FLOURIDE RELEASE AND RECHARGE ABILITY OF GLASS-IONOMER AND FLUORIDE RELEASING RESIN-BASED TOOTH SEALANT

Yuwadee Asvanund[1], Praphasri Rirattanapong[1], Wannaprapai Akulchakit[2]

[1]Department of Pediatric Dentistry, Faculty of Dentistry, Mahidol University, Bangkok;
[2]Dental Department, Muangraj Hospital, Ratchaburi Province, Thailand

Abstract. Fluoride has been added to tooth sealant to increase its efficacy. In this study we aimed to determine the ability of fluoride-releasing resin-based and glass ionomer cements to release fluoride over time and if this fluoride releasing ability can be recharged by exposure to fluoride gel in order to inform sealant decisions of dental providers. We conducted an *in vitro* study of 3 sealants: Concise white sealant™ (a non-fluoride-releasing resin-based sealant) used as the control, Clinpro™ (a fluoride-releasing resin-based sealant) and Fuji VII® (a glass ionomer, fluoride-releasing sealant). We prepared 45 discs, 15 discs made from each of the 3 studied sealants; each disc was 11 mm diameter and 1 mm thick. We placed each disc in a plastic container containing 10 ml deionized water and replaced this water daily throughout the study. We measured the fluoride concentration in the water in each container using a fluoride ion analyzer on Days 1, 2, 3, 4, 5, 6, 7, 14 and 21. On Day 21 each sample was submerged in 5 ml 1.23% acidulated phosphate fluoride (APF) gel for 4 minutes and then the sample was placed back in fresh deionized water and replaced daily. The fluoride concentration of the water was checked daily for 5 days after gel exposure. We used the one-way ANOVA and least significant difference tests to determine significant differences in fluoride concentration. Significance was set at $p \leq 0.05$. The highest mean fluoride concentrations were on Day 1: 6.62±2.07 ppm for the glass ionomer cement and 0.41±0.06 ppm for the fluoride-releasing resin-based sealant. The lowest mean fluoride concentrations were on Day 21: 0.55±0.31 ppm for the glass ionomer cement and 0.02±0.00 ppm for fluoride-releasing resin-based sealant. Mean fluoride concentration for the control was 0.00±0.00 ppm throughout the 21-day initial study period. The glass ionomer cement released significantly ($p<0.05$) more fluoride during the initial 21-day study period than the control and the fluoride-releasing resin-based sealant. The fluoride-releasing resin-based sealant released significantly ($p<0.05$) more fluoride during the initial 21-day study period than the control. After exposure to 1.23% APF gel, the highest mean fluoride concentrations were on Day 22 (Day 1 after fluoride gel exposure): 15.42± 2.48 ppm for the glass ionomer cement, 0.16±0.02 ppm for the fluoride-releasing resin-based sealant and 0.10±0.03 ppm for the control. The lowest mean fluoride concentration was on Day 26 (Day 5 after fluoride gel exposure): 1.24±0.31 ppm for the glass ionomer cement,

0.02±0.00 ppm, for the fluoride-releasing resin-based sealant and 0.01±0.00 ppm for the control. There was a significant (p<0.05) increase in fluoride release from all groups during the 5-day post fluoride gel exposure study period, with the glass ionomer cement releasing significantly (p<0.05) more fluoride than both the resin-based sealants, which released fluoride in levels not significantly different (p>0.05) from each other. In our study, the glass ionomer cement released more fluoride than the other tested sealants and was recharged with 1.23% APF gel and released more fluoride after recharge than the other sealants. Therefore, we conclude for patients requiring a sealant releasing fluoride, the glass-ionomer sealant is the better option. Further studies are needed to determine how often glass-ionomer sealant should be recharged with 1.23% APF gel and whether it can play a role in caries inhibition.

Keywords: fluoride release, fluoride recharge, glass ionomer, resin-based sealant

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; Fax: +66 (0) 2200 7820 E-mail: praphasri.rir@mahidol.ac.th

INTRODUCTION

Dental caries area major public health problem, especially during childhood. Pit and fissure sealants, such as glass ionomer cement (GIC) and resin-based sealant, have been recommended as a solution to this problem (Cvikl *et al*, 2018). Fluoride has been added to some pit and fissure sealants in order to enhance these anti-caries effects (Bayrak *et al*, 2010).

Fluoride-releasing sealants may lose their abilities to release fluoride over time. However, the fluoride-releasing property of the sealant has been reported to be recharged by exposure to fluoride (Dionysopoulos *et al*, 2013; Preston *et al*, 2003). Recharging this fluoride release may improve the ability to prevent caries (Vieira *et al*, 1999).

Few studies have evaluated the long-term capacity of sealants to release fluoride and be recharged by fluoride gel. In this study, we aimed to determine the ability of fluoride-releasing resin-based and glass ionomer cement to release fluoride over time and the ability to recharge this fluoride release by exposure to 1.23% acidulated phosphate fluoride (APF) gel in order to guide dental provider decision making regarding these sealants.

MATERIALS AND METHODS

We conducted this *in vitro* study by evaluating three sealants: Concise white sealant™ (3M EPSE, St Paul, MN) a non-fluoride-releasing resin-based sealant used as the control, Clinpro™ (3M EPSE, St Paul, MN) a fluoride-releasing resin-based sealant and Fuji VII® (GC Corporation, Tokyo, Japan) a glass ionomer fluoride-releasing sealant.

In our study we prepared disc shaped (11 mm diameter x 1 mm thick) samples of each study sealant by mixing each sealant according to the manufacturer's instructions and pouring it into a mold with an inserted nylon thread until solid. The thread would be used to suspend the sample in a polyethylene tube containing 3 ml deionized water replaced daily throughout the study. Each sample was maintained at 37°C throughout the study.

The fluoride concentration of the deionized water in each tube was measured and recorded on Days 1, 2, 3, 4, 5, 6, 7, 14 and 21 by mixing the water with 3 ml TISAB III (Total ionic strength adjustment buffer, 940911, Orion Research Inc, Beverly, MA), stirred for 3 minutes (Bayrak *et al*, 2010) and the fluoride concentration was checked using a fluoride ion-selective electrode (ORION 9409 BN, Thermo Electron Corp, Waltham, MA) calibrated before each measurement. The fluoride concentration in parts per million (ppm) was then calculated.

After the initial 21-day study period described above, each specimen was then rinsed with deionized water, dried on paper and then submerged in 1.23% APF gel (12,300 parts per million of fluoride (ppm F)), pH 3.5) (Sultan Healthcare Inc, Englewood, NJ) for 4 minutes. Each specimen was then rinsed in deionized water, dried on absorbent paper and placed back in deionized water which was replaced daily. The tubes were maintained at 37°C for the additional 5-day period of the second part of this study and the fluoride concentration was measured and recorded daily during this period.

The one-way ANOVA and least significant difference post hoc tests to compare differences in fluoride concentration for each studied sample and among the studied sealants. Significance was set at $p \leq 0.05$. Statistical analysis was performed using then Statistical Package for the Social Science (SPSS) for Windows software, version 20.0 (IBM, Armonk, NY).

RESULTS

The highest mean fluoride concentrations were on Day 1: 6.62±2.07 ppm for the glass ionomer cement and 0.41±0.06 ppm for the fluoride-releasing resin-based sealant. The lowest mean fluoride concentrations were on Day 21: 0.55±0.31 ppm for the glass ionomer cement and 0.02±0.00 ppm for fluoride-releasing resin-based sealant. Mean fluoride concentration for the control was 0.00±0.00 ppm throughout the 21-day initial study period. The glass ionomer cement released significantly ($p<0.05$) more fluoride during the initial 21-day study period than the control and the fluoride-releasing resin-based sealant. The fluoride-releasing resin-based sealant released significantly ($p<0.05$) more fluoride during the initial 21-day study period than the control (Table 1, Fig 1).

After exposure to 1.23% APF gel, the highest mean fluoride concentrations were on Day 22 (Day 1 after fluoride gel exposure): 15.42± 2.48 ppm for the glass ionomer cement, 0.16±0.02 ppm for the fluoride-releasing resin-based sealant and (0.10±0.03 ppm for the control. The lowest mean fluoride concentration was on Day 26 (Day 5 after fluoride gel

exposure): 1.24±0.31 ppm for the glass ionomer cement, 0.02±0.00 ppm, for the fluoride-releasing resin-based sealant and 0.01±0.00 ppm for the control. There was a significant (p<0.05) increase in fluoride release from all groups during the 5-day post fluoride gel exposure study period, with the glass ionomer cement releasing significantly (p<0.05) more fluoride than both the resin-based sealants, which released fluoride in levels not significantly different (p>0.05) from each other (Table 2, Fig 1).

DISCUSSION

In our study, the glass-ionomer sealant released significantly more fluoride than the resin-based sealant, similar to the findings of previous studies (Bayrak *et al*, 2010; Mousavinasab and Meyers, 2009).

In our study the glass ionomer cement released more fluoride during the first 2 days and then the amount of fluoride released gradually decreased, similar to the findings of other studies (Bayrak *et al*, 2010; De Moor *et al*, 1996). This initial large release of fluoride by glass ionomer cement is referred to as the "burst effect" and is due to rapid fluoride release from the glass particles (Attar and Turgut, 2003). Resin-based fluoride-releasing sealants release the fluoride through slow diffusion (Ananda and Mythri, 2014), resulting in less of a burst effect.

Previous studies (Rao *et al*, 2015; Xu and Burgress, 2003) have reported sealants with higher initial fluoride release tend to have greater fluoride recharging capacity, as was seen in our study with the glass ionomer cement.

The fluoride recharge mechanism is unclear (Preston *et al*, 1999) and may be influenced by the composition of the sealant material, the concentration of fluoride distributed in the material and differences in the surface energy of the sealant material (Dionysopoulos *et al*, 2013).

Glass ionomer cement has been reported to act as a better fluoride reservoir than resin-based sealant (Preston *et al*, 2003). Glass ionomer cement has a loosely bound water-solute product in the porous part of the cement that can be exchanged with the external medium by passive diffusion (Xu and Burgress, 2003). A more permeable material can better absorb fluoride than a less permeable material (Xu and Burgess, 2003). The slight increase in fluoride release seen in our study with the resin-based sealants after fluoride gel exposure is probably due to the release of fluoride from the surface of the resin-based sealant (Attar and Onen, 2002; Bayrak *et al*, 2010).

To summarize, in our study glass ionomer cement gave better fluoride release and was recharged more effectively than resin-based sealant. We conclude glass ionomer cement is better for patients requiring a fluoride releasing sealant. Further studies are needed to determine how often glass-ionomer sealant should be recharged with 1.23% APF gel and whether it can play a role in caries inhibition.

CONFLICT OF INTEREST DISCLOSURE

The authors declare no conflicts of interest.

Table 1

Mean (±standard deviation) concentration in parts per million of fluoride released by studied tooth sealants over time

Sealant	Time in days								
	1	2	3	4	5	6	7	14	21
Concise™	0.00±0.00[a]	0.00± 0.00[a]	0.00± 0.00[a]	0.00± 0.00[a]	0.00± 0.00[a]	0.00± 0.00[a]	0.00± 0.00[a]	0.00± 0.00[a]	0.00± 0.00[a]
Clinpro™	0.41±0.06[a]	0.07± 0.01[b]	0.05± 0.01[b]	0.04± 0.00[b]	0.03±0.00[b]	0.03± 0.03[b]	0.03± 0.00[b]	0.02± 0.01[b]	0.02± 0.00[b]
Fuji VII®	6.62± 2.07*[a]	2.92±0.99*[b]	1.42±0.59*[c]	1.41± 0.44*[c]	1.34± 0.70*[c]	1.32± 0.81*[c]	0.99± 0.40*[c]	0.71± 0.31*[c]	0.55± 0.31*[c]

*: statistically significant differences within columns; superscript letters: statiscially significant differences within rows (p<0.05)

Table 2

Mean (±standard deviation) concentration of fluoride released in parts per million by studied tooth sealants over time after exposure to 1.23% acidulated phosphate fluoride gel

Sealant	Days after gel / Total study days				
	1 / 22	2 / 23	3 / 24	4 / 25	5 / 26
Concise™	0.10±0.03[a]	0.02±0.02[b]	0.02±0.02[b]	0.01±0.00[b]	0.01 ±0.00[b]
Clinpro™	0.16±0.02[a]	0.03±0.00[b]	0.03±0.00[b]	0.02±0.00[b]	0.02±0.00[b]
Fuji VII®	15.42±2.48*[a]	3.52±0.99*[b]	1.93±0.60*[c]	1.64±0.32*[c]	1.24±0.31*[c]

*: statistically significant differences within columns; superscript letters: statiscially significant differences within rows (p<0.05)

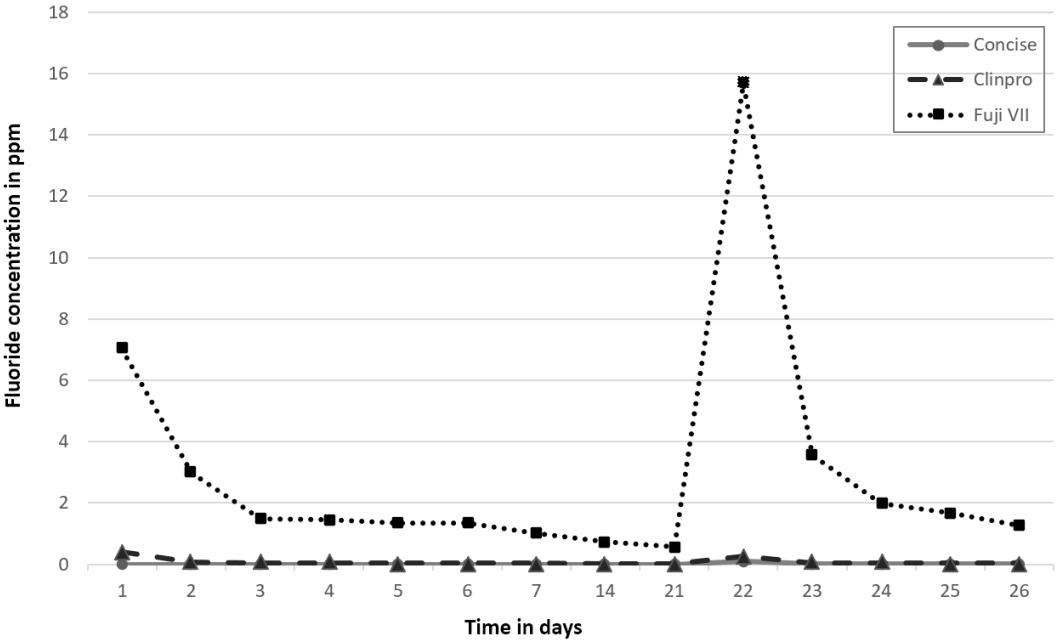

Fig 1 - Concentration of fluoride released in parts per million from studied sealants before and after exposure to 1.23% APF gel

ppm: part per million

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