THE EFFECT OF INGESTED FLUORIDE ADMINISTERED IN SALT, MILK, AND TABLETS ON SALIVARY AND URINARY FLUORIDE CONCENTRATIONS

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SUMMARY: The effect of fluoride administered in salt, milk, and tablets on fluoride secretion in saliva and excretion in urine was compared in a medium-term study in 20 healthy adults 19–45 years of age (mean 25.6±7.4 yrs). After an introductory two-week control period, three four-week test periods were employed—each separated by two-week washout periods. In each test period, the subjects ingested one mg of fluoride daily in the morning as one of the following: fluoridated salt containing 250 mg F/kg, fluoridated milk containing 5 mgF/L, and fluoride tablets containing 1.1 mg F/tablet (Dentocar, Hungary). Samples of stimulated saliva and 24-hour urine were collected at the beginning (baseline) and at the end of each test period (final). Levels of salivary flow, pH, and fluoride in all baseline samples and in the final samples for the overall control period were practically unchanged. The level of fluoride (mg/L) secreted in saliva and excreted in urine was significantly higher (p<0.001) in the final samples after consumption of fluoridated salt, milk, and tablets, although it was less pronounced in case of salt.

Keywords: Fluoride in milk; Fluoride in salt; Fluoride tablets; Salivary fluoride, Urinary fluoride.

INTRODUCTION

During the last 25–30 years it has become increasingly clear that dental health has improved even in areas where fluoridation of public drinking water has not been implemented.¹ Because of the multifactorial etiology of dental caries, improved nutrition, including ingestion of more calcium and fiber-rich foods² and consumption of less refined sugar, plus better dental care could be responsible for much of this improvement.³ In countries with a high prevalence of dental caries, systemic fluoridation combined with topical application (e.g., fluoridated toothpaste and mouthrinses) continues to be recommended by supporters of dental fluoride in the World Health Organization,⁴ although in 1978 Tijmstra et al.⁵ reported finding no difference in dental caries between groups of fluoride tablet and fluoride toothpaste users and groups of non-users matched for socioeconomic status, toothbrushing habits, and frequency of candy-eating. Although fluoridated salt and milk are reported to be as effective in controlling tooth decay as fluoridated water,⁶,⁷ the importance of systemic administration of fluoride has come under question.³,⁸-¹¹ According to the US Centers for Disease Control and Prevention, the results of more recent epidemiological and laboratory studies indicate that the dominant role of fluoride in caries prevention is posteruptive (topical), which may be accented by ingested (systemic) fluoride.¹²-¹⁴

Over the years, the effect of fluoride administered systemically has been studied extensively in relation to its excretion in urine and saliva.⁶,¹⁵-²⁰ As far as
we have been able to ascertain, most investigations have compared the effects of different forms of fluoride supplementation on its excretion in urine in children. The present study was therefore undertaken to compare in adults the effect of physiological exposure to fluoride administered in different ways such as in salt, milk, and tablets on the ecology of the oral cavity (salivary flow rate, pH, and fluoride content of stimulated saliva) and on the urinary fluoride excretion.

**MATERIALS AND METHODS**

Twenty healthy dentate adults of normal body weight (nine men and eleven women) participated in the study. They ranged in age from 19 to 45 years (mean 25.6±7.4 yrs), and all were free of any illness and were not taking any medications. All had regular dental care and maintained good oral hygiene. After being given verbal and written information about the research, all the subjects consented to participate. The study protocol was approved by the Scientific and Ethical Committee of the Semmelweis University, Budapest, Hungary.

Each participant was asked to abstain from drinking black tea and fluoride mineral water, from eating high fluoride food (fish), and to refrain from using fluoride-containing toothpaste, gels, and mouthrinses for the duration of the study. The subjects were provided with non-fluoride toothpaste (Dabur herbal toothpaste, Northern Aromatics Ltd, New Delhi, India) and new toothbrushes throughout the study.

The study consisted of four 30-day test periods that were separated from each other by a two-week washout period. The tests were performed sequentially with four experimental regimens accompanying the normal diet: (1) no fluoride (control period, normal dietary habits, tap water with less than 0.1 mg F/L); (2) fluoridated salt (4 g fluoridated salt containing 250 mg F/kg, Bad Ischl, Austria); (3) fluoridated milk (200 mL containing 5 mg F/L and 1.5% fat, UHT milk, Parmalat, Hungary); and (4) fluoride tablets containing 1.1 mg F/tablet, Dentocar, Hungary).

Both saliva and urine samples were collected at baseline and after the four-week test periods. Paraffin-stimulated saliva samples were collected between 8.00 a.m. and noon after overnight fasting, and salivary flow rates (cm$^3$/min) were recorded. In both the saliva and urine samples, the fluoride concentration was determined with a fluoride ion specific electrode (9609, ORION Research Inc, Cambridge, Mass, USA), and the pH of the samples was measured by using the ORION pH electrode.

Statistical analysis between the test and control groups was carried out using Student’s t test, and the differences between baseline and four-week final data of both groups were compared with Student’s paired t test. The level of statistical significance was selected to be p<0.05.
RESULTS

Changes of secretion rate and pH in the stimulated whole saliva after the four experimental regimens are shown in Table 1. There were no statistically significant changes between the baseline and the final values of all groups.

Table 1. Changes in secretion rate and pH in the paraffin-wax stimulated saliva

<table>
<thead>
<tr>
<th>Regimen</th>
<th>n</th>
<th>Secretion rate (mL/min)</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Baseline (day 0)</td>
<td>Final (day 29)</td>
</tr>
<tr>
<td>Control</td>
<td>19</td>
<td>1.85±0.58</td>
<td>1.66±0.47</td>
</tr>
<tr>
<td>Fluoridated salt</td>
<td>20</td>
<td>1.91±0.46</td>
<td>1.70±0.62</td>
</tr>
<tr>
<td>Fluoridated milk</td>
<td>20</td>
<td>1.55±0.38</td>
<td>1.63±0.41</td>
</tr>
<tr>
<td>Fluoride tablets</td>
<td>20</td>
<td>1.72±0.66</td>
<td>1.82±0.39</td>
</tr>
</tbody>
</table>

Table 2 summarizes the changes in the amount of fluoride in the saliva. The fluoride content of the saliva samples increased significantly (p<0.001) in the three fluoride groups after four weeks of consuming fluoride in salt, milk, and tablets, with a less pronounced increase from the fluoridated salt.

Table 2. Changes in the amount of fluoride (mg/L) in paraffin-wax stimulated saliva

<table>
<thead>
<tr>
<th>Regimen</th>
<th>n</th>
<th>Fluoride (mg/L)</th>
<th>Statistical significance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Baseline (day 0)</td>
<td>Final (day 29)</td>
</tr>
<tr>
<td>Control</td>
<td>19</td>
<td>0.067±0.010</td>
<td>0.077±0.011</td>
</tr>
<tr>
<td>Fluoridated salt</td>
<td>20</td>
<td>0.055±0.018</td>
<td>0.360±0.071</td>
</tr>
<tr>
<td>Fluoridated milk</td>
<td>20</td>
<td>0.069±0.012</td>
<td>0.610±0.089</td>
</tr>
<tr>
<td>Fluoride tablets</td>
<td>20</td>
<td>0.047±0.010</td>
<td>0.570±10.078</td>
</tr>
</tbody>
</table>

The pH of the urine in the control and the different test groups did not change appreciably during the test period (Table 3).

Table 3. Changes in urine pH

<table>
<thead>
<tr>
<th>Regimen</th>
<th>n</th>
<th>pH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Baseline (day 0)</td>
</tr>
<tr>
<td>Control</td>
<td>19</td>
<td>6.12±0.58</td>
</tr>
<tr>
<td>Fluoridated salt</td>
<td>20</td>
<td>5.90±0.34</td>
</tr>
<tr>
<td>Fluoridated milk</td>
<td>20</td>
<td>6.35±0.78</td>
</tr>
<tr>
<td>Fluoride tablets</td>
<td>20</td>
<td>6.08±0.76</td>
</tr>
</tbody>
</table>
The four-week consumption of fluoride administered in salt, milk, or tablets significantly increased (p<0.001) the amount of fluoride in the urine samples of the different test groups (Table 4). As with the salivary fluoride, the increase from fluoridated salt was less pronounced, although it was still statistically significant (p<0.001).

**DISCUSSION**

This study compared the urinary and salivary concentration of fluoride after physiological exposure to fluoride administered in dietary salt, milk, and tablets. After four weeks of consumption of one mg fluoride/day from these sources, the amount of fluoride in 24-hr urine and stimulated whole saliva increased significantly in every case (Tables 2 and 4). These results agree with previous studies reporting increased levels of fluoride in saliva and urine following consumption of fluoridated salt, fluoridated milk, and fluoride tablets. Salivary fluoride concentrations peak rapidly (1 to 15 min) after ingestion, but the return to baseline takes 20 to 60 min, depending on the experimental conditions. These findings reflect exposure and bioavailability of fluoride to the salivary and urinary systems from these vehicles. Increased fluoride concentration in urine in long-term studies after exposure to fluoridated salt and to fluoridated milk has been well established.

Available data on the excretion of fluoride in saliva and urine after the consumption of fluoridated salt are somewhat limited and vary according to the duration and frequency of intake as well as in the number of subjects examined. In the small number of probands examined, Hefti et al. found similar values of excreted fluoride in 24-hr urine after consumption of fluoridated salt and fluoridated water. Schulte et al. observed increased fluoride excretion in the afternoon urine of persons consuming fluoridated salt only once a day in their food for lunch. Elevation of salivary fluoride levels was also noticed after single intakes of fluoridated salt-containing baked food items and meals containing fluoridated salt.

In the absence of comparable data on fluoride levels in saliva and urine following successive ingestion of fluoridated salt, milk, and tablets by the same group of subjects as in the present study, it is difficult to relate the results in the studies quoted above to all aspects of our findings. For example, the present study

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**Table 4. Changes in the amount of fluoride (mg/L) in urine**

<table>
<thead>
<tr>
<th>Regimen</th>
<th>n</th>
<th>Fluoride (mg/L)</th>
<th>Statistical significance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Baseline (day 0)</td>
<td>Final (day 29)</td>
</tr>
<tr>
<td>Control</td>
<td>19</td>
<td>0.286±0.083</td>
<td>0.232±0.036</td>
</tr>
<tr>
<td>Fluoridated salt</td>
<td>20</td>
<td>0.218±0.066</td>
<td>0.451±0.233</td>
</tr>
<tr>
<td>Fluoridated milk</td>
<td>20</td>
<td>0.247±0.079</td>
<td>0.671±0.319</td>
</tr>
<tr>
<td>Fluoride tablets</td>
<td>20</td>
<td>0.228±0.077</td>
<td>0.610±0.213</td>
</tr>
</tbody>
</table>
showed that although fluoride content of saliva and 24-hr urine was significantly higher (p<0.001) after administration of fluoridated salt, milk, and tablets, it was nevertheless less pronounced with fluoridated salt than after ingestion of fluoridated milk and tablets. Our subjects were given 4 g of salt containing 1 mg of fluoride as a daily single dose to be taken at breakfast in the morning. Some of the subjects used the daily dose for flavouring breakfast bread and butter whereas others, depending upon their dietary habits, used it for cooking as well. Since up to 59% of salt used for cooking can be lost due to the cooking procedure,35 this might explain the less pronounced increase in the level of fluoride in urine and saliva from fluoridated salt than from fluoridated milk and tablets.

It thus appears reasonable to suggest that, based upon the data related to the level of fluoride in urine and saliva obtained from the same individuals under similar experimental conditions, physiological exposure and bioavailability of fluoride in fluoridated salt, milk and tablets are comparable.

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