EFFECT OF RESIN MODIFIED GLASS IONOMER CEMENT ON MICROHARDNESS OF INITIAL CARIES LESIONS

Woranun Prapansilp[1], Kadkao Vongsavan[1], Praphasri Rirattanapong[1] and Rudee Surarit[2]

[1]Department of Pediatric Dentistry, [2]Department of Oral Biology, Faculty of Dentistry, Mahidol University, Bangkok, Thailand

Abstract. Resin modified glass ionomer cement (GIC) can inhibit caries lesion formation directly adjacent to the application site but there are few studies examining the remineralization effects of resin modified GIC at other sites more remote from the application site. We conducted an *in vitro* study to evaluate the distance at which resin modified GIC is able to exert a remineralization effect on initial caries lesions from the application site. We immersed 60 bovine incisors for 24 hours in lactic acid to create artificial initial caries lesions. These teeth were then randomly divided into 2 groups of 30 teeth per group: Group 1 received no treatment (control group); in Group 2 resin-modified GIC was applied on the labial surface of the tooth. The teeth were then tested for microhardness at distances of 0.5, 1, 2 and 3 mm from where the resin modified GIC was applied. Microhardness was tested in all teeth at baseline, after initial caries lesion formation and after treatment. The mean microhardness at each site at each testing was compared using the one-way analysis of variance (ANOVA) and Tukey comparison tests. Significance was set at $p<0.05$. After treatment, there was no significant change in microhardness value at any site tested in the control group ($p=0.994$). However, in the resin modified GIC group after treatment, all sites tester increased significantly in microhardness ($p<0.05$) and were significantly greater in microhardness than the control group ($p<0.05$). In the resin modified GIC group, the mean microhardness values at 0.5 and 1 mm from the resin modified application site higher than at 2 and 3 mm ($p<0.05$). The mean microhardness values were not significantly different in the treatment group between 0.5 mm and 1 mm and between 2 mm and 3 mm from the application site ($p>0.05$). In this *in vitro* study, resin-modified GIC provided a remineralization effect on initial caries lesions up to 3 mm from the application site but had its greatest benefit within 1 mm from the application site.

Keywords: resin modified glass ionomer cement, microhardness, remneralization, remote site

Correspondence: Praphasri Rirattanapong, Department of Pediatric Dentistry, Faculty of Dentistry, Mahidol University, Yothi Road, Bangkok 10400, Thailand.
Tel: 66 (0) 2200 7821 ext 30
E-mail: praphasri.rir@mahidol.ac.th

INTRODUCTION

Dental caries constitute an international public health problem, especially among young children, who have a higher incidence than adults and among needier populations that do not have access to

curative or preventive treatments (Çolak *et al*, 2013).

For people with limited access to conventional treatment, Atraumatic Restorative Treatment (ART) such as resin modified glass ionomer (GIC), can be of benefit, especially in communities lacking sophisticated dental equipment or electricity (Smales and Yip, 2002).

GIC is commonly used in restorative dentistry, especially among patients at high caries risk, such as children, and is a choice material for ART due to its fluoride releasing properties and remineralization abilities (Dionysopoulos *et al*, 2013), which also inhibit demineralization (Dionysopoulos *et al*, 2016). It is convenient due to its chemical adhesion properties (Nicholson, 2016) and its good biocompatibility to tooth tissues (Rodriguez *et al*, 2013). Resin modified GIC has greater strength and is less resistant to loss than low viscosity GIC (Mount, 2005).

Several studies (Amaral *et al*, 2006; Vojinović *et al*, 2010) have reported demineralization inhibition of normal tooth structure and remineralizatin of enamel lesions adjacent to GIC application areas but there are few studies of the effect of resin modified GIC in areas near GIC applications. The aim of this study was to investigate effect of resin-modified GIC on the microhardness of teeth on areas around GIC application sites.

MATERIALS AND METHODS

Specimen preparation

Sixty bovine teeth were chosen for this study. The radicular part of each tooth was removed and the tooth was then embedded in self-curing acrylic resin. The enamel side of each tooth specimen was ground flat with 400, 800, 1,000, 1,200, 2,500 and 4,000-grit silicon carbide grinding paper (Buehler, Lake Bluff, IL) with a rotating polishing machine (Grinder-Polisher, Metaserv 2000; Buehler, Lake Bluff, IL). Specimens were stored in deionized water at room temperature until use.

Microhardness determination

Tooth microhardness was measured using a Vicker's diamond indenter using a 100 gm load for 15 seconds at 4 sites: 0.5, 1, 2, 3 mm from the edge of a 4 mm diameter circle on the tooth (Vongsavan *et al*, 2016). The microhardness was measured 4 times at each distance described above and the average microhardness for that distance was recorded.

Artificial caries lesion creation

Artificial caries lesions were formed in the enamel of the tooth samples by placing each tooth in 0.1 M lactic acid, 0.2% Carbopol, 4.1 mM $CaCl_2 \times 2H_2O$, 8.0 mM KH_2PO_4, adjusted to a pH of 5.0 using KOH for 15 hours at 37°C (Lippert *et al*, 2012).

Microhardness of lesion formation

After demineralization the microhardness of each tooth was again detected in the same manner as the baseline at 0.5, 1, 2, 3 mm from the edge of the 4 mm circle.

Control and treatment groups

The specimens were randomly divided into 2 groups (*n*=30 each): Group 1: no treatment (control group); Group 2 (treatment group): resin modified GIC (GC Fuji II LC®; GC, Tokyo, Japan) cylinders (4x4 mm in length and 1 mm height) were made in a silicone elastomer mold and placed on specimen in the 4 mm circle described above. Each specimen was then immersed in artificial saliva at 37ºC for 7 days (Maneenut *et al*, 2003).

Table 1
Microhardness of studied bovine teeth be distance from resin modified glass ionomer cement.

Distance from resin modified glass ionomer cement application site	Tooth microhardness at baseline, Mean ± SD (VHN)	Tooth microhardness post lesion formation, Mean ± SD (VHN)	Tooth microhardness after treatment	
			No treatment, Mean ± SD (VHN)	Resin modified glass ionomer cement treated, Mean ± SD (VHN)
0.5 mm	286.26±15.85[aA]	90.30±13.35[bB]	108.97±18.26[bC]	205.68 ±18.81[cD]
1 mm	282.10±19.66[aA]	92.43±13.72[bB]	109.05±19.97[bC]	185.93±12.22[cD]
2 mm	287.80±15.35[aA]	90.80±13.24[bB]	109.17±12.06[bC]	160.74±11.48[cE]
3 mm	290.96±12.73[aA]	92.80±13.82[bB]	109.55±18.86[bC]	153.31±14.46[cE]

SD: standard deviation; VHN: Vicker hardness number.
Within columns, differences in lower-case superscript letters indicate significant differences by periods ($p<0.05$).
Within columns, differences in upper-case superscript letters indicate significant differences by distance from application sites ($p<0.05$).

Microhardness determination

The tooth microhardness was again measured at the same distance from the circle as mentioned previously.

Statistical analysis

The mean sample microhardrness at each distance and at each period was calculated. These were then compared using the one-way analysis of variance (ANOVA) and Tukey multiple comparison tests. The computer program SPSS version 18.0 software for Windows (Statistical Package, for the Social Science; IBM, Armonk, NY) was used for data analysis.

RESULTS

The means and standard deviations for sample microhardness at baseline, post-lesion formation and post-treatment are shown in Table 1. There was no significant difference in microhardness values at baseline at any of the sites tested ($p=0.988$).

Post-lesion formation, there was no significant difference in microhardness at any of the sites tested ($p=0.874$) but compare to baseline, all the teeth had significantly lower microhardness ($p=0.008$).

After treatment, there was no significant change in microhardness at any of the sites in the control group ($p=0.994$) compared to post-lesion formation but in the treatment group (Group 2) there was a significant increase in microhardness at all sites ($p<0.05$). The microhardness post-treatment was significantly greater in the treatment group (Group 2) than in the control group (Group 1) ($p<0.05$). In the treatment group (Group2), the mean microhardness values at 0.5 and 1 mm were significantly higher than at 2 and 3 mm ($p<0.05$). However, in the treatment group (Group 2) there were no significant differences in microhardness between 0.5 and 1 mm and between 2 and 3 mm ($p>0.05$).

DISCUSSION

Resin modified GIC was more effective than the control group in our study to assist in tooth remneralization, as seen in previous studies (Jang *et al*, 2001; Vermeersch *et al*, 2001). GIC has anticariogenic properties (Tay, 1995) and can inhibit demineralization of teeth around application areas, which is thought to be due to its fluoride release (Reteif *et al*, 1984; Mickenautsch and Yengopal, 2010). In addition to preventing demineralization, GIC used to fill caries in teeth has been found to more effectively prevent well lesions than teeth filled with composite and amalgam (Dionysopoulos *et al*, 1994). Fluoride released from GIC has been found to be acquired by enamel and cementum as far as 7.0 mm from the application site (Retief *et al*, 1984; Tantbirojn *et al*, 1997). In our study, we found a remineralization effect up to 3 mm from the application site.

Tantbirojn *et al* (1997) reported the inhibitive effect of enamel demineralization of resin modified GIC was greatest within 1.0 mm of the application site, similar to our findings. This is most likely because the concentration of fluoride is the greatest within 1 mm of the application site (Ferracane *et al*, 1998).

Resin modified GIC has a remineralization effect on initial caries lesions up to 3 mm from the application site, but is greatest within 1.0 mm of the application site.

REFERENCES

Amaral MT, Guedes-Pinto AC, Chevitarese O. Effects of a glass-ionomer cement on the remineralization of occlusal caries--an *in situ* study. *Braz Oral Res* 2006; 20: 91-6.

Çolak H, Dülgergil CT, Dalli M, Hamidi MM. Early childhood caries update: a review of causes, diagnoses, and treatments. *J Nat Sci Biol Med* 2013; 4: 29-38.

Dionysopoulos D, Koliniotou-Koumpia E, Helvatzoglou-Antoniades M, Kotsanos N. Fluoride release and recharge abilities of contemporary fluoride-containing restorative materials and dental adhesives. *Dent Mater J* 2013; 32: 296-304.

Dionysopoulos D, Koliniotou-Koumpia E, Helvatzoglou-Antoniades M, Kotsanos N. In *vitro* inhibition of enamel demineralisation by fluoride-releasing restorative materials and dental adhesives. *Oral Health Prev Dent* 2016; 14: 371-80.

Dionysopoulos P, Kotsanos N, Koliniotou-Koubia, Papagodiannis Y. Secondary caries formation in *vitro* around fluoride releasing restorations. *Oper Dent* 1994; 19: 183-8.

Ferracane JL, Mitchem JC, Adey JD. Fluoride penetration into the hybrid layer from a dentin adhesive. *Am J Dent* 1998; 11: 23-8.

Jang KT, Garcia-Godoy F, Donly KJ, Segura A, Remineralizing effects of glass ionomer restorations on adjacent interproximal caries. *ASDC J Dent Child* 2001; 68:125-8, 142.

Lippert F, Martinez-Mier EA, Soto-Rojas AE. Effects of fluoride concentration and temperature of milk on caries lesion rehardening. *J Dent* 2012; 40: 810-3.

Maneenut C, Nikaido T, Foxton RM, Tagami J. Effect of glass ionomer cements on nanohardness of caries-affected dentin. *Int Chin J Dent* 2003; 3: 122-30.

Mickenautsch S, Yengopal V. Demineralization of hard tooth tissue adjacent to resin-modified glass-ionomers and composite resins: a quantitative systematic review. *J Oral Sci* 2010; 52: 347-57.

Mount GJ. Periodontal considerations in tooth restoration. In: Mount GJ, Hume WR, eds. Preservation and restoration of tooth structure. 2nd ed, Brisbane: Knowledge Books and Software, 2005: 225-34.

Nicholson JW. Adhesion of glass-ionomer

cements to teeth: a review. *Int J Adhesion Adhesives* 2016; 69: 33-8.

Retief DH, Bradley EL, Denton JC, Switzer P. Enamel and cementum uptake from a glass ionomer cement. *Caries Res* 1984; 18: 250-7.

Rodriguez IA, Rozas Ferrara CA, Campos-Sanchez F, Alaminos M, Echevarría JU, Campos A. An in *vitro* biocompatibility study of conventional and resin-modified glass ionomer cements. *J Adhesive Dent* 2013; 15: 541-6.

Smales RJ, Yip HK. The atraumatic restorative treatment (ART) approach for the management of dental caries. *Quintessence Int* 2002; 33: 427-32.

Tantbirojn D, Douglas WH, Versluis A. Inhibitive effect of a resin-modified glass ionomer cement on remote enamel artificial caries. *Caries Res* 1997; 31: 275-80.

Tay WM. An update on glass ionomer cements. *Dent Update* 1995; 22: 283-6.

Vermeersch G, Leloup G, Vreven J. Fluoride release from glass-ionomer cements, compomers and resin composites. *J Oral Rehabil* 2001; 28: 26-32.

Vojinović J, Ćupic S, Mirjanic O, Sukara S, Polić O, Obradević M. Remineralization of early caries lesions with glass ionomer cements. *Contemp Mater* 2010; 2: 175-8.

Vongsavan K, Rirattanapong P, Surarit R. Comparison of children's follow-on instant powdered cow's milk formula, buffalo milk formula and chicken-based formula on enamel microhardness of bovine teeth *in vitro*. *Southeast Asian J Trop Med Public Health* 2016; 47: 328-33.