Inhibition of artificial secondary caries by fluoride – releasing restorative materials

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ABSTRACT

Background: Fluoride releasing restorative materials was developed to reduce the possibility of secondary caries. This study aims to examine the effects of fluoride-releasing restorative materials on the inhibition of artificial caries-around restorations.

Materials and Methods: The materials used in this study are conventional Glass-ionomer cement (Kavitan plus), Modified resin glass ionomer cement (photac-fill quick), compomer (Dyract), fluoride-releasing resin composite (crystal Essence) and Spectrum composite without fluoride (Dentsply). Forty extracted human mandibular and maxillary premolars were used and standardized CL V cavities were prepared in buccal and lingual aspects of each tooth, the lingual cavities were restored with each of the fluoride-releasing materials while the buccal cavities were restored with Spectrum Dentsply composite act as a control according to the manufacturer's instructions. The restored teeth were incubated in the acidified gelatin gel at 4.0pH, and the artificial secondary lesion created around the restoration was observed by using poloraide light microscope.

Results: Glass ionomer cement created a thick-radio-opaque zone in the artificial lesion along the restorations-dentin interface, while the fluoride-releasing composite created a thin radio-opaque zone due to the formation of acid-resistance zone by bonding infiltration.

Conclusion: Fluoride-releasing restorative materials including conventional Glass-ionomer cement (GIC), Modified resin glass ionomer cement (RMGIC), compomer, and fluoride-releasing resin composite have the potential to inhibit secondary caries formation around restorations and the conventional GIC have a stronger effect than other material.

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INTRODUCTION

The etiological factors of primary and secondary caries are assumed to be the same, but a bad connection between the restoration and the tooth surface may accelerate the caries attack. Marginal defects of different kinds are common for most dental filling materials (1).Secondary caries formation represents the primary reason for replacement of amalgam and composite resin restorations (2,3). A recent clinical study found that secondary caries was responsible for 72% and 43% of the total number of replacements necessary for amalgam and composite restorations respectively (2).Therefore, the ability of the restorative material to resist secondary caries attack and microleakage at it's margin will, to a great extent, determine whether the restoration will succeed or fail (4).

To diminish the microleakage around restorations, great efforts have been made including developing adhesive system (5,6).

These efforts have improved the adhesion of composite restoration to the tooth substances, particularly to dentin. However, it has been reported that the adhesion to cervical sclerotic dentin was weaker than adhesion to normal dentin even when using some effective adhesive systems (7). Therefore, dental clinicians are still confronted with difficulty in obtaining the perfect seal at the cervical margins. Such considerations highlight the importance of adding an inhibitory effect against secondary caries to the restorative materials (7).

Silicate cement is the oldest material to be identified as caries preventive, a property presumably conferred by the material's fluoride content (8-11). In the past, dentists who used silicate cement in their practices seldom found dental caries around silicate cement restorations (9-14) .The caries prevention mechanism of silicate cements has led to numerous investigations designed to capture this

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anticariogenic characteristics by the addition of fluoride compounds to resin, amalgam, zinc phosphate cement zinc-oxide eugenol, pit and fissure sealants, cavity varnishes, bonding gent and even chewing gums [8,11,14,15,]. It is generally accepted that the conventional GIC has been recommended for higher caries risk patients and it has the ability to inhibit secondary caries formation around the existing restorative material due to it's fluoride releasing ability [7].In spite of the excellent biocompatibility of GIC and its adhesive bond to enamel and dentin, its low mechanical properties and poor wear resistance prevent it's use in large stress bearing restorations ([16].

New fluoride releasing restorative materials have been developed to overcome the limitations of conventional GIC, such as short working time, long-setting time and water sensitivity. Resin modifications GICs introduce to improve mechanical properties while they retain the esthetic, adhesive and fluoride releasing properties of conventional GIC [16,17]. Modifications of the conventional and resin modified GICs have led to the development of fluoride releasing light-cured composite and compomer filling materials [18]. The amount of fluoride released from these materials varied within these different materials [16,17]. The fluoride releasing from these restorative materials have been extensively researched for many years [19].

Fluoride uptake has been shown to occur in enamel and dentin adjacent to fluoride, secondary caries inhibition and even remineralization of adjacent demineralized enamel have been reported (in vitro study) [20,21].The purpose of this study is therefore, to estimate the inhibitory effect of these restorative materials on artificial secondary caries extension.

MATERIALS AND METHODS

Forty newly extracted sound human maxillary and mandibular first premolars were used in this study. The age of the patients, from whom the teeth were collected, were 18-25 years .These teeth were free of restorations and caries. The teeth were then debrided of soft tissue remnants and cleaned with a fluoride – free prophylaxis paste using a soft bristle toothbrush. Each tooth was examined under magnifying eye lens (X2) to detect any persisting defects (crack), and any tooth with any defect was excluded , the teeth were then stored in deionized water throughout the study. Standardized ClV cavity preparations were performed on the buccal and lingual surfaces of each tooth, which is 1mm above the CEJ. The dimension of the Cl V cavity was 2.0mm in width occluso-gingivaly, 1.5mm in depth. The occlusal and gingival margins were located in enamel [5].

Standardized Cl V cavities were prepared (cubic in shape), by using a carbide fissure bur No.56 mounted on high speed a turbine hand piece with continuous water coolant then the cavity was finished by using a stainless steel fissure bur No. 53 mounted on low speed hand piece with a mark on it's shank which is about 1.5m. The carbide and stainless steel burs were changed after each 5 cavities preparation to ensure that all cavities were prepared with sharp instrument [22].

The teeth were then randomly divided into 4 groups (each group contain10 teeth) as following:

Group 1: The cavities were restored with kavitan plus GIC.

Group 2: The cavities were restored with photac-fillquick MRGIOC.

Group 3: The cavities were restored with Dyract compomer.

Group 4: The cavities were restored with Crystal Essence fluoride releasing resin composite. {The restorative materials used in this study are listed in table 1}.

All the buccal cavities of the forty teeth samples were restored with spectrum resin composites using Prime and bound NT adhesive system as control (Group 5) while the lingual cavities were restored with each of the fluoride-releasing restorative materials tested (the manufactures instruction were followed during this procedure). The restorations were polished after 24 hours, storage in water at 37C°

Table 1: The materials used in this study.

Composite with out fluoride	**Spectrum**
Composite with fluoride	**Crystal essence**
GIC	**Kavitan plus**
RMGIC	**Photac fill quike**
Compomer	**Dyract**

The restored teeth were then coated with nail varnish leaving only the restoration and a 1.0m peripheral exposed. The teeth were then embedded for 12 weeks in a polyethylene container (10ml/volume) containing 5ml of

20% acidified gelatin gel, which was made by dissolving 20 gram of gelatin gel powder media in 100ml of deionized water then adjusted by lactic acid in to 4.0 pH, to act as a media for carious lesion induction [23,24].During the preparation of the media a heating plate was used to prevent solidification of the media and gelatin formation.

After 12 weeks, the teeth were removed from this media cleaned and poured into a blocks of 3.0 cm × 3.0 cm of autopolymerizable clear cold cure acrylic resin for easily handling during sectioning procedure. 180 µm thick, longitudinal sections were done through the autopolymerizable clear cold cure acrylic blocks at the tooth-restoration interface by the use of a cutting machine with a diamond slitting wheel (Figure 1). Slides were made from these sections then they were embedded in water to be examined under polarized light microscope in two powers, 6.3 and 2.5 for perfect evaluation [5,24-27] (Figure 2).

The evaluation of the carious lesion in vitro was done by the use of a polarized light microscope. As index of the degree of artificial secondary caries lesion, two lengths were measured on polarized microscope. One is the depth of the artificial secondary caries at outer lesion (LD) was measured at a distance of 100 µm from the restoration margin. The other index is a thickness of the radio – opaque zone (TZ) formed between the restorative materials and outer lesion which was measured at a depth of 250 µm beneath the restoration surface [5,25-27]. (Figure 3).

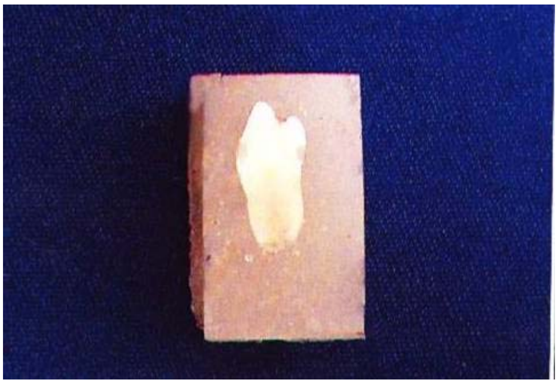

Figure 1: Specimen after sectioning. procedure.

Figure 2: Polaroid microscope with digital camera that used in this study.

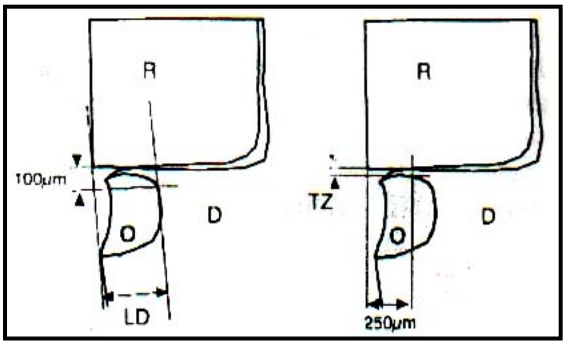

Figure 3: Schematic representation of the artificial carious lesion. R: restoration. O:outer lesion D: dentin LD: lesion depth TZ: thickness of

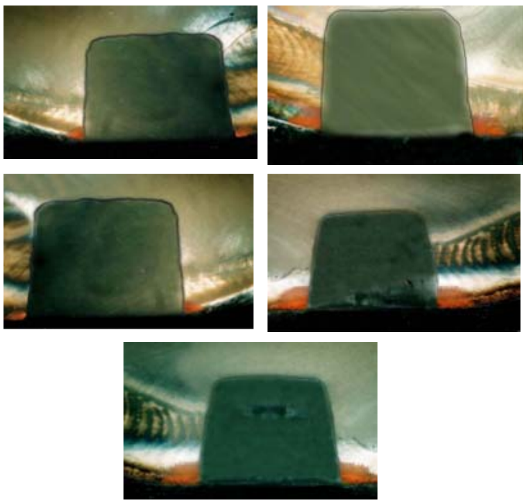

Figure 4: Polaroid photographs of GIC, RMGIC, compomer, crystal essence composite and spectrum composite respectively.
R: restoration, D: Dentin, E: Enamel, O: outer lesion, T: thickness of the radiopaque zone

RESULTS

In all specimens there were outer lesions on the exposed tooth surface but no wall lesion, formed as a result of leakage between the restoration and the cavity wall, was observed (Figure 4).

Figures 4 shows typical photographs of the lesion around the margins of the cavities restored with, conventional GIC, MRGIC, compomer, fluoride releasing composite (crystal essence composite) and spectrum composite respectively. Moreover, radiopaque zones were observed in the lesion adjacent to the restoration. The radiopaque zones appeared most markedly in the specimens' restored with conventional and resin modified GIC). Zones adjacent to compomer were observed with intermediate clearness. The fluoride-releasing resin composites created weak and thin radiopaque zones. Even in the specimens' restored with a control resin-composite which released no fluoride, a radio-opaque zone was observed even though it, was extremely thin and weak.

Table 2 shows the depths of the outer lesions at the cavity gingival margins and the thickness of the radio-opaque zones in each group. The outer lesions observed in the gingival margins restored with conventional GIC, resin modified GIC and compomer were significantly shallower than those for fluoride-releasing resin composite. The conventional and RMGIC created relatively thick radio-opaque zones along the restoration-dentin interface (figure 5).

Two way ANOVA test of depth of the lesion and the thickness of the radio-opaque zone of each material at F=225.6301 and P=0.0001, P<0.001 showed a high significant difference between all groups (table 3). When t-test applied a high significant difference was found between all of the groups. Application of Two way ANOVA test of depth of the outer lesion and the thickness of the radio-opaque zone of all restorative materials reveals a high significant difference between all of the groups. T-test between the depth of the outer lesion and the thickness of the radio opaque zone between different materials used. This test shows a high significant difference, except for compomer and crystal Essence composite, between them in the depth of the outer lesion but not significant in the thickness of the radio-opaque zone.

DISCUSSION

This study investigated the inhibitory effect of the fluoride-releasing restorative materials on artificial secondary caries around restorations. Most of the investigations focusing on the caries-inhibiting effect of restorative materials have been performed in chemical-caries inducing test systems such as using acidified gelatin gel (20% gelatin) with pH adjusted at 4.0 by the addition of lactic acid. and kept the teeth samples in it for 10-12 weeks, after that we can notice artificial caries formation around the existing restorations [24, 25, 27].

In all specimens restored with fluoride-releasing restorative materials, there were outer lesions on the exposed root surface but no wall lesion was observed along the restoration-dentin interface. Moreover, radio-opaque layers in the lesion were recognized adjacent to the restoration. In some previous studies, the lesion area was evaluated to determine the rivals [23, 27, 28]. However, any shrinkage of the lesion would lead to inaccurate evaluation. For the evaluation of material effect, therefore, this study measured the depth of the outer lesion in the root surface at a distance of 100µm from the restoration margin and the thickness of the radio-opaque zone at a depth of 250µm beneath the restoration surface. It was considered that this method was more accurate than evaluating the lesion area.

The lesions in the specimens restored with GIC and RMGIC were relatively shallow. However compomer and fluoride-releasing resin composite showed no inhibitory effect on lesion depth compared with the control resin composite without fluoride release. As the restored teeth were immersed and incubated in a gelatin media with 4.0 pH as caries inducing system, fluoride released from the restoration might diffuse rapidly into the media and the concentration of fluoride might have a low-level even at the root surface adjacent to the restoration. Therefore, some fluoride-releasing materials with low amounts of fluoride release could not inhibit the development of outer lesions. It should be noted that the fluoride released from the restorative materials could be diluted in the oral cavity due to a flow of saliva, whereas there is no flow in this experimental system. Therefore, the anticaries activity against the outer lesion may be limited even when the materials with high amounts of fluoride release are clinically used for the restoration.

Table 2: Distribution of depth of outer lesion and thickness of radio-opaque zone adjacent to various restorative materials.

Materials	Lesion depth µm		Thickness µm	
	Mean	SD	Mean	SD
Group 1	314.60	4.168	26.230	0.6325
Group 2	343.180	2.094	21.120	0.8677
Group 3	353.090	2.893	10.450	0.4790
Group 4	408.800	3.966	10.520	1.3742
Group 5	416.200	1.549	1.8660	0.6049

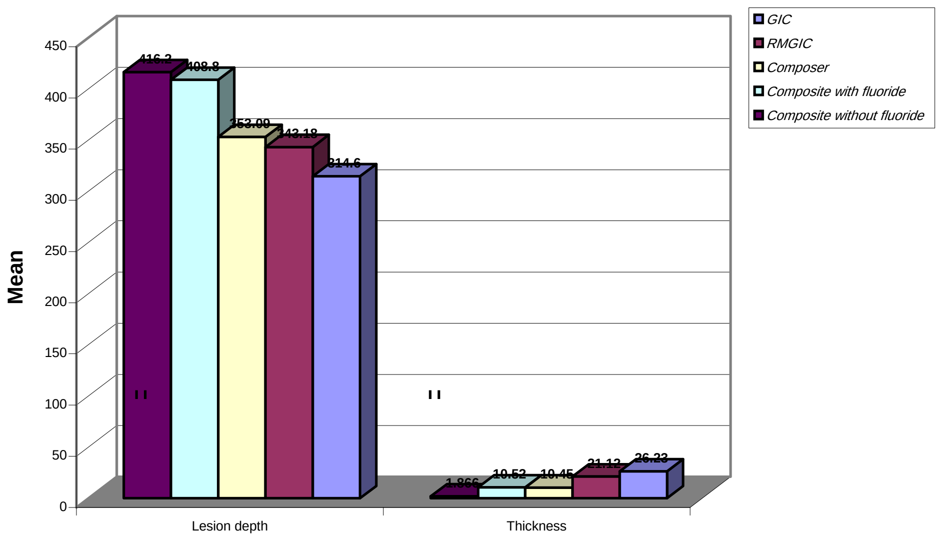

Figure 5: Histograph showing the mean of the depth of the outer lesion and the thickness ofthe radiopaque zone.

Table 3: ANOVA two way of Depth of Outer Lesion & Thickness of the Radio-opaque zone.

Source of Variation	Sum of Sq.	df	Mean square	F-tes	P-value
Between Measures	311763.99	1	311763.99	225.63	0.0001 HS
Residual	5526.8472	4	1381.7118		
Total	317290.84	5	313145.71		

****P<0.0001 High significant**

On the other hand, a radio- opaque layer was clearly recognized adjacent to the restoration in the artificial secondary carious lesions. This is probably identical to the zone that Tsaoidis & Koulourides in 1992 [29] referred to as an acid-resistance zone in their paper. Hicks and others in 1986[30] reported the same finding in conventional glass-ionomer cement restoration subjected to a chemical caries-inducing test.

The findings of this study also agreed with those reported by Nagamine & others in

1997[31], where resin-modified glass-ionomer cements created a radio-opaque zone in artificial secondary caries lesions. It was considered that, the resistance of dentin wall against acid-attack created the zone during the artificial caries inducing process. It was interesting to note that the control resin composite without fluoride release also presented no wall lesion with a thin and weak radio- opaque zone. This is probably associated with the adhesion of the restoration-to-cavity wall promoted by the adhesive system used in this study. The formation of a hybrid layer by the infiltration of bonding resin into the dentin is an essential mechanism for dentin adhesion [32]. The hybrid layer might present acid-resistance, although is effect was extremely weak.

REFERENCES

1. Derand B, Johansoon. Experimental secondary caries around Restorations in Roots. Caries Res 1984; 8: 548-54.
2. Mjor IA. Frequency of secondary caries at various anatomical locations Oper Dent 1985; 10: 88-92.
3. Mjor I.A, Leinfelder KJ. Oper. Dent. P:93-123. in I.A. Mjor (ed.). Dental Materials: Biological properties and clinical evaluations. Boca, Fluoride: CRC press. Inc., 1985.
4. Hicks J. Secondary caries formation in vitro around Glass ionomer restorations. Quin Int 1986; 17: 527-31.
5. Buonocore MG. A simple Method of increasing the adhesion of acrylic filling materials to enamel surface. J Dent Res 1955; 34: 849-53, cited by Eriksen and others. In vitro caries related to marginal leakage around composite resin restorations. J of Oral Rehab 1978; 5:15-20.
6. Forsten I, Rytomaa A. Fluoride uptake from restorative dental materials by human enamel. Scand J Dent Res 1976; 84: 391-5.
7. Torii T, Itato M, Okamoto. Inhibition of Artificial secondry caries in root by fluoride-releasing restorative materials. Oper Dent 2001; 26: 36-43.
8. Anusvice KJ(ed.). Philips Science of Dental Materials. 1996; 10th Ed. W.B. Saunders company.
9. Mjor IA. Placement and replacement of restorations. Oper Dent 1981; 6: 49-54.
10. Hakon N, Harald M. Permeability and fluoride release of lining materials containing amine fluorides. Scand J Dent Res 1976; 89: 386-90.
11. Forsten I, Rytomaa A. Fluoride uptake from restorative dental materials by human enamel. Scand J Dent Res 1976; 84: 391-5.
12. Gordon J, Christensen D. Need for caries-preventive restorative materials. JADA 2000; 131: 1347-9.
13. Kitty M, Stephen. Clinical evaluation of compomer in primary teeth:1-year Results. JADA 1997; 128: 1088-96.
14. Heintze, Mornstad. Artificial caries-like lesion around conventional, fluoride containing and dispersed amalgams. Caries Res 1980; 14: 414-21.
15. 0nhicks and others. Secondary caries formation in vitro around glass ionomer cement. Quint Int 1986; 17(9); 527-32.
16. Iazzetti JC, Burgess D. Selected Mechanical properties of fluoride-releasing restorative materials. Oper Dent 2001; 26:21-6.
17. Carig R. Restorative Dental Materials. Mosby 10th Ed. 1997 chapter 10 p:244.
18. Sturdevant CM, Roberson TM, Haymgun O, Sturdevant JR(ed.). The Art and science of operative Dentistry.1995.3rd Ed. Mosby-year bock. Inc. chapter 3 and 6.
19. Ferracane et al, John C. Fluoride penetration into the hybride layer from a dentin adhesive. American J of Dent 1998; 11(1): 23-8.
20. Kevin J, Donly D. Evaluating the effects of fluoride-releasing Dental materials on adjacent inter proximal caries. JADA 1999; 130: 817-25.
21. Triolo PT, Wefel JS, Jensen ME. Fluoride releasing core build-up materials and artificial caries. Am J Dent 1991; 4: 207-10, cited by Kevin J, Donly D. JADA 1999. Evaluating the effects of fluoride-releasing Dental materials on adjacent inter proximal caries.
22. Munro TJ, Hilton. Etched and rebounded class V composite Resin restorations. Oper Dent 1996; 212: 203-8.
23. Hicks J, Catherine M. Secondary caries formation in vitro around glass-ionomer restoration Quin Int 1986; 17(9): 527-32.
24. Kidd M, Joyston S, Bechal. Histopathological appearance of caries- like lesions of enamel created artificially in vitro in acidified gels containing fluoride. Caries Res 1980; 14: 40-4.
25. Aboush YEY, Torabzadeh H. Fluoride release from tooth- colored restorative Materials: A12-Month. Report.
26. Vin J, Donlly. Evaluating the effect of fluoride-releasing dental materials on adjacent inter proximal caries. JADA 1999; 30: 817-25.
27. Brackett WD. Two year clinical performance of a polyacid-Modified Resin composite and a resin-modified glass-ionomer restorative Materials. Oper Dent 2001; 26: 12-6.
28. Hus & others. Effect of a fluoride-containing restorative materials on recurrent caries. J Dent Res 1998;77(2): 418-25.
29. Tsaoidis V, Koulourides T. An in vitro model for assessment of fluoride uptake from glass-ionomer cements by dentin and its effect on acid resistance. J Dent Res 1992; 71(1): 7-12.
30.. Hicks and others. Secondary caries formation in vitro a round glass-ionomer cement. Quin Int 1986; 17(9): 527-32.
31. Nagamine M and others. Effect of resin modified glass-ionomer cements on secondary caries Amer J of Dent 1997; 10(4): 173-9.
32. Pashley DH and others. Dentin permeability and dentin adhesion. J Dent 1997; 25(5): 355-72.