COMPARISON OF FLUORIDE RELEASE FROM FLUORIDE RELEASING BONDING AGENTS

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Abstract. Fluoride releasing tooth sealants are widely used as a public health measure to prevent caries, but usually require bonding agents to prevent failure. The aim of this study was to measure and compare fluoride release from commercially available bonding agents in order to inform prescribing practices. The products evaluated were Clearfil liner F (LF), Optibond XTR (XTR), FL–Bond II (FLB). These were also compared to a non-fluoride releasing bonding agents as a control, Clearfil SE bond (SE). Five samples of each product were placed in a Teflon mold, placed in a dark sealed chamber for 12 hours and then light cured for 20 seconds. After that, each specimen was stored in a plastic container containing deionized water and incubated at 37°C. The fluoride ions released from each product were measured daily for 1 week and then weekly for 1 month with the first measurement taken 24 hours after preparation. The data were analyzed using the two-way ANOVA. A p-value<0.05 was considered statistically significant. SE (control) released 0.01 ppm of fluoride at day 1 and this remained the same for all the readings. LF released 0.39 ppm fluoride on day 1. This did not increase significantly for all readings. XTR released 4.06 ppm fluoride on day 1 and this continued to increase significantly to 6.33 ppm by 28 days. FLP released 3.21 ppm fluoride on day 1 and this also increased significantly to 7.10 ppm by 28 days. Our results show LF released less fluoride than XTR and FLB and this did not change significantly throughout the study. However, XTR and FLB did release more fluoride and those levels increased over the 28 days study period. This result can guide dental practitioners in the selection of the appropriate bonding agent for the appropriate subject. Further studies are needed to determine if these bonding agents result in different caries rates among human subjects *in vivo*.

Keywords: Fluoride, fluoride release, fluoride-releasing bonding agents

INTRODUCTION

Dental caries are a public health problem. Young permanent molars have been shown to be at an increased risk for caries because of the complex nature of their occlusal surface morphology (Demirci *et al*, 2010). Caries preventing strategies, including pit and fissure sealant application, have significantly decreased caries rates on sealed occlusal surfaces (Naaman *et al*, 2017). Pit and fissure sealants are widely used in public health in dentistry in Thailand (Suwansingha

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and Rirattanapong, 2012). However, sealants can leak or be partially or totally loss, resulting in failure, with failure rates being reported to be 5-10% per year (Simonsen, 2002). These high failure rates are most likely due to inadvertent moisture contamination (Naaman *et al*, 2017).

Several studies have shown application of bonding agents before sealant application improves bond strength, decreases microleakage and increases flow into pits and fissures (Feiga *et al* 2000; Borsatto *et al*, 2004; Das and Suma, 2009).

Fluoride-releasing bonding agents have been developed in order to inhibit secondary caries by promoting adhesion to dental tissues and releasing fluoride ions (Dionysopoulous *et al*, 2016). Some studies reported these adhesives can contribute to the inhibition of secondary caries formation (Han *et al*, 2006).

There is little data about the amount of fluoride release from these bonding agents. In this study, we aimed to measure and compare fluoride release from commercially available bonding agents in order to inform prescribing practices.

MATERIALS AND METHODS

Specimen preparation

The following fluoride releasing bonding agents were evaluated for the study: Clearfil liner bond F (LF) with the fluoride component consisting of sodium fluoride (NaF) (Kuraray Medical Inc, Okayama, Japan), Optibond XTR (XTR) with the fluoride component consisting of sodium hexafluorosilicate (Na_2SiF_6) (Kavo Kerr, Orange, CA) and FL-bond II (FLB) containing surface reaction-type pre-released glass ionomer (S–PRG) filler (fluoroaluminosilicate glass; a fluoride in an amount of from 0.01 to 5 parts by weight based on 100 parts by weight of the glass powder) (Shofu, Kyoto, Japan). The non-fluoride releasing bonding agent used as a control was Clearfil SE bond (SE) (Kuraray Medical Inc, Okayama, Japan). Twenty cylindrical Teflon molds (10 mm diameter and 2 mm height) (Han *et al*, 2006) were divided into 4 groups (5 specimens/group). Each specimen was kept in a dark sealed chamber for 12 hours to allow the solvent to thoroughly dry preventing interference with the study (Pongprueksa *et al*, 2014). Each specimen was then light cured for 20 seconds on all surfaces (Dionysopoulous *et al*, 2015).

Fluoride ion measurement

Each prepared specimen was suspended with non-fluoride dental floss in 5 ml deionized water in a plastic container and incubated in an incubator at of 37±0.5°C for the duration of the study (Dionysopoulous *et al*, 2016).

The fluoride released by each specimen was measured daily for 1 week and then weekly for 1 month (Dionysopoulous *et al*, 2015). The specimen was transferred to a new container with fresh deionized water daily after each measurement so the individual measurements only reflect fluoride released during a 24-hour period. A 0.3 ml of total ionic strength adjustment buffer (TISABIII) was used for fluoride analysis. This resulted in a measurement of the fluoride released each day (Han *et al*, 2006).

The fluoride concentration was measured using a fluoride ion selective electrode (Expandable ion Analyzer E940, Orion research incorporated, USA) attached to an ion meter. The fluoride ion (F^- ion) concentrations (ppm) were measured 3 times with each evaluation and the results averaged (Han *et al*, 2002).

Statistical analysis

Data were analyzed using a two–way ANOVA (Statistical Package for the Social Science: SPSS; IBM, Armonk, NY) version 20.0 software for Windows. Significant was set at $p < 0.05$. Differences among experimental groups were evaluated using the Dunnett T3 test.

RESULTS

The results of the fluoride concentration measurements are shown in Table 1 and Fig 1. The minimum fluoride concentration measurable by the electrode in this study was 0.02 ppm.

No fluoride was detected from the control bonding product (SE). The fluoride released by LF varied from 0.39 to 0.50 ppm throughout the study but these readings were not significantly different from each other, suggesting a constant release. XTR released fluoride at a concentration of 4.06 ppm at 24 hours and the daily concentration released significantly increased until day 28 when it released a concentration of 6.33 ppm. FLB released fluoride at a concentration of 3.21 ppm at 24 hours and the daily concentration released increased significantly until day 28 when it released a concentration of 7.10 ppm (Table 1) (Fig 1).

DISCUSSION

In our study, two of the 3 tested bonding products (XTR and FLB) released fluoride in increasing amounts until the end of the study. The third product (LF) release a much lower fluoride concentration that did not change significantly during the study. Our results differ than those of Basso *et al* (2013) who found the studied bonding agents released the greatest amount of fluoride during the first 6 hours of the study and then gradually release decreasing amounts over the 7-day period of the study. A study by Dionysopoulos *et al* (2015) reported the studied bonding agents released the greatest amount of fluoride during the first 24 hours of the study followed by a slightly lower concentration of fluoride released daily over the rest of 30-day study but this did not differ significantly.

In our study, XTR and FLB released more fluoride that LF. The reason for this is unclear and the release mechanism of

Table 1
Mean±SD (ppm) concentration of fluoride ion measured for each study product over time

Group	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 14	Day 21	Day 28
SE	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02	<0.02
LF	0.39 ±0.04	0.43 ±0.01	0.44 ±0.01	0.45 ±0.00	0.45 ±0.00	0.46 ±0.00	0.47 ±0.00	0.48 ±0.00	0.50 ±0.00	0.51 ±0.00
XTR	4.06* ±0.22	4.85* ±0.05	5.20* ±0.02	5.43* ±0.01	5.57 ±0.01	5.68 ±0.01	5.77 ±0.01	6.09* ±0.03	6.24 ±0.01	6.33* ±0.01
FLB	3.21* ±0.14	4.08* ±0.02	4.52* ±0.02	4.87* ±0.02	5.11* ±0.01	5.33* ±0.01	5.50 ±0.01	6.17* ±0.07	6.69* ±0.04	7.10* ±0.05

Note: *describes changes in fluoride concentration indicating statistically significant changes by time.
F: Fluoride, SE: Clearfil SE bond, LF: Clearfil liner bond F, XTR: Optibond XTR, FLB: FL-bond II

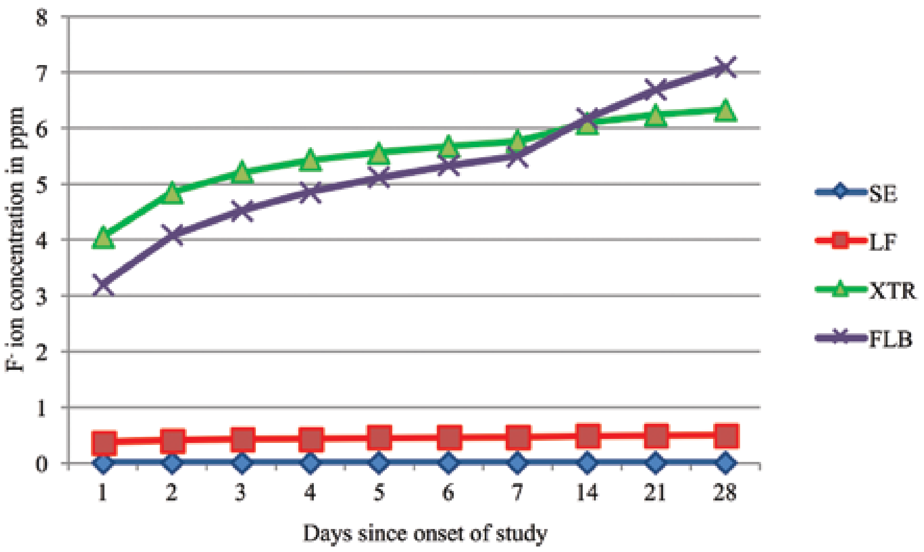

Fig 1-Fluoride concentration measured from studied product by time

F: Fluoride; SE: Clearfil SE bond; LF: Clearfil liner bond F; XTR: Optibond XTR; FLB: FL-bond II

each product have not been revealed by the manufacturers (Han *et al*, 2002). The amount and rate of fluoride release can vary by bonding, complexity of molecules and the pH, along with other factors. Sodium fluoride dissociates completely in water.

The S–PRG used by FLB is formed by an acid-base reaction between the fluoroaluminosilicate glass particles and polyalkenoic acid (Ito *et al*, 2011). These molecules release fluoride following a concentration gradient resulting in a release of fluoride into areas with a low fluoride concentration (Yap *et al*, 2002). This explains the reason for the significant increase in fluoride concentration over time seen in our study but does not explain the significant increasing release of fluoride by XTR, which is unclear due to the mechanism not being released by the manufacturer. By cylindrical Teflon model, the amount of fluoride released is usually more than the amount of fluoride releasing bonding agents used in patient. In summary, LF, XTR and FLB all release fluoride during the study period but the amounts released by XTR and FLB were significantly greater than that released by LF and these levels increased over time for XTR and FLB but remained constant for LF. This information can guide practitioners in the choice of bonding agent used with sealant.

REFERENCES

Basso GR, Borba M, Della Bona A. Influence of different mechanisms of fluoride release from adhesive systems. Braz Dent J 2013; 24: 522-6.

Borsatto MC, Corona SA, Alves AG, Chimello DT, Catirse AB, Palma-Dibb RG. Influence of salivary contamination on marginal microleakage of pit and fissure sealants. *Am J Dent* 2004; 17: 365-7.

Das UM, G S. Bonding agents in pit and fissure sealants: a review. *Int J Clin Pediatr Dent* 2009; 2: 1-6.

Demirci M, Tuncer AS, Yuceokurb AA. Prevalence of caries on individual tooth surfaces and its distribution by age and gender in university clinic patients. *Eur J Dent* 2010; 4: 270-9.

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 D, Koliniotou–Koumpia E, Kotsanos N. The effect of low–concentration fluoride solutions on fluoride recharge ability of contemporary dental restoratives and adhesives. *Fluoride* 2015; 48: 351-63.

Feigal RJ, Musherure P, Gillespie B, Levy-Polack M, Quelhas I, Hebling J. Improved sealant retention with bonding agents: A clinical study of two-bottle and single-bottle systems. *J Dent Res* 2000; 79: 1850-6.

Han L, Edward C, Okamoto A, Iwaku M. A comparative study of fluoride-releasing adhesive resin materials. *Dent Mater J* 2002; 21: 9-19.

Han L, Okamoto A, Fukushima M, Okiji T. Evaluation of a new fluoride-releasing one-step adhesive. *Dent Mater J* 2006; 25: 509-15.

Ito S, Iijima M, Hashimoto M, Tsukamoto N, Mizoguchi I, Saito T. Effects of surface pre-reacted glass-ionomer fillers on mineral induction by phosphoprotein. *J Dent* 2011; 39: 72-9.

Naaman R, El-Housseiny AA, Alamoudi N. The use of pit and fissure sealants - a literature review. *Dent J* (Basel) 2017; 5(4). pii: E34.

Pongprueksa P, Senawongse P, Vongphan N. Effect of dentinal tubule orientation on the modulus of elasticity of resin-infiltrated demineralized dentin. *Dent Mater J* 2014; 33: 54-8.

Simonsen RJ. Pit and fissure sealant: review of the literature. *Pediatr Dent* 2002; 24: 393-414.

Suwansingha O, Rirattanapong P. Effect of fluoride varnish on caries prevention of partially erupted of permanent molar in high caries risk. *Southeast Asian J Trop Med Public Health* 2012; 43: 808-13.

Yap AU, Tham SY, Zhu LY, Lee HK. Short–term fluoride release from various aesthetic restorative materials. *Oper Dent* 2002; 27: 259-65.