The Effects of Fluoride, Strontium, Theobromine and their Combinations on Caries Lesion Rehardening

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Background

- Theobromine was recently shown to enhance caries lesion remineralization in vitro [Ameachi et al., 2013].
- Strontium (Sr) has a long, controversial history in caries research [Lippert and Hara, 2013].
- Unlike calcium, Sr can be formulated in the presence of fluoride (F).
- Potentially synergistic effects between Sr, F and theobromine?

Materials and Methods

- **Experimental Design:**
  - Caries lesion creation: human enamel (4×3mm), demineralized for 24h at 37°C using a solution containing 50mM lactic acid and 0.2% Carbopol 907 which was 50% saturated with respect to hydroxyapatite at pH 5.0
  - Lesions assigned to nine treatment groups (n=16) based on Knoop surface microhardness (5 indentations, 50g load, 11s dwell time)
  - Treatment groups were (pH unadjusted, 6.5-7.0, aqueous solutions):

<table>
<thead>
<tr>
<th>Group</th>
<th>NaF [mM]</th>
<th>SrCl₂·6H₂O [mM]</th>
<th>Theobromine [mM]</th>
</tr>
</thead>
<tbody>
<tr>
<td>placebo</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2xF</td>
<td>11.91</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sr</td>
<td>23.82</td>
<td>1.14</td>
<td>-</td>
</tr>
<tr>
<td>theo</td>
<td>-</td>
<td>1.14</td>
<td>1.11</td>
</tr>
<tr>
<td>F+Sr</td>
<td>11.91</td>
<td>1.14</td>
<td>1.11</td>
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<tr>
<td>F+theo</td>
<td>11.91</td>
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<tr>
<td>Sr+theo</td>
<td>-</td>
<td>1.14</td>
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</tr>
<tr>
<td>F+Sr+theo</td>
<td>11.91</td>
<td>1.14</td>
<td>1.11</td>
</tr>
</tbody>
</table>

- 5-day pH cycling period:
  - 20 min: Artificial Saliva
  - 60 min: Demineralization Solution
  - 60 min: Artificial Saliva
  - 60 min: Demineralization Solution
  - 60 min: Artificial Saliva

- Artificial saliva composition: 1.5mM CaCl₂×H₂O, 0.9mM KH₂PO₄, 130mM KCl, 20mM HEPES, 3.08mM NaN₃, pH 7.0
- Demineralization solution: 50mM acetic acid, 2.2mM CaCl₂×H₂O, 2.2mM KH₂PO₄, 3.08mM NaN₃, pH 5.0
- Knoop surface microhardness measured again
- Percent surface microhardness recovery (%SMHr) calculated as follows: %SMHr = (ILlesion- ILpost)/(ILlesion-ILbase) × 100
- Enamel fluoride uptake (EFU) determined with acid-etch technique (15s with 0.5ml of 1M HClO₄ per specimen)

- **Statistical Analysis:**
  - one-way ANOVA; p<0.05; Fisher LSD Method

Results

- **Model showed F dose-response for %SMHr and EFU**
- The combinations of F+Sr and F+Sr+theo resulted in more rehardening than F alone, although F+theo was only directionally superior to F alone
- Neither Sr nor theo (or their combination) offered any rehardening in comparison to the placebo in absence of F
- For EFU, F+Sr was inferior to F alone
- Neither F+theo or F+Sr+theo delivered more fluoride to early caries lesions than F alone

Reference


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Fig. Mean %SMHr and EFU as a function of treatment during pH cycling period. Statistically significant differences are highlighted by different letters.

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