THE EFFECT OF CHANGES IN THE POWDER LIQUID RATIO OF GLASS-IONOMER SEALANT ON THE AMOUNT OF FLUORIDE RELEASED

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Abstract. Glass-ionomer sealant is used to seal teeth pits and fissures in order to prevent caries formation and release fluoride. It is made by mixing powder and liquid, where the powder contains fluoride and the liquid enables it to penetrate into small pits and fissures. The powder to liquid (P/L) ratio can determine the efficiency of the sealant. We aimed to determine the amount of fluoride released by varying P/L ratios in order to obtain the best penetration versus fluoride released ratio. The study was performed on 4 groups of 5 sealent specimens each: Group 1 – the P/L ratio was that recommended by the manufacturer; Groups 2, 3 and 4 had 25%, 50% and 75% less powder than recommended by the manufacturer. In each group the prepared sealant was placed in a mold and light cured for 20 seconds. Each group of specimens was placed in deionized water and the amount of fluoride released in each group was measured in the water on days 1, 7, 14 and 21. The measured results for each group at each time period were compared with the one-way ANOVA and Tukey's tests. In all the groups the fluoride levels were highest on day 1 slowly decreased for 7 days and then remained the same after 7 days for the duration of the study. Group 4 released significantly more fluoride than Groups 1-3 on day 1 (p=0.000). Groups 3 and 4 were not significantly different from each other in fluoride release after 1 day (p>0.05) but both released significantly more fluoride than Groups 1 and 2 at all times sampled (p<0.05). There were no significant differences in fluoride release between Groups 1 and 2 (p>0.05). Reducing the amount of powder to lower than the manufacturer's recommendations resulted in significantly greater release of fluoride. Further studies are needed to determine the duration of fluoride release is affected for greater than 21 days and whether the protective effect of the sealant is altered by the lower powder to liquid ratio.

Keywords: fluoride, fluoride releasing sealant, glass ionomer, powder/liquid ratio, release

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INTRODUCTION

Dental caries are one of the most common oral health problems in childhood (Benzian *et al*, 2011). Pit and fissure caries on the occlusal surfaces of the teeth comprise 90% of the caries incidence in children and adolescents (Chen and Liu, 2013). Pit and fissure sealant application is effective in preventing caries progression and tooth loss (Simonsen, 2002). Resin-based and glass-ionomer sealants are commonly used pit and fissure sealants (Seppä *et al*, 1993). Resin-based sealants have high retention rates (Llodra *et al*, 1993) but are clinically difficult to apply in a moist environment. Glass-ionomer sealant can be effective in newly erupted molars or when resin sealant is too difficult to effectively apply. Glass-ionomer sealant is easier to apply in a moist environment, has good chemical adhesion to teeth, releases fluoride and its preventive effeciency can persist even with visible loss of the material (Smales and Gao, 2000).

Glass-ionomer sealant is prepared by manual mixing a powder with a liquid. The power/liquid (P/L) ratio is important to the physical property of the glass-ionomer sealant (Eames *et al*, 1977). One study (Fleming *et al*, 1999) found the ideal mixing conditions of glass-ionomer sealant are seldom achieved. The P/L ratio used by the clinician may vary from that recommended by the manufacturer. Some clinicians reduce the P/L ratio in order to make it flow into the pits and fissures more easily (Celiberti and Lussi, 2007). Visual measurements and careless use of the measuring spoon and liquid dropper can also affect the P/L ratio (Torabzadeh *et al*, 2011). A change in the mixing ratio may affect the properties of glass-ionomer sealant (Torabzadeh *et al*, 2015).

Fluoride release is one of the most important characteristics of glass-ionomer sealant. The effects of altering the P/L ratio of the glass-ionomer sealant on its efficiency is controversial (Torabzadeh *et al*, 2015). Since altering the P/L ratio can affect the properties of glass-ionomer sealant and since the effect of altering the P/L ratio on fluoride release is unclear, we determined to evaluate the effect of altering the P/L ratio of glass-ionomer sealant on the amount of fluoride released.

MATERIALS AND METHODS

Study groups

The glass-ionomer sealant used for this study was Fuji VII (GC Corp, Tokyo, Japan). We studied the fluoride varnish release by dividing the study into 4 groups with 5 specimens each. In Group 1, the sealant was prepared using the manufacturer's recommended P/L ratio; Groups 2, 3 and 4 had 25%, 50% and 75% less powder than the ratio recommended by the manufacturer, respectively.

Specimen preparation

The powder and liquid were mixed within the appropriate time period recommended by the manufacturer. The various concentrations of sealant were poured into plastic molds measuring 3×5 mm and a piece of thread was placed in each mold in order to suspend the block in distilled water in order to test the fluoride concentration. Each specimen was light cured for 20 seconds on both sides using a curing unit (3M™ ESPE™ Curing Light XL3000; 3M, Grafenass, Germany) and then suspended in 10 ml deionized water at 37°C. The water containing the specimens was tested for fluoride level on days 1, 7, 14 and 21. After each fluoride measurement, the specimen was removed from the distilled water, rinsed with distilled water and placed in a new container containing 10 ml new distilled water.

Fluoride analysis

The concentration of fluoride ions released from the sealant was measured using a fluoride-specific ion electrode (Orion EA940 expandable, Orion Research,

Table 1
Fluoride concentrations released by the studied glass-ionomer sealant at different powder/liquid ratios over time.

Study groups	Fluoride concentrations in ppm (±SD) at time of sampling after beginning the study.			
	Day 1	Day 7	Day 14	Day 21
Group 1	8.27 (±0.56)^{aA}	0.66 (±0.12)^{bA}	0.65 (±0.11)^{bA}	0.62 (±0.12)^{bA}
Group 2	3.2 (±0.52)^{aB}	0.64 (±0.19)^{bA}	0.60 (±0.10)^{bA}	0.57 (±0.09)^{bA}
Group 3	1.51 (±0.14)^{aC}	0.28 (±0.05)^{bB}	0.26 (±0.03)^{bB}	0.24 (±0.02)^{bB}
Group 4	1.36 (±0.30)^{aC}	0.25 (±0.02)^{bB}	0.23 (±0.02)^{bB}	0.21 (±0.03)^{bB}

ppm, parts per million; SD, standard deviation; P/L, powder/liquid.
Within columns, differences in lower-case superscript letters indicate significant differences by sample time.
Within columns, differences in upper-case superscript letters indicate significant differences by P/L ratio.

Beverly, MA) connected to an Orion digital ion analyzer (Orion 96-09, Beverly, MA). The electrode was calibrated using five standard fluoride solutions of 0.1, 1, 10 and 100 ppm fluoride (Gao and Smales, 2001) prior to each measurement.

Measurement of the fluoride concentration was performed by pipetting 10 ml of each sample solution into a clean plastic test tube, adding 1 ml TISAB III (total ionic strength adjustment buffer, 940911; Thermo Scientific Orion®, Beverly, MA) and stirring for 3 minutes with a magnetic stirrer before measurement (Bayrak *et al*, 2010). The measurements were repeated three times and the mean fluoride concentrations were recorded. The fluoride concentration was then converted into parts per million (ppm).

Statistical analysis

Differences in fluoride concentrations among the study groups were analyzed using the one-way ANOVA and Tukey's multiple comparison tests. Differences in fluoride concentrations in the same group at the different time points were analyzed using the one-way repeated measures ANOVA follow by the Tukey's multiple comparison test. Significance for all tests was set at $p<0.05$.

RESULTS

The means and standard deviations (SD) for the fluoride concentrations (ppm) at the different times using the different P/L ratios of glass-ionomer sealant are shown in Table 1 and Fig 1. In all groups, the largest concentration of fluoride was found on day 1. This decreased in all groups by 7 days and then remained constant until the end of the study on day 21. The concentration of fluoride in Group 4 on day 1 was significantly ($p=0.000$) higher than the other groups. There was no significant difference in fluoride concentration between Groups 3 and 4 on day 1 ($p>0.05$). Groups 3 and 4 had significantly higher concentrations of fluoride than the other groups at all times sampled. There were no significant differences ($p>0.05$) in fluoride concentration between Groups 1 and 2 at any of the times sampled.

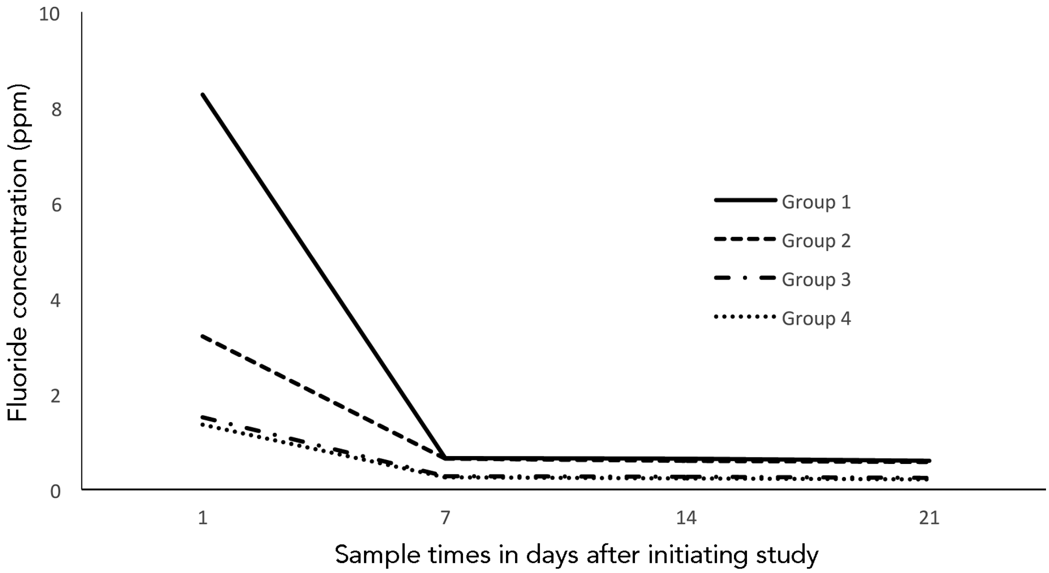

Fig 1–Fluoride concentrations of sample groups at different sample times. ppm = parts per million.

DISCUSSION

Our finding of a high concentration of fluoride found on day 1, decreasing by 7 days and then staying constant has also been reported in other studies (Torabzadeh *et al*, 2015; Prapansilp *et al*, 2017). The large initial fluoride concentration on day 1 was likely due to the burst effect of fluoride released from the glass particles due to its relatively weak bond from exposure to water during polymerization (Lin *et al*, 2008) and the constant level of fluoride released found at the later sampling times occurred because of the ability of fluoride to diffuse through the cement pores (Mousavinasab and Meyers, 2009).

The specimens with P/L ratios less than the manufacturer's recommended ratio had siginificantly higher fluoride concentrations than the specimens with the manufacturers recommended P/L ratio. A reason for this could be the greater solubility of fluoride at a lower P/L ratio, resulting in more fluoride release from the sealant (Muzynski *et al*, 1988). It is unclear if this will exhaust the sealant fluoride earlier with the lower P/L ratios resulting in a loss of the protective effect of the sealant, since we only studied fluoride concentrations.

To summarize, glass-ionomer sealant released a large amount of fluoride initially and this decreased by 1 week and remained the same for at least 21 days. Sealant with lower P/L ratios resulted in greater release of fluoride. The effect of this on caries prevention is unknown. Further studies are needed to determine this.

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