

Fluoride Release from Different Powder Liquid Ratios of Fuji VII

Woranun Prapansilp¹, Praphasri Rirattanapong¹, Rudee Surarit², Kadkao Vongsavan¹

¹ Department of Pediatric Dentistry, Faculty of Dentistry, Mahidol University

² Department of Oral Biology, Faculty of Dentistry, Mahidol University

Introduction: The quantity of fluoride ions released from glass-ionomer cements is of major importance in the prevention of dental caries in children. Fuji VII is a glass-ionomer that releases more fluoride ions than other fluoride releasing materials.

Purpose: To evaluate the concentration of fluoride ions released from the Fuji VII with differing powder liquid (P/L) mixing ratios.

Methods: Eight cylindrical specimens from four groups with different P/L ratios were prepared and immersed independently in 10 mL of deionized water. The fluoride release was evaluated on days 1-7 using a fluoride ion specific electrode. Statistical analyses of the difference between fluoride concentrations were analyzed using one-way ANOVA and Tukey's multiple comparison test.

Results: The fluoride released by the glass ionomers (GIs) was found to be highest during the first 24 h and decreased significantly; lower levels were obtained on day 7. Fuji VII P/L ratio 4:4 and Fuji VII P/L ratio 3:4 showed similar patterns and quantity of fluoride release, which were significantly lower than Fuji VII P/L ratio 2:4 and Fuji VII P/L ratio 1:4.

Conclusions: Fuji VII P/L ratio 2:4 and Fuji VII P/L ratio 1:4 released more fluoride than Fuji VII P/L ratio 4:4 and Fuji VII P/L ratio 3:4.

Keywords: fluoride release, fluoride releasing materials, Fuji VII, glass ionomer, powder liquid (P/L) ratio.

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Introduction

Dental caries, a common oral disease among Thai children, can result in pain and chewing difficulties. Recently, the Thai Dental Health Division (2012) [1] showed the prevalence of caries in Thai children in their report based on the findings of the Thai National Oral Health Survey. They found that more than 45 % of Thai children aged 3-12 years with dental caries did not receive dental treatment. This situation is a cause of concern for pediatric dentists as they recognize the importance of and have the responsibility for oral health of children. Dental treatment today not only removes caries lesions but also changes the

demineralization process caused by acid fermentation by bacteria into the remineralization process in enamel, helping the prevention of initial caries in children². The role of fluoride in preventing dental caries is well-established [3-5]. It is well understood that fluorides have an anti-cariogenic property and they prevent initiation and progression of caries [2].

Various restorative materials containing fluoride in their formulation are currently available on the market. These materials, including composite, compomers, and glass ionomers are able to release fluoride ions. The amount of fluoride release has been found to be consistently higher in glass ionomer materials than in other restorative

materials [6-8]. Glass ionomers (GIs) have been used for more than 20 years and their major advantage is their potential to inhibit caries in children [9,10]. There are many types of glass ionomers, including Fuji II LC, Fuji IX and Fuji VII. Fuji VII is a glass ionomer that was developed from conventional glass ionomers. It was developed to correct the disadvantageous properties of conventional glass ionomers. It is used as sealant and is a surface protectant material that can prevent dental caries. Among fluoride releasing materials, Fuji VII has shown the highest fluoride release [11]. This property may be useful in prevention of initial caries in Thai children. Fuji VII has is used as a hand-mixed preparation; some studies have shown that by varying the powder/liquid (P/L) mixing ratio of GIs it is possible to change their mechanical and physical properties [12,13]. Moreover Torabzadeh *et al* (2015) [14] has demonstrated that changing the P/L mixing ratio has an effect on the amount of fluoride release. Considering the significant the effect of P/L ratio on the fluoride release from glass ionomers, there is a lack of adequate studies and many of the issues in controversial studies have not been addressed. Therefore, this *in vitro* study aimed to investigate the amount of fluoride release from the glass ionomer Fuji VII, changed with varying P/L ratios.

Materials and Methods

This experimental study was conducted using the GI Fuji VII (GC Corporation, Tokyo, Japan).

Four groups of 8 specimens were prepared. Each group used a different P/L ratio

Group P/L ratio 4:4, mixed as recommended by the manufacturer

Group P/L ratio 3:4, this is 25% less powder than the ratio recommended by the manufacturer

Group P/L ratio 2:4, this is 50% less powder

than the ratio recommended by the manufacturer

Group P/L ratio 1:4, this is 75% less powder than the ratio recommended by the manufacturer

The powder and liquid were mixed according to the Fuji VII manufacturer's instructions (GC Corporation) within the instructed time period. To make the specimen the Fuji VII specimen was transferred to a plastic mold measuring 3 mm in diameter and 5 mm in depth. A piece of thin thread was placed inside the molds in such way that one end of the thread was out of the mold. This thread was used to suspend the specimens in the container which prepared for immersed the specimen. A plastic strip and a glass slab were placed on the molds to better pack the Fuji VII into the mold and allow any excess material to leak out. All specimens were polymerized for 20 s on both sides with a curing unit (3M™ ESPE™ Curing Light XL3000, 3M, Germany). After hardening, the specimens were removed from the mold and transferred into 10 mL of deionized water and stored at 37 °C. Specimens were transferred to new plastic containers with fresh deionized water every 24 h.

Fluoride analysis

Concentrations of released fluoride ions were measured using a fluoride-specific ion electrode (ORION EA™ 940 expandable, ORION, USA) connected to a ORION digital ion analyzer (ORION MODEL 96-04, 96-09, USA). Prior to each measurement, the electrode was calibrated using five standard fluoride solutions of 0.1, 1, 10, 20 and 100 ppm fluoride. The slope of the calibration curve varied between -54 to -60 at 25 °C.

Measurements were performed by pipetting 10 mL of each sample solution into a clean plastic test tube, adding 1 mL of TISAB II (Total ionic strength adjustment buffer, 940911, USA) and stirring for 3 min by magnetic stirrer (Clifton Cerastir™, CHARAN Associates CO, LTD.) before measurement. The measurement was repeated three times, the mean (\pm SD) of the

fluoride concentrations were recorded. Fluoride concentrations were automatically displayed on the analyzer and converted to parts per million (ppm).

Statistical Analysis

The difference in fluoride concentrations among experimental groups at the same time points were analyzed using one-way ANOVA and Tukey's multiple comparison test, with the level of significance set at $p < 0.05$. Differences in fluoride concentrations in the same group at the different time points were analyzed using one-way repeated measures ANOVA follow by Tukey's multiple comparison test, with the level of significance set at $p < 0.05$.

Results

Mean (\pm SD) concentration of fluoride released (ppm) from specimens in the four groups day 1-7 are shown in Table 1 and Fig 1. One-way ANOVA indicated that, at the same time point, the maximum fluoride release for days 1-7 was found in P/L ratio 1:4 group (75% less powder than

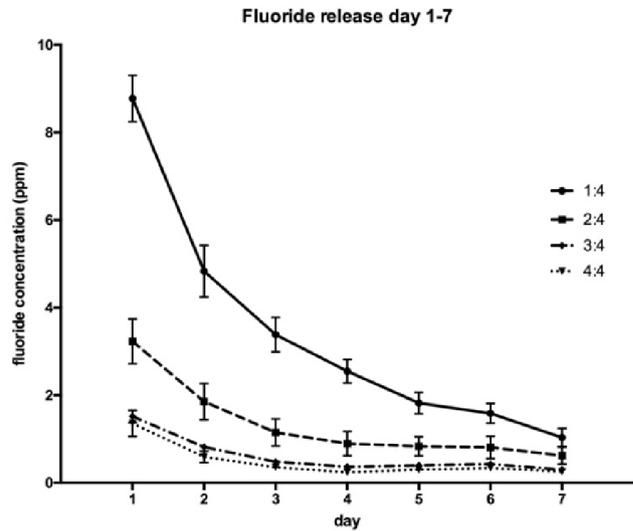


Figure 1. The mean (\pm SD) of the amount of fluoride (ppm) released from Fuji VII with different P/L mixing ratios.

recommended by the manufacturer). The P/L ratio 2:4 group had significantly higher fluoride release than the P/L ratio 3:4 group and the P/L ratio 4:4 group. Between day 1 and 7 there was no statistically significant differences in fluoride release between the P/L ratio 3:4 group and the P/L ratio 4:4 group, the ratio recommended by the manufacturer ($p > 0.05$).

Table 1. The mean (\pm SD) of the amount of fluoride (ppm) released from Fuji VII with different P/L mixing ratios. Differences in superscript letters indicate statistically significant differences within columns, and differences in superscript numbers indicate significant differences within rows ($p < 0.05$)

Group P/L ratio	1 st day	2 nd day	3 rd day	4 th day	5 th day	6 th day	7 th day
Gr 1 4:4	1.35 \pm 0.30 ^{a1}	0.59 \pm 0.13 ^{a2}	0.35 \pm 0.07 ^{a3}	0.24 \pm 0.04 ^{a4}	0.30 \pm 0.06 ^{a5}	0.34 \pm 0.05 ^{a6}	0.26 \pm 0.02 ^{a7}
Gr.2 3:4	1.51 \pm 0.14 ^{a1}	0.81 \pm 0.08 ^{a2}	0.48 \pm 0.03 ^{a3}	0.37 \pm 0.05 ^{a4}	0.40 \pm 0.07 ^{a5}	0.42 \pm 0.05 ^{a6}	0.30 \pm 0.05 ^{a7}
Gr.3 2:4	3.23 \pm 0.51 ^{b1}	1.85 \pm 0.42 ^{b2}	1.15 \pm 0.31 ^{b3}	0.89 \pm 0.28 ^{b4}	0.83 \pm 0.22 ^{b5}	0.81 \pm 0.26 ^{b5}	0.62 \pm 0.19 ^{b6}
Gr.4 1:4	8.78 \pm 0.53 ^{c1}	4.83 \pm 0.59 ^{c2}	3.38 \pm 0.39 ^{b3}	2.54 \pm 0.27 ^{c4}	1.82 \pm 0.25 ^{c5}	1.59 \pm 0.23 ^{c6}	1.03 \pm 0.21 ^{c7}

Discussion

Dental caries is one of the most prevalent chronic dental diseases affecting Thai children. Its progression or control depends on the balance between the demineralization and remineralization processes. One strategy for caries prevention focuses on stopping demineralization and improving the remineralizing process by using fluoride².

Many studies have showed that GI materials were the most suitable materials for prevention dental caries in children because of their continuous fluoride release [7,10,15]. This continuous fluoride release promotes reduction of the mineral dental structure solubility [10,13]. Because fluoride ion concentrations are essential for caries prevention and treatment, measuring of the amount of fluoride released from GIs is significant in understanding the cariostatic properties of GIs.

We found that the pattern of fluoride release from specimens in all groups released the highest amount of fluoride during the first 24 h and the levels of release decreased sharply in the following 7 days. This result was similar to the finding of Vermeersch *et al* (2001) [6], Bayrak *et al* (2010) [8] and Torabzadeh *et al* (2015) [14]. Two mechanisms have been proposed by which fluoride may be released from glass-ionomers. One mechanism is an initial high fluoride release over the first 24 h, likely due to the burst effect of fluoride released from the glass particles when reacting with the polyalkenoate acid during the setting reaction; this mechanism is short-term and rapid. The second mechanism is more gradual and results in the sustained diffusion of ions through the bulk cement [13,15]. Since fluoride is released from glass ionomer cements, it has been suggested that they will be clinically cariostatic [10,16].

The specimens with P/L ratio less than the manufacturer's recommended ratio appeared to

release significantly more fluoride than specimens prepared as recommended by the manufacturer. Similar results were reported by Torabzadeh *et al* (2015) [14] Muzynski *et al* (1988) [17], and Perrin *et al* (1994) [18]. The reason for decreased P/L ratios increasing the amount of fluoride released may be explained by the fact that an increase in solubility increases the dissolution of the exposed surface areas of the cement being release to higher amounts of fluoride ions [13, 19, 20].

With an increased P/L ratio the solubility of the glass ionomer increases and consequently its constituents, including the fluoride ions, also become more soluble. The high initial release and followed by a low but sustained release of fluoride ions from Fuji VII are vitally important in the remineralization of dental enamel and dentine [9]. This release- remineralization mechanism may have clinical therapeutic implications in vivo. This short-term in vitro study can be used to inform in future in vivo studies.

Conclusion

The results showed that the release of fluoride from the glass ionomers, Fuji VII, was time-dependent and decreased over-time. Decreasing the P/L mixing ratio had a significant effect on increasing fluoride release.

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