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RESTORATIVE DENTISTRY

MICROLEAKAGE IN CLASS I RESIN COMPOSITE RESTORATIONS LINED WITH GLASS IONOMER AS DENTIN SUBSTITUTE : AN IN-VITRO STUDY

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ABSTRACT

The purpose of this in vitro study was to compare the microleakage of occlusal resin composite and three glass ionomer/ resin composite techniques. Class I occlusal preparations were initiated on forty molar teeth. Teeth were randomly assigned to four groups of ten. Groups were restored as follow: 1) Solo Plus / Point 4 resin composite, 2) Fuji IX/ Fuji Bond LC/ Point 4, 3) Fuji IX/ Experimental Liquid-Liquid glass ionomer bonding material! Point 4, 4) Fuji IX/ Solo Plus / Point 4. After 24 hours storage in distilled water at 37°C, the restoration was subjected to 2500 thermal cycles between 8°C and 48°C with a 30 second dwell time and 10-second transit time. They were placed in a 5% aqueous solution of methylene blue dye for 18 hours. Then, the teeth were sectioned bucco-lingually for microleakage assessment. Results were analyzed using a Kruskal- Wallis One-way ANOVA and Tukey All Pairwise Multiple Comparison procedures. Results showed the glass ionomer/ resin composite treatment groups lined with an experimental liquid-liquid glass ionomer showed significantly less leakage than the resin composite group at p<0.05. There was not a statistical difference between any other groups. It is concluded that using a high strength glass ionomer as a dentin substitute enhances resistance to microleakage when compared to an adhesive resin composite resin.

Key words: *Microleakage, Dentin substitute; Class I/ composite and Glass ionomer.*

INTRODUCTION

Posterior composite is allowing the practitioner to place a conservative initial restoration, one that preserves considerably more tooth structure than an amalgam restoration. Posterior composite generally are indicated for initial carious lesion in low stress bearing areas.

Resin composites have been improved during the past several years, especially with regard to their physical properties. [1,2] Significant advantages, such as esthetic, relatively low thermal conductivity, wear resistance and easy handling has been obtained. [3] However, a major disadvantage of a resin based material is polymerization shrinkage that causes gap formation, especially at dentin margin, which enable bacterial penetration. [4] Enamel is a more reliable substrate than dentin in direct adhesive restorations, because of its homogenous structure and hydrophobic character.[5]

The Atraumatic Restorative Treatment (ART) is a procedure based on removing carious tooth tissues using hand instruments alone and restoring the cavity with an adhesive material. [6] At present, the restorative material used is glass ionomer. The procedure has been developed because millions of people in less-industrialized countries, refugees, and people living in deprived communities are unable to obtain restorative dental care. Their teeth gradually decay until extraction is the only treatment option. The main reason for this situation is absence of electrically driven equipment. In contrast, the ART approach provides restorative treatment where the community cannot afford

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expensive dental equipment. [6] Glass ionomer cement (GIC) is used in ART as it bonds to the tooth and halts or slows the progression of lesions, mainly because it slowly releases fluoride. [6,7] In short clinical trials, high success rates have been observed with ART technique. [6,8] However, there is a concern on the long-term success of ART because of susceptibility to fracture of GIC in high stress areas.[8]

Clinically, it is not unusual to have small occlusal carious lesion in the enamel undermined by large carious dentin. These cavities are mostly restored by direct metal restoration or indirect tooth colored restorations which need more extensive preparation. Based on ART clinical studies and excellent performance of composite resin at enamel, [6,8,9] placing glass ionomer cement in dentin and composite in enamel could be successful and more conservative treatment.

Microleakage is defined as the passage of bacteria, fluids, molecules or ion between the cavity wall and the restorative material. [1o] Microleakage primarily results in postoperative sensitivity, marginal staining, recurrent caries and/or possible loss of the restoration.[9, 11, 12] Assessment of microleakage is usually by dye penetration tests. [13, 14] In the absence of clinical data, in-vitro microleakage studies are an acceptable method to evaluate adhesive restorative materials for adequate marginal adaptation. [15] The purpose of this study was to compare the microleakage of occlusal resin composite and three glass ionomer/ resin composite restorative techniques.

MATERIALS AND METHODS

Recently forty extracted human molar teeth were collected, treated with 10% formalin for two weeks, hand scaled, and stored in deionized water at 4°C. Teeth were randomly assigned to four groups of ten. Class I occlusal preparations were initiated with a No. 557 plain tungsten carbide bur in a high- speed hand-piece equipped with air/ water spray. A minimum buccal-lingual dimension of 2mm and a depth of 2mm were obtained and the entire groove included in the preparation. Following initial preparation, a No. 4 round bur in a slow- speed handpiece was used to remove dentin from underneath the enamel walls of the preparation to the depth of the bur. The preparations were rinsed and lightly air- dried to remove any pooled water.

Group 1:

The preparations were etched with 37.5% phosphoric acid (Kerr Corporation, Orange, CA) for 15 seconds, rinsed for 15 seconds, and lightly air- dried with compressed air to eliminate pooling. Optibond Solo Plus (Kerr Corporation, Orange, CA) was placed for 15 seconds using a light brushing motion, air-thinned for 3 seconds and light cured for 20 seconds. An increment of Point 4 resin composite (Kerr Corporation, Orange, CA) was placed to cover the pulpal floor and the buccal axial wall. Additional increments were used to finish the restoration as needed (Fig 1). Each increment was cured for 40 seconds. The restoration was then finished and polished using Jiffy Polishing & Jiffy HiShine (Ultradent, South Jordan, Utah).

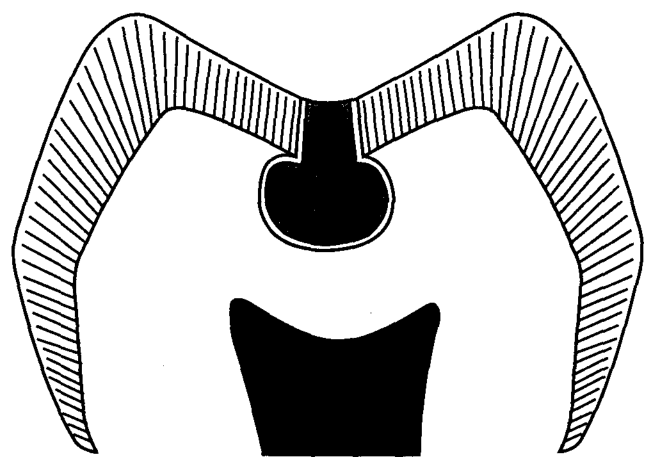


Fig 1: Group 1

Group 2:

The preparations were treated with GC Cavity Conditioner for 10 seconds, rinsed and lightly air-dried. The Fuji IX applicap glass ionomer cement (GC America, Alsip, IL) was activated, mixed for 10 seconds at -4000 rpm and applied to the dentin surface of the preparation. Fuji Bond LC (GC America, Alsip, IL) on a microbrush was used to compact the Fuji IX into the undercut areas and to clear the enamel walls of any restorative material. The Fuji Bond was then light cured for 10 seconds. Two minutes after the Fuji IX is mixed, a layer of Point 4 was placed to restore the occlusal surface (Fig 2). The restoration was then finished and polished using Jiffy Polishing & Jiffy HiShine (Ultradent, South Jordan, Utah).

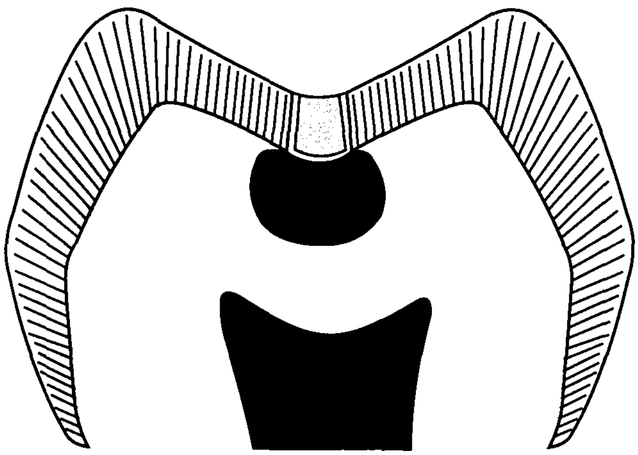
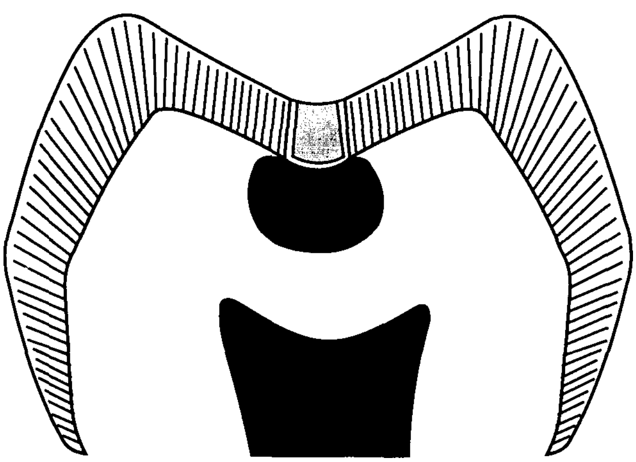


Fig 2: Group 2

Group 3:

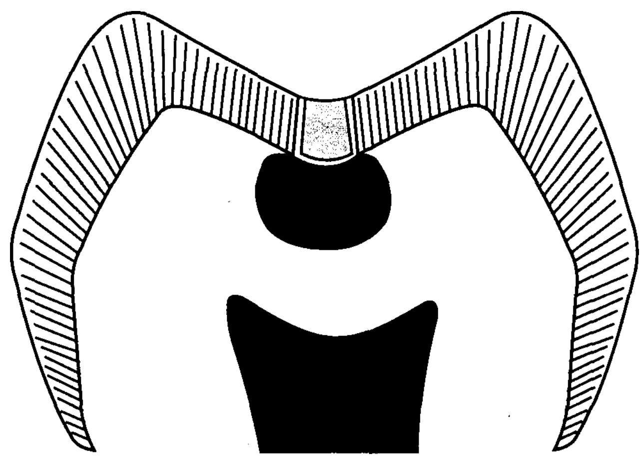
The procedure was the same as for Group 2. The exception was use of an experimental liquid-liquid glass ionomer dentin/ enamel bonding material (GC America, Alsip, IL) on a microbrush to compact the Fuji IX intd the undercut areas and to clear the enamel walls of any restorative material (Fig 3).



- Fig 3: Group 3

Group 4:

The preparation was etched with 37.5% phosphoric acid for 15 seconds, rinsed for 15 seconds, and lightly air- dried with compressed air to eliminate pooling. The Fuji IX applicap was activated, mixed for 10 seconds at -4000 rpm and applied to the dentin surface of the preparation. Optibond Solo Plus on a microbrush was used to compact the Fuji IX into the undercut areas and to clear the enamel walls of any restorative material. Optibond Solo Plus will then be air-thinned for 3 seconds and light cured for 20 seconds. Two minutes after the Fuji IX is mixed, a layer of Point 4 was placed to restore the occlusal surface (Fig 4), The restoration was then finished and polished using Jiffy Polishing & Jiffy HiShine (Ultradent, South Jordan, Utah).



Thermocycling and Microleakage Procedures:

After 24 hours storage in distilled water at 37°C, teeth were subjected to 2500 thermal cycles between 8°C and 48°C with a 30 second dwell time and 10-second transit time. Following the cycling procedure, the apices of the roots were prepared and restored with glass ionomer. The teeth were sealed with a double layer of fingernail polish leaving -1 mm of exposed tooth surface around the margins of the restoration. After that, they were placed in a 5% aqueous solution of methylene blue dye for 18 hours. Then, the teeth were lightly brushed to remove superficial dye.

TABLE 1: MICROLEAKAGE RESULTS. NO DIFFERENCE IN MEANS WITH THE SAME LETTER AT P<0.05

Scores / Groups	1	2	3	4	Mean	Std Dev
Group 1	3	7	1	9	2.80[8]	1.19
Group 2	1	16	1	2	2.20 [ab]	0.69
Group 3	7	10	2	1	1.85 b	0.81
Group 4	7	5	2	6	2.35 [ab]	1.26

Microleakage Examination:

The teeth were sectionesize,co-lingually with a diamond saw to intersect the mesial cusps. The sectioned specimens were polished with suspended alumina to a 1- micron particles size. The microleakage was evaluated with a stereomicroscope at 25X magnification for both the buccal and lingual margin of both halves. The lowest score at each margin was registered. Therefore, twenty data points were collected for each group. The degree of microleakage was determined by the extent of penetration of the methylene blue and scored as follows: 1) equals no penetration into the marginal interface, 2) equals dye penetration just into the enamel margin, but not more than 1/4 of the distance to the pulpal floor of the preparation, 3) equals dye penetration greater than 1/4 of the distance to but short of the pulpal floor, and 4) equals dye penetration to the pulpal floor of the preparation. The data failed to normality test. Therefore, a Kruskal-Wallis One-way ANOVA and Tukey All Pairwise Multiple Comparison procedures were used to analyze the results.

RESULTS

The microleakage results are posted in Table 1. The glass ionomer/ P<0.05omposite treatment group lined with an experimental liquid-liquid glass ionomer showed significantly less leakage than the resin composite group at p<60.05. There was no statistical difference between any other groups.

DISCUSSION

Laboratory microleakage studies are a popular method of screening restorative materials for the integrity of their interface with regard to determining how their adhesion to tooth structure affects their adaptation. It was shown that the Optibond Solo Plus and Point4 composite resin performed well in microleakage study. (16) Therefore, it was selected to serve as a control in this study. There is no system prevent microleakage completely. In this study, the glass ionomer placed in dentin performed better than the resin composite. This is in agreement with different studies were glass ionomer provide better seal than resin composite. (17, 18, 19, 20) In addition to its superior marginal seal, the experimental liquid- liquid is quit easy to mix and to place.

To reproduce the physical characteristics of enamel and dentin, two different restorative materials are needed: one must be hard and rigid like enamel and the other resilient like dentin. The material used to replace lost dentin also can serve as a lining.

Glass ionomer cements have been recommended as a dentin substitute with composite completing the restoration as an enamel replacement. (21, 22) This is because of their favorable flow characteristics, and having the desirable properties of releasing of fluoride ions, biocompatibility, ability to chemically bond to tooth structure, and exhibiting minimal expansion, similar to that of tooth structures. (7, 23) Ngo & others (24) reported that composite resin did not show the ability to facilitate a mineral deposition within the tooth structure, yet glass ionomer show this ability. Fuji IX revealed an intimate adaptation between the glass ionomer and enamel and dentin without gap formation.(25)

Application of an intermediate layer of glass ionomer cement between the dentin and the restoration has been shown to relieve polymerization contraction stress by 20 to 50 percent.(26, 27) This might be due to an effective decrease in the decrease in the C-factor of overlying composite and/or due to forming an absorption layer that might absorb dentinal fluid and swelled. Different resin modified glass ionomer materials found to form a layer between the cement and the. [28,29] These materials marketed as a stress-relieving bonding system for composites, in which the interfacial stresses from a shrinking, polymerizing composite restoration are dissipated by glass ionomer cement that sets or polymerizes at a slower rate. The mechanism to counteract the polymerization shrinkage of composite is one of swelling and movement within immature cement as taken up fluid from the dentin [18,30]

The major weakness of glass ionomer restorative cement, manufactured for the ART technique, was occlusal wear and marginal breakdown. [31,32,33,34] Under controlled clinical conditions, posterior resin composite restorations have the potential to present a high success rate at 4 years. [35,36]

As this study represents the benefit of using a glass ionomer as a dentin substitute, glass ionomer cement veneered with composite resin in enamel could provide more reservation for unsupported enamel with favorable clinical results. Therefore, the ART concept need not be confined to less industrialized countries. Because it is based on the concept of minimal intervention and minimal cavity preparation, there is potential for its application in restorative treatment in children, the physically or mentally handicapped, persons living in shelters, those receiving home care services. Also, this technique is applicable to conserve enamel when it is undermined by large carious dentin.

CONCLUSION

This study represents the benefit of using a high strength glass ionomer as a dentin substitute. Glass ionomer cement veneered with composite resin in enamel could provide more reservation for unsupported enamel with favorable microleakage results.

REFERENCES

1 Lee BB & White GE, Chamfered margin effect on occlusal microleakage of primary molar Class I composite resin restorations *in vitro, Journal of Clinical Pediatric Dentistry,* 1998, Vol, 22, No,, 2; 113-116.

2 Nash RW, Lowe RA & Leinfelder K, Using packable composites for direct posterior placement, *Journal of the American Dental Association,* 2001. Vol, 132, No,, 8; 1099-1104,

3 Manhart J, Kunzelmann KH, Chan HY & Hickel R, Mechanical properties and wear behavior of light cured packable composite resin, *Dental Materials,* 2000, Vol, 16, No., 1; 33-40,

4 Haller B & Trojanski A, Effect of multi-step dentin bonding systems and resin modified glass ionomer cement liner on marginal quality of dentin bonded resin composite Class II restorations, *Clinical Oral Investigation,* 1998, Vol, 2, No,, 3; 130-136,

5 Schwartz RS, Fundamental of Operative Dentistry: A Contemporary Approach, Quintessence Publishing, Chicago, Chapter 6; 141-170,

6 Frencken J, Phantomvanit P, Pilot T, SongpaisanY, Amerongen E, Manual for the Atraumatic restorative treatment approach to approach to control dental caries: 1997; 3rd edition Groningen: WHO,

7 Hatibovic-Kofman 5, Koch G, Ekstrand J, Glass ionomer materials as a rechargeable fluoride-release system, *International Journal of Paediatric Dentistry,* 1997, Vol, 7, No., (2); 65-73.

8 Frencken J, Songpaisan Y, Pilot T, An Atraumatic restorative treatment (ART) technique: evaluation after one year, *International Dental Journal ,* 1994, Vol, 44; 460-464,

9 Roulet JF& Degrange M, Adhesion: The Silent Revolution in Dentistry, Quintessence Pub, Chicago, 2000,

10 Kidd EA, Microleakage: A review, *Journal of Dentistry,* 1976, Vol, 4, No, 5; 199- 206,

11 Aboushala A, Kugel G & Hurley E, Class II composite resin restorations using glass ionomer liners: Microleakage studies, *Journal of Clinical Pediatric Dentistry,* 1996, Vol, 21, No, 1; 67-70,

12 Al-Ehaideb AA & Mohammed H, Microleakage of one bottle Dentin Adhesives, *Operative Dentistry,* 2001, Vol, 26, No, 1; 172- 175.

13 Derhami K, Coli P & Brannstrom M, Microleakage in Class II composite resin restorations, *Operative Dentistry,* 1995, Vol, 20, No, 3; 100- 105,

14 Dejou J, Sinderes V & Camps J, Influence of criteria on the results of *in vitro* evaluation of microleakage, *Dental Materials,1996,* Vol, 12, No, 6; 342- 349,

15, Brackett WW, Gunnin TD, Johanson WW & Conkin JE, Microleakage of light cured glass ionomer restorative materials, *Quentessence International,* 1995. Vol, 26, No, 8; 583585,

16 Duke E, Platt J, Rhodes B, Investigation of an adhesive system used with direct and indirect application, *Compendium,* 2000, Vol 21, No, 12; 1043- 1053,

17 Toledano M, Oserio E, Osoerio R, Garcia-Godoy F, Microleakage of glass ionomer and compomer restorations, *Journal Prosthetic Dentistry,* 1999. Vol 81, No, 5; 610- 615,

18 Crim GA, Marginal leakage of visible light cured glass ionomer restorative materials, *Journal of Prosthetic Dentistry,* 1993, Vol, 69; 561- 563,

19 Yip HK, Tay FR, Ngo HC, Smales RJ, Pashley DH, Bonding of contemporary glass ionomer cements to dentin *Dental Materials,* 2001, Vol, 17, No, 5; 456- 457.

20 Wibowo G, Stockton L, Microleakage of class II composite restorations, *American Journal of Dentistry,* 2001. Vol, 14, No, 3; 177- 185,

21 Gladys S, Van Meerbeek B, Lambrechts P, Vanherle G, Microleakage of adhesive restorative materials, *American Journal of Dentistry,* 2001. Vol, 14, No, 3; 170- 176,

22 Trushkowsky RD, Gwinnett AJ, Microleakage of class V composite, resin-modified glass ionomers, *American Journal of Dentistry,* 1996. Vol, 9, No, 3; 96-99,

23 Mount GJ, Clinical placement of modern glass ionomer cements, *Quintessence International,* 1993. Vol, 24; 99-107,

24 Mitra SB, Conway WT, Coefficient of thermal expansion of some methacrylate-modified glass ionomer, *Journal of Dental Research,* 1994, Vol, 73: 219 (abstract No, 944),

25 Ngo HC, Fraser M, Mount G, Mcintyre J, Tuisuva J, Doussa R, Remineralization of carious dentin by glass ionomer, an in-vivo study, *Journal of Dental Research,* 2001. Vol, 80 (IADR Abstract No, 919).

26 Hosoya Y, Garcia-Godoy F, Bonding mechanism of KetacMolar Aplicap and Fuji IX GP to enamel and dentin, *American Journal of Dentistry,* 1998, Vol, 11, No, 5; 235- 239.

27 Kemp-Scholte CM, Davidson CL, Marginal integrity related to bond strength and strain capacity of composite resin restorative system, *Journal of Prosthetic Dentistry,* 1990. Vol, 64; 658- 664,

28 Sidhu SK, Watson TF, Fluid permeability and other interfacial characteristics of light cured glass ionomer restoration, *Journal of Dental Research,* 1994. Vol, 73: 183 (Abstract No, 651),

29 Sidhu SK, Watson TF, Interfacial characteristics of resin modified glass ionomer cements, *Journal of Dental Research,* 1998, Vol, 77:1749- 1759,

30 Swift EJ, Pawlus MA, Vargas, Shear bond strength of resin modified glass ionomer restorative materials, *Operative Dentistry,* 1995, Vol, 20: 138- 143,

31 Yee R, An ART field study in western Nepal *International Dental Journal,* 2001, Vol, 51, No,, 2; 103- 108,

32 Ho TF, Smales RJ, Fang DT, A 2-year clinical study of two glass ionomer cements used in the atraumatic restorative (ART) technique, *Community Dentistry and Oral Epidemiology,* 1999, Vol, 27, No,, 3; 195-201,

33 Frencken JE, Makoni F, Sithole WD, Hackenitz E, Three-year survival of one-surface ART restorations and glass ionomer sealants in a school oral health program in Zimbabwe, *Caries Research,* 1998. Vol, 32; 119- 126.

34 Smith A, Chimimba P, Kalf-Scholtes S, Bouma J, Clinical pilot study on new dental filling materials and preparation procedures in developing countries, *Community Dentistry and Oral Epidemiology,* 1990, Vol, 18; 309- 312

35 Mandari G, Truin G, Forsten L, Vant Hof M, The clinical performance of class I amalgam and GIC restoration placed in posterior permanent teeth in Tanzania *Journal of Dental Research* 1997. Vol, 76:972 (abstract# 2938).

36 Baratieri L, Ritter A, Four-year clinical evaluation of posterior resin based composite restorations placed using the total-etch technique, *J Esthetic and Restorative Dentistry,* 2001, Vol, 13, No,, 1; 50- 57