean and standard deviation of microleakage scores of four study groups was compared using analysis of variance (ANOVA) test followed by post hoc Bonferroni Test and paired t-test to determine the significant difference at enamel and cementum margin. $P < 0.05$ will be considered to be statistically significant.

**Results**

The statistical correlation was done with the mean value scores of all the four tested groups for occlusal and gingival scores using ANOVA, and it was found to be statistically significant ($P < 0.05$) [Tables 1 and 2]. The intergroup comparison of occlusal and gingival scores of all the four study groups was done using Post hoc test that showed a highly significant difference between Groups I (RMGIC) and III (Giomer), Groups II (Zirconomer) and IV (Nano-ionomer), Group III (Giomer) and Group IV (Nano-ionomer) ($P < 0.05$). And, whereas it was insignificant between Group I (RMGIC) and II (Zirconomer) and Group I (RMGIC) and IV (Nano-ionomer) [Table 3 and Figures 1, 2].

The paired test was done to compare the occlusal and gingival microleakage scores of the same group were done. It was shown that there was no significant difference between the microleakage of occlusal and
gingival margins for each group even though the gingival score was more compared to occlusal score for all restorative groups [Table 4 and Figure 3].

Thus, the results obtained from the study showed that the maximum microleakage was present in Giomer followed by Zirconomer, resin-modified glass ionomer, and the least was in Nano-ionomer.

**Table 1: Mean microleakage in the groups at occlusal margin and statistical analysis of variance for microleakage of four study groups**

| Groups  | n  | Mean | SD   |
|---------|----|------|------|
| Group I | 15 | 1.73 | 0.79 |
| Group II | 15 | 2.26 | 0.59 |
| Group III | 15 | 2.46 | 0.63 |
| Group IV | 15 | 1.46 | 0.51 |

| Source of variation | Sum of squares | Degree of freedom | P     |
|---------------------|----------------|-------------------|-------|
| Total               | 32.98          | 59                | 0.000*|

*The mean difference is significant at the P<0.05 level. n: Number; SD: Standard deviation

**Table 2: Mean microleakage in the groups at gingival margin and statistical analysis of variance for microleakage of four study groups**

| Groups  | n  | Mean | SD   |
|---------|----|------|------|
| Group I | 15 | 1.80 | 0.67 |
| Group II | 15 | 2.33 | 0.61 |
| Group III | 15 | 2.60 | 0.50 |
| Group IV | 15 | 1.53 | 0.51 |

| Source of variation | Sum of squares | Degree of freedom | P     |
|---------------------|----------------|-------------------|-------|
| Total               | 29.733         | 59                | 0.000*|

*The mean difference is significant at the P<0.05 level. n: Number; SD: Standard deviation

**Table 3: Comparison of mean microleakage at occlusal margin**

| Groups | Group I | Group II | Group III | Group IV |
|--------|---------|----------|-----------|----------|
| Mean   | 1.73    | 2.26     | 2.46      | 1.46     |
| SD     | 0.79    | 0.59     | 0.63      | 0.51     |
| Group I |         | 0.165    | 0.018*    | 1.000    |
| Group II | 0.165 | 1.000    | 0.008*    | 0.001*   |
| Group III | 0.018* | 1.000    | 0.001*    | 1.000    |
| Group IV | 1.000 | 0.008*   | 0.001*    | -        |

*The mean difference is significant at the P<0.05 level. SD: Standard deviation

**Table 4: Intragroup comparison of microleakage at occlusal and gingival margin**

| Group            | P     | Significance |
|------------------|-------|--------------|
| Resin-modified GIC | 0.707 | Not significant |
| Zirconomer       | 0.349 | Not significant |
| Giomer           | 0.876 | Not significant |
| Nano-ionomer     | 0.483 | Not significant |

GIC: Glass-ionomer cements

**DISCUSSION**

One of the cardinal requirements for the better prognosis of restoration is to prevent the microleakage, which is achieved with the proper adhesion of restorative material to the cavity walls. The inability of the restorative materials to attain the complete marginal seal leads to the occurrence of microgaps in which the seepage of fluids, ions, and bacteria occurs, which causes secondary caries, hypersensitivity, and pulpal infection. These are the most common reasons to replace or repair an adhesive restoration.[7] The microleakage is used as criteria by which researchers and clinicians can predict the performance of a restorative material.[8] The need for restorative material with better adhesive characteristics leads to the more recent advances in the restorative materials.

The morphology of Class V cavities with margins partly in enamel and partly in dentin/cementum presents a challenging condition for the restorative materials. Class V cavities were selected for this study because of its configuration or “C” factor. The “C” factor of Class V restoration is 5, which is the reason for the internal bond disruption as well as microfissures around the restorations and cavity walls,[9] so microleakage is more important in Class V cavities because of this high C factor. At present, restorative materials such as glass ionomers, hybrid ionomers, composite resins, and compomers are recommended to restore Class V cavity restoration.[3]

Nano-ionomers a novel restorative material with the incorporation of nanoparticles led to wider particle size distribution, which resulted in higher mechanical properties. Nanotechnology can, however, improve continuity between the tooth structure and the nano-sized filler particle and provide a more stable and better quality interface between the mineralized hard tissues of the tooth and these restorative materials.[10]
This study was aimed to evaluate the adaptability of new novel restorative material Nano-ionomer with resin-modified glass ionomer, Zirconomer, Giomer to tooth surface by measuring the degree of microleakage at gingival and occlusal restorative margins of Class V cavities and compare the same among the groups using Stereomicroscopic study. Microleakage studies use dyes, radioactive isotopes, air pressure, bacterial activity, neutron activation analysis, scanning electron microscope, dye penetration, and micro-computed tomography all come with both advantages and drawbacks. The dye penetration study of microleakage using colored agents is the most commonly used technique. The dye penetration assay has many advantages over other techniques. First, no reactive chemicals are used along with any radiation. Second, the technique is highly feasible and easily reproducible, notably, the most commonly used solutions are 0.5% basic fuchsin, 2% methylene blue, and 50% silver nitrate. Dye penetration assay was the technique used in this study. Methylene blue was used as the dye in our study, since it can diffuse easily through the interface, easily detectable and it is not absorbed by dentinal matrix hydroxyapatite crystals. As its having a lower molecular weight, it has high penetrability and penetrates the voids better than isotopes. In this study, we were using the stereomicroscope as an aid to evaluate the true extent of dye leakage.

In this study, almost all the tested restorative materials show microleakage to some extent. Gladys et al. suggested that microleakage can be expected with all the restorative materials developed and used till date. According to the results of the present study, we found that the least microleakage occurred around the Nano-Ionomer group and the maximum microleakage was seen in Giomer group.

Results of the present study go in a good agreement with the previous study by Abd El Halim and Zaki who observed that under in vitro conditions Nano-ionomer showed least microleakage when compared to RMGIC. Good sealing ability of Nano-ionomer may be related to high filler loading and lower coefficient of thermal expansion which compensate the polymerization contraction stresses. A study by Gupta et al. also in accordance to our study results, says that Nano-ionomer shows less microleakage compared to conventional glass ionomers and resin-modified glass ionomer. The higher mean value scores of RMGIC and Zirconomer compared to Nano-ionomer may be due to the reason that primer was not used with them, while Nano-ionomer gets the benefits of using primer which helps to wet the tooth surface adequately and modify the smear layer to facilitate adhesion of the material to the hard tissue.

In our study, RMGIC had higher microleakage score than Nano-ionomer although it is also a type resin-modified GIC with nanoparticles may be due to the immediate postrestorative finishing/polishing procedure which was employed in our study according to the manufacturer’s instruction. It has been reported by Yap and Mok that in addition to increasing the surface roughness, immediate finishing/polishing compromise the marginal seal of RMGIC to cavity walls.

The microleakage score of Zirconomer indicated that it has lesser microleakage score than Giomer but more than RMGIC and Nano-ionomer. These findings were according to the results obtained in a study by Patel et al. who found almost similar outcomes when they tested the dye penetration of Zirconomer in human molar teeth. This could be explained due to the fact that the chemical structure of Zirconomer which comprises ceramic particles (zirconia) as fillers. It is possible that the zirconia fillers would cause interference in the chelating reaction between the calcium ions (Ca2+) of hydroxyapatite and carboxylic group (−COOH) of polyacrylic acid, another possible explanation may be the bigger size of the filler particle in Zirconomer prevents proper adaptation of this material to the tooth structure.
The giomer showed maximum microleakage, which was in accordance with the study by Deliperi et al.[18] and Yadav et al.[1] A study by Karim et al.[19] said that the reason for maximum microleakage may be the high filler content, without bonding of the resin with S-PRG filler (surface pre-reacted glass). Reduced marginal adaptation of giomer in the present in vitro study may also be due to polymerization shrinkage resembling its typical resin composite like nature. Some authors suggest that the hygroscopic expansion which is an intrinsic property of this restorative material is the main cause of marginal deterioration of giomer restorations.[20] In-vivo studies conducted by U. M. Abdel-Karim et al.[21] also showed marginal deterioration of giomer restorations over a period of 3 years of clinical evaluation. 

According to the results of this study, the mean microleakage was highest at gingival margin compared to occlusal margins. Phair and Fuller[22] suggested that challenges are encountered with dentin surface bonding due to the reason that inorganic hydroxyapatite volume of dentin is 45%, while that of enamel is 92%. Furthermore, Joseph et al.[23] suggested that this may be due to reason that the cementum has less organic phase and coarser collagen fibers making it a weaker bonding substrate. These differences may be due to a difference in the quality of the bond between the materials and enamel and dentin structures.[24]

Based on the results of the present in vitro dye leakage study, it can be clinically inferred that because of good marginal adaptation of Nano-ionomer when compared to RMGIC, Zirconomer and giomer, better resists staining around the restorations and prevents postoperative sensitivity, secondary caries, and pulpitis in Class V cavities.

**Conclusion**

Within the limitation of this in vitro study, it can be concluded that none of the tested materials were able to eliminate microleakage at occlusal or gingival margins in a Class V cavity preparation. There was a statistical significance difference in microleakage among all the four tested materials. Within the experimental conditions of this in vitro study, the microleakage was lower at the occlusal margins than at the gingival margins for the all four restorative materials tested. Nano-ionomer performed better at both occlusal and gingival margin with least mean microleakage. Resin-modified glass ionomers performed better than Zirconomer and Giomer in both occlusal and gingival margin. Giomer showed the highest mean microleakage at both the margins of the cavity. Since Nano-ionomer performed better at the occlusal and gingival margin compared to other tested material, it can be a good choice of restorative material for Class V cavities.

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**Conflicts of interest**

There are no conflicts of interest.

**References**

1. Yadav G, Rehani U, Rana V. A comparative evaluation of marginal leakage of different restorative materials in deciduous molars: An in vitro study. Int J Clin Pediatr Dent 2012;5:101-7.
2. Öztürk F, Ersöz M, Öztürk SA, Hatunoglu E, Malkoç S. Micro-CT evaluation of microleakage under orthodontic ceramic brackets bonded with different bonding techniques and adhesives. Eur J Orthod 2016;38:163-9.
3. Bolu IP, Hari A, Thumu J, Velagula LD, Bolla N, Varri S, et al. Comparative evaluation of microleakage between nano-ionomer, giomer and resin modified glass ionomer cement in class V cavities- CLSM study. J Clin Diagn Res 2016;10:ZC66-70.
4. Gladys S, Van Meerbeek B, Lambrechts P, Vanherle G. Microleakage of adhesive restorative materials. Am J Dent 2001;14:170-6.
5. Abdulsamee N, Elkhadem AH. Zirconomer and zirconomer improved (white amalgams): Restorative materials for the future. Review. EC Dent Sci 2017;15:134-50.
6. Wahab F, Abu-Tabra IT, Wala MA. An in vitro study of micro leakage of different types of composites with respect to their matrix compositions. Br J Med Med Res 2014;4:1908.
7. Casselli DS, Faria-e-Silva AL, Casselli H, Martins LR. Marginal adaptation of class V composite restorations submitted to thermal and mechanical cycling. J Appl Oral Sci 2013;21:68-73.
8. Patel MU, Punia SK, Bhat S, Singh G, Bhargava R, Goyal P, et al. An in vitro evaluation of microleakage of posterior teeth restored with amalgam, composite and zirconomer – A stereomicroscopic study. J Clin Diagn Res 2015;9:ZC65-7.
9. Pasricha SK. Comparative evaluation of microleakage of tooth coloured restorative materials after exposure to 33% hydrogen peroxide in vitro study. J Contemp Dent Pract 2011;2.
10. Nassar AM, Abdalla AI, Shalaby ME. One year clinical follow up of nano filled glass ionomer and composite resin restorations. Tanta Dent J 2014;11:21-35.
11. Diwanji A, Dhar V, Arora R, Madhusudan A, Rathore AS. Comparative evaluation of microleakage of three restorative glass ionomer cements: An in vitro study. J Nat Sci Biol Med 2014;5:373-7.
12. Yavuz I, Tumen EC, Kaya CA, Dogan MS, Gunaý A, Unal M, et al. The reliability of microleakage studies using dog and bovine primary teeth instead of human primary teeth. Eur J Paediatr Dent 2013;14:42-6.
13. Shetty V, Hegde P, Chauhan RS, Chaurasia VR, Sharma AM, Taranath M, et al. A spectral photometric comparative evaluation of apical sealing ability of three different sealers; calcium hydroxide based, resin based and zinc oxide eugenol based sealers. J Int Oral Health 2015;7:25-7.
14. Abd El Halim S, Zaki D. Comparative evaluation of microleakage among three different glass ionomer types. Oper Dent 2011;36:36-42.
15. Hussein TA, Bakar WZ, Ghani ZA, Mohamad D. The assessment of surface roughness and microleakage of eroded tooth-colored dental restorative materials. J Conserv Dent 2014;17:531-5.
16. Gupta SK, Gupta J, Saraswathi V, Ballal V, Acharya SR. Comparative evaluation of microleakage in class V cavities using various glass ionomer cements: An in vitro study. J Interdiscip Dent 2012;2:164.
17. Yap AU, Mok BY. Surface finish of a new hybrid aesthetic restorative material. Oper Dent 2002;27:161-6.
18. Deliperi S, Bardwell DN, Wegley C, Congiu MD. In vitro evaluation of giomers microleakage after exposure to 33% hydrogen peroxide: Self-etch vs. total-etch adhesives. Oper Dent 2006;31:227-32.
19. Karim UM, Eraky ME, Etman WM. Threeyear clinical evaluation of two nanohybrid giomer restorative composites. Tanta Med J 2014;11:21322.
20. Sumico MC, Shinkai K, Katoh Y. Two-year clinical performance of occlusal and cervical giomer restorations. Oper Dent 2005;30:282-9.
21. Abdel-Karim UM, El-Eraky M, Etman WM. Three-year clinical evaluation of two nano-hybrid giomer restorative composites. Tanta Dent J 2014;11:213-22.
22. Phair CB, Fuller JL. Microleakage of composite resin restorations with cementum margins. J Prostheth Dent 1985;53:361-4.
23. Joseph A, Santhosh L, Hegde J, Panchajanya S, George R. Microleakage evaluation of silorane-based composite and methacrylate-based composite in class II box preparations using two different layering techniques: An in vitro study. Indian J Dent Res 2013;24:148.
24. Sumitha D, Rao A. Nanoionomer: Evaluation of microleakage. J Indian Soc Pedod Prev Dent 2011;29:20-4.