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# Effect of a Calcium Prerinse on Salivary Fluoride after a 228-ppm Fluoride Rinse

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**Key Words**
Calcium · Fluoride · Prerinse · Saliva

**Abstract**
The objective of this study was to determine if a concentrated calcium prerinse given before a fluoride rinse would cause an increase in the post rinse salivary fluoride (F). A panel of 5 subjects used a 30, 150 or 300 mmol/l calcium lactate prerinse followed by a 1-min NaF rinse. All calcium prerinses significantly increased the 1-hour saliva F relative to the NaF control without a prerinse. The maximum increase was produced by the 150 mmol/l calcium lactate prerinse and was about ninefold higher than the NaF control.



Increases in fluoride (F) in the fluid bathing the teeth profoundly affect the rate of dental de- and remineralization in vitro [ten Cate, 1990]. This observation has focused attention on the oral reservoirs in the mucosa and in the plaque that maintain saliva and plaque fluid F in vivo. Although the exact nature of these reservoirs is the subject of some dispute, they appear to be in the form of calcium-F moieties such as the mineral calcium fluoride ($CaF_2$), deposited on dental hard tissue and dental plaque [Rølla and Saxegaard, 1990], and bacterial calcium-F complexes in plaque [Rose et al., 1996]. Unfortunately during F dentifrice or F rinse usage oral formation of these calcium-F deposits is limited by a low concentration of unbound (bioavailable) oral calcium (about 1 mmol/l; Margolis and Moreno [1994]) relative to the amount of applied F (typically equal to or greater than 12 mmol/l). Attempts to remedy this situation by applying both calcium and F together in a single solution are of limited value due to the nearly instantaneous precipitation of $CaF_2$ particles that occurs when high concentrations of these ions are mixed [Chow et al., 1992]. Such particles do not appear to adhere to tooth surfaces [Chow et al., 1992] and are subsequently expectorated or swallowed. Several methodologies have been proposed to overcome this limitation, most notably a procedure that uses the slow hydrolysis of $Na_2SiF_6$ in a solution containing 10 mmol/l calcium [Chow et al., 1992]. While this 'controlled release' rinse has been shown to increase F deposition on sound enamel or root surfaces by nearly 20 times, concentrations in plaque fluid and salivary F produced by the experimental rinse were only about twice that of a conventional NaF rinse with the same total F content [Vogel et al., 1992, 2000, 2001]. In this study, we tested a different approach in an effort to produce a greater increase in salivary F: first apply a high concentration of calcium, and then apply the F therapeutic agent.

## Materials and Methods

*Subject Protocol*

Rinse administration and the collection of samples were done with the informed consent of the subjects following protocols reviewed and approved by the appropriate institutional review boards. The subjects (5 males) were screened before participation

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to insure good oral health, normal oral architecture, oral physiology and normal salivary gland function. All subjects lived in an area with fluoridated water and were instructed to use their normal oral hygiene procedures. The experiments were done at least 1 h after food ingestion and 3 or more hours after toothbrushing. Three or more days separated each experiment.

*Rinse Administration*

A 20-ml volume was used in all experimental rinses. In the first experiment, the optimum concentration of calcium for use as a prerinse was estimated using calcium lactate pentahydrate as the calcium source (Sigma-Aldrich, St. Louis, Mo., USA)[1]. The subjects rinsed for 1 min with a 30 mmol/l, 150 mmol/l or 300 mmol/l calcium lactate solution, expectorated the prerinse, and then immediately rinsed with an NaF rinse (12 mmol/l F – 228 ppm) for 1 min. A 228-ppm F NaF rinse, with no prerinse, served as a control. One potential problem with the highest (300 mmol/l) concentration calcium prerinse is the potential 'carryover' of calcium into the subsequent F rinse and hence the loss of F by $CaF_2$ precipitation in the rinse rather than on oral substrate surfaces. Indeed, preliminary experiments with these same subjects found a 6% carryover of calcium into the subsequent F rinse. However, another preliminary experiment showed that a 10-second water rinse reduced calcium carryover by 96%. Thus, in a second experiment, the subjects rinsed with 300 mmol/l calcium lactate for 1 min, rinsed with water for 10 second, and then rinsed with 12 mmol/l F NaF rinse for 1 min.

*Sample Collection and Analysis*

One hour after application of the F rinses in experiments 1 and 2, unstimulated saliva samples were collected by expectoration for 2 min [Vogel et al., 2001], centrifuged and the supernatant diluted 9 parts specimen with 1 part TISAB III (Thermo-Orion, Shelton, Conn., USA). The specimens were then analyzed using the inverted electrode apparatus previously described [Vogel et al., 1990].

*Statistical Procedures*

A significance level of $p < 0.05$ was used in all statistical tests which were performed using Winks statistical software (Texasoft, Cedar Hill, Tex., USA). An initial examination indicated that the data were not normally distributed. Thus, in order to normalize the data [Zero et al., 1992a; Vogel et al., 2000; Whitford et al., 2005], a logarithmic transformation of the salivary F levels was used prior to an analysis of variance test of the null hypothesis that there is no difference among the rinses in experiment 1. The Newman-Keuls multiple comparison test was then used on the transformed data to examine the effect of the rinses. For this same reason [Zero et al., 1992a], the geometric mean of the F values was used in place of the arithmetic means and the standard deviation factor (SDF) is presented in place of the standard deviation as a measure of the standard uncertainty. These are calculated by taking the log of the F concentrations, finding the means of the logs and their standard deviations, and then taking the antilogs. The SDF acts multiplicatively rather than additively: geometric means $\times/\div$ SDF.

[1] Disclaimer: certain commercial materials and equipment are identified in this paper to specify the experimental procedure. In no instance does such identification imply recommendation or endorsement by the National Institute of Standards and Technology or the ADA Health Foundation or that the material or the equipment identified is necessarily the best available for the purpose.

## Results

The results, given as the geometric mean and SDF, were NaF rinse only 16.8 (SDF 2.1); 30 mmol/l calcium prerinse/NaF rinse 36.2 (SDF 1.3); 150 mmol/l calcium prerinse/NaF rinse 152 (SDF 2.1), and 300 mmol/l calcium prerinse/NaF rinse 126.5 (SDF 1.3). The increases in F relative to the NaF rinse with the calcium prerinses were all statistically significant with the maximum increase (about $\times 9$) being observed with the 150 mmol/l calcium prerinse. The decrease from this maximum with the 300 mmol/l calcium prerinse was not significant. A further decrease in the 1-hour post rinse salivary F, to 81.7 (SDF 1.8), was seen in the second experiment when the 10-second water rinse was used between the 300 mmol/l calcium prerinse and the F rinse.

## Discussion

The 1-hour post rinse value obtained for the control NaF rinse is larger than values reported in previous studies (about 12 μmol/l) perhaps due to overnight fasting in these previous studies [Vogel et al., 1992, 2001]. Only two studies seem to have been done previously in which a simple calcium rinse was administered before an F treatment. In one in vitro study [Blake-Haskins et al., 1992], a 4.5 mmol/l calcium prerinse reduced lesion depth by 14% compared to the use of F rinse alone. In agreement with these modest results, Whitford et al. [2005] found in an in vivo study that a 20-mmol/l $CaCl_2$ prerinse used immediately before brushing with an F dentifrice had no effect on salivary F concentrations in which samples were collected 1 h and 12 h after brushing. These results are consistent with the relatively small effect on salivary F observed with the 30 mmol/l prerinse observed in the present study. This suggests that relatively high levels of calcium are required to produce a large amount of deposition of oral calcium F.

The nonsignificant decrease in F with the 300 mmol/l calcium prerinse relative to the 150 mmol/l prerinse might indicate $CaF_2$ precipitation from calcium carryover into the F rinse. However, when a water rinse was used to reduce calcium carryover (experiment 2), saliva F was further reduced, suggesting that the water rinse removed free calcium from oral tissue.

As noted in the introduction, a 'controlled release' type of enhanced F rinse produced a twofold increase in salivary F relative to NaF. As a result, this rinse induced much more remineralization in enamel lesions in an in-

traoral model [Chow et al., 2000]. This suggests that the very large increases in salivary F produced by the 150 mmol/l calcium prerinse could lead to a still greater cariostatic effect.

The type of calcium therapy described here can be applied in a variety of ways (i.e., as a rinse, a chewing gum, a calcium lozenge, or a calcium dentifrice), and appears to be compatible with most types of F therapies [Vogel et al., 2005]. The only requirement appears to be that the F agent should be applied soon after the application of a soluble calcium agent. Although the large increases in salivary F in this preliminary study is primarily the result of the formation of large bioavailable deposits on soft tissue surfaces [Zero et al., 1992b], the treatment is also likely to deposit large F reservoirs in phases, such as plaque, that are more relevant to caries progression and remission. The effect of the treatment described here on the F concentrations in plaque, and more importantly, its effect on plaque fluid F, remains to be investigated.

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