EFFECT OF RESIN-MODIFIED GLASS IONOMER CEMENT ON TOOTH MICROHARDNESS UNDER TREATED CARIES

Praphasri Rirattanapong[1], Kadkao Vongsavan[2], Woranun Prapansilp[1] and Rudee Surarit[3]

[1]Department of Pediatric Dentistry, [3]Department of Oral Biology, Faculty of Dentistry, Mahidol University, Bangkok; [2]International College of Dentistry, Walailak University, Nakhon Si Thammarat, Thailand

Abstract. Dental caries are the most common oral disease. Resin-modified glass ionomer cement (GIC) is used to treat caries by promoting remineralization of these caries. However, the microhardness of teeth under these caries treated with GIC has been little studied. We conducted an *in vitro* study to evaluate the microhardness of teeth under caries treated with GIC in order to determine if it is improved with treatment and to what extent. The teeth used in this study were 20 bovine incisors. Knoop indentations were made on each studied tooth with a load of 50 grams for 15 seconds and then caries were produced on the labial surface of each tooth by immersing the tooth in demineralizing solution for 120 hours at 37°C. The 20 study teeth were divided into two groups of 10 teeth each group: Group 1 (control group) received no treatment; in Group 2 resin-modified GIC was applied to the center of the labial surface of each sample tooth in the treatment group. Both groups were immersed for 7 days at 37°C in artificial saliva. After 7 days, all the teeth were labio-lingually sectioned in sagittal plane through the middle of the tooth. The enamel microhardness was measured at 6 locations on each tooth 50 μm apart in a vertical direction: 50, 100, 150, 200, 250, 300 μm from the enamel surface where the caries were created in both the control and treatment teeth. The mean microhardnesses were calculated at each depth for both the treatment and control groups and compared using an independent *t*-test and a one-way ANOVA test followed by a Tukey's HSD multiple comparison test with a 95% confidence interval. There were significant ($p<0.05$) differences between the control and treatment groups at 50, 100 and 150 μm from the enamel surface but not at 200, 250, 300 μm from the surface ($p>0.05$). In the control group, the mean [± standard deviation (SD)] microhardness at 50 μm from the enamel surface was the lowest [145.4±17.4 Knoop Hardness Number (KHN)] and significantly ($p<0.05$) less hard than all the other depths. In the treatment group, the mean (±SD) microhardness at 50 μm (208.9±15.4 KHN) and 100 μm (206.1±20.8 KHN) were significantly ($p<0.05$) greater than at 300 μm (180.9±13.6 KHN). In conclusion, the resin-modified GIC treatment significantly increased the microhardness of the enamel under the treated caries in bovine teeth down to a depth of 150 μm.

Keywords: initial enamel caries, microhardness, remineralization, resin-modified glass ionomer cement

Correspondence: Praphasri Rirattanapong, Department of Pediatric Dentistry, Faculty of Dentistry, Mahidol University, 6 Yothi Road, Ratchathewi District, Bangkok 10400, Thailand.
Tel: +66 (0) 2200 7821; E-mail: praphasri.rir@mahidol.ac.th

INTRODUCTION

Dental caries are the most common oral disease worldwide (Garg *et al*, 2015). They are often left untreated in both developing and industrialized countries (Lopez *et al*, 2005). Atraumatic Restorative Treatment (ART) is a preventive and restorative treatment to managing dental caries. It includes sealing caries-prone pits, fissures and active enamel caries and excavating cavitated dentine caries with hand instruments and then restoring filling in the cavity (Garg *et al*, 2015). This approach was introduced to provide dental care to less-affluent populations, making caries management possible for underserved communities with limited resources (Garg *et al*, 2015). The World Health Organization has promoted ART for treating dental caries (Lopez *et al*, 2005).

One of factors which may have affected the success rates of ART is the material used (Mallow *et al*, 1998). Glass ionomer cement (GIC) is the material of choice for ART because of its ability to bond enamel and dentin, its fluoride release and ease of use (Berg, 2002). Resin-modified GIC has a higher success rate due to its greater strength and resistance to loss than low viscosity GIC (Wadenya *et al*, 2010).

Remineralization of carious lesions is enhanced by fluoride release from the resin-modified GIC used as the filling material. Enhanced remineralization of lesions adjacent to the resin-modified GIC restorations also occurs (Sidhu and Nicholson, 2016). However, little is known about the remineralization effect of resin-modified GIC on the part of the tooth under the treated caries. Therefore, we aimed to evaluate the microhardness of the teeth under caries treated with resin-modified GIC in order to determine if it is improved with treatment and to what extent.

MATERIALS AND METHODS

Specimen preparation

Twenty bovine teeth were chosen for this study. The radicular part of each tooth was removed and the remaining tooth was then embedded in acrylic resin. The enamel of the labial surface of each tooth was ground flat progressively using 400, 800, 1,000, 1,200, 2,500 and 4,000-grit silicon carbide grinding paper (Buehler, Lake Bluff, IL).

Microhardness determination

Tooth microhardness in Knoop Microhardness Number (KHN) was measured with a Knoop with a 50 g load for 15 seconds (Gelani *et al*, 2014) at 4 areas at least 100 μm apart within 3 mm of the middle of the labial surface of each studied tooth. The mean KHN of these 4 areas was used as the mean for the tooth. Only teeth with a mean microhardness at baseline of 300-350 KHN were used in the study (Gelani *et al*, 2014).

Artificial caries creation

Artificial caries were created in all 20 studied teeth following the method of Lippert and Lynch (2014). Each tooth was immersed for 5 days at 37ºC in a mixture of 0.05 M lactic acid, 0.2% carbopol, 4.1 mM calcium chloride and 8.0 mM potassium dihydrogen phosphate, adjusted to a pH of 5.0 using potassium hydroxide.

Microhardness measurement of artificial caries

After demineralization, the microhardness of each tooth was measured again in the same manner as at baseline. Only specimens with a mean microhardness at the caries site of 40-60 KHN were used in the study (Vongsavan *et al*, 2014).

Control and treatment groups

The 20 studied teeth were divided

into 2 groups of 10 teeth each: Group 1: no treatment (control group); Group 2: treated with resin-modified GIC (GC Fuji II LC®; GC, Tokyo, Japan) (treatment group). A cylinder 3 mm in diameter and 1 mm long was made of silicone elastomer and placed over the area that microhardness were measured at 4 areas within 3 mm of the middle of the labial surface of each studied tooth at baseline and after demineralization. Each tooth was then immersed for 7 days at 37°c in artificial saliva composed of calcium chloride (0.111 g), sodium chloride (2.05 g), sodium acetate (2.05 g) and sodium dihydrogen phosphate (0.156 g) in 1,000 ml of deionized water, a pH of 7 was adjusted by adding potassium hydroxide (Karantakis *et al*, 2000). After 7 days, each tooth was labio-lingually sectioned in sagittal plane through the middle of tooth.

Microhardness determination

The microhardness of each specimen was measured at 6 locations on the cut surface under the caries: 50, 100, 150, 200, 250, 300 μm from the tooth surface where the caries were (Hotta *et al*, 2001).

Statistical analysis

The mean microhardness values at each distance from the tooth surface for both groups were calculated. These values were then compared within each group using the one-way analysis of variance (ANOVA) and Tukey multiple comparison tests. The mean microhardness values were also compared between the control and treatment groups using the independent *t*-test. Significance was set at $p<0.05$. The Statistical Package for Social Sciences, version 18.0 for Windows (IBM, Armonk, NY) was used for statistical analysis.

RESULTS

There were no differences in microhardness values at baseline and after demineralization before treatment between the 2 groups. There were significant ($p<0.05$) differences between the control and treatment groups at 50, 100, 150 μm

Table 1
Microhardness of studied teeth with and without treatment.

Distance from the tooth surface	Tooth microhardness in Knoop Hardness Number units	
	Control group, no treatment Mean (±SD)	Resin-modified GIC, treatment group Mean (±SD)
50	145.4 ± 17.4^{A}	$208.9 \pm 15.4^{C*}$
100	170.6 ± 14.2^{AB}	$206.1 \pm 20.8^{C*}$
150	174.6 ± 18.5^{B}	$195.5 \pm 15.3^{CD*}$
200	174.6 ± 22.9^{B}	193.2 ± 21.5^{CD}
250	175.1 ± 21.8^{B}	186.8 ± 17.1^{CD}
300	173.2 ± 22.0^{B}	180.9 ± 13.6^{D}

GIC, glass ionomer cement; SD, standard deviation. Values in the same column with different superscript letters were significantly different. *Significantly different between the control and treatment groups.

from the enamel surface but not at 200, 250, 300 μm from the surface ($p>0.05$). In the control group, the mean [± standard deviation (SD)] microhardness at 50 μm from the enamel surface was the lowest [145.4±17.4 Knoop Hardness Number (KHN)] and significantly ($p<0.05$) less hard than all the other depths. In the treatment group, the mean (±SD) microhardness at 50 μm (208.9±15.4 KHN) and 100 μm (206.1±20.8 KHN) were significantly greater ($p<0.05$) than at 300 μm (180.9±13.60 KHN).

DISCUSSION

In our study, the microhardness of the teeth after treatment with resin-modified GIC (treatment group) was significantly higher than the untreated teeth (control group) at 50,100 and 150 μm from the tooth surface, suggesting remineralization occurred under the treated caries down to a depth of 150 μm from the surface, but no deeper. These findings are in agreement with other studies (Melo *et al*, 2014; Prapansilp *et al*, 2018). The remineralization seen in our study is likely due to fluoride release by the studied GIC (Lobo *et al*, 2005) and the caries probably facilitated the fluoride diffusion (Lippert, 2017).

In conclusion, resin-modified GIC significantly increased microhardness of treated enamel caries down to a depth of 150 μm from the surface.

REFERENCES

Berg JH. Glass ionomer cements. *Pediatr Dent* 2002; 24: 430-7.

Garg Y, Bhaskar DJ, Suvarna M, Singh N, Lata S, Bose S. Atraumatic restorative treatment in dentistry. *IJOHMR* 2015; 2: 126-9.

Gelani R, Zandona AF, Lippert F, Kamocka MM, Eckert G. *In vitro* progression of artificial white spot lesions sealed with an infiltrant resin. *Oper Dent* 2014; 39: 481-8.

Hotta M, Li Y, Sekine I. Mineralization in bovine dentin adjacent to glass-ionomer restorations. *J Dent* 2001; 29: 211-5.

Karantakis P, Helvatjoglou-Antoniades M, Theodoridou-Pahini S, Papadogiannis Y. Fluoride release from three glass ionomers, a compomer, and a composite resin in water, artificial saliva, and lactic acid. *Oper Dent* 2000; 25: 20-5.

Lippert F. Effect of enamel caries lesion baseline severity on fluoride dose-response. *Int J Dent* 2017; 2017: 4321925.

Lippert F, Lynch RJM. Comparison of knoop and vickers surface microhardness and transverse microradiography for the study of early caries lesion formation in human and bovine enamel. *Arch Oral Biol* 2014; 59: 704-10.

Lobo MM, Peccharki GD, Tengan C, *et al*. Fluoride-releasing capacity and cariostatic effect provided by sealants. *J Oral Sci* 2005; 47: 35-41.

Lopez N, Simpser-Rafalin S, Berthold P. Atraumatic restorative treatment for prevention and treatment of caries in an underserved community. *Am J Public Health* 2005; 95: 1338-9.

Mallow PK, Durward CS, Klaipo M. Restoration of permanent teeth in young rural children in Cambodia using the atraumatic restorative treatment (ART) technique and Fuji II glass ionomer cement. *Int J Paediatr Dent* 1998; 8: 35-40.

Melo MAS, Morais WA, Passos VF, Lima JPM, Rodrigues LKA. Fluoride releasing and enamel demineralization around orthodontic brackets by fluoride-releasing composite containing nanoparticles. *Clin Oral Investig* 2014; 18: 1343-50.

Prapansilp W, Vongsavan K, Rirattanapong P, Surarit R. Effect of resin-modified glass ionomer cement on microhardness of initial caries lesions. *Southeast Asian J Trop Med Public Health* 2018; 49: 155-9.

Sidhu SK, Nicholson JW. A review of glass-ionomer cements for clinical dentistry. *J Funct Biomater* 2016; 73: 16.

Vongsavan K, Surarit R, Rirattanapong P. The combined effect of xylitol and fluoride in varnish on bovine teeth surface microhardness. *Southeast Asian J Trop Med Public Health* 2014; 45: 505-10.

Wadenya R, Smith J, Mante F. Microleakage of nano-particle-filled resin-modified glass ionomer using atraumatic restorative technique in primary molars. *NY State Dent J* 2010; 76: 36-9.