Occurrence of Dental Decay in Children after Maternal Consumption of Xylitol Chewing Gum, a Follow-up from 0 to 5 Years of Age

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**Occurrence of Dental Decay in Children after Maternal Consumption of Xylitol Chewing Gum, a Follow-up from 0 to 5 Years of Age**

**INTRODUCTION**

Dental caries is one of the most common infectious diseases seen in all populations. Mutans streptococci (MS), in particular *Streptococcus mutans* and *Streptococcus sobrinus*, are the major causative bacteria in human dental decay. Most children appear to acquire these bacteria from their mothers by saliva contacts during the emergence of the primary teeth at the age of 6-30 months (Berkowitz et al., 1981; Caulfield et al., 1993; Mohan et al., 1998). The initial establishment of MS cannot happen before the eruption of the first teeth, because tooth surfaces are needed as the habitat for the bacteria. After the initial colonization of MS, successful establishment of other bacteria on the tooth surfaces is impaired. Once MS have colonized on the teeth of a child, their presence is rather stable. Children whose teeth are colonized early by MS show greater caries occurrence than children with later or no MS colonization (Alaluusua and Renkonen, 1983; Köhler et al., 1988). In primary dentition, the presence of MS has been shown to be the most accurate indicator of caries risk. (For a recent review, see Powell, 1998.) It has been demonstrated that a reduction of MS in the saliva of the mothers has resulted in delayed acquisition of MS in children (Köhler et al., 1983, 1984). For example, Köhler et al. (1983) used chlorhexidine (CHX) in mothers with a high level of MS in saliva. The results showed that the reduction in the MS level of saliva of the mother had a long-term effect on the MS colonization and also on the caries experience of the child (Köhler and Andréen, 1994).

Short-term habitual consumption of xylitol has reduced the MS levels in saliva and in plaque (Loesche et al., 1984; Söderling et al., 1989). Xylitol also reduces the amount of plaque (for reviews, see Mäkinnen and Isokangas, 1988; Trahan, 1995). In long-term consumption, xylitol appears to select for MS which are easily shed into the saliva from the plaque (Söderling et al., 1991; Trahan et al., 1992). It is therefore possible that xylitol could affect the transmission of MS from the mother to her child. To test this hypothesis, we carried out a clinical trial at the Ylivieska Health Care Center, Finland, starting in 1991. The bacteriological results revealed that habitual xylitol consumption by mothers was associated with a statistically significant reduction in the probability of mother-child transmission of MS assessed in children at 2 years of age. The effect was superior to that obtained with either chlorhexidine or fluoride varnish treatments performed as single applications in mothers at six-month intervals. The study design and the results have been published earlier in detail (Söderling et al., 2000).

The aim of the present study was to analyze caries occurrence, up to the age of 5 years, in those children whose mothers had participated in the clinical trial described above.

**SUBJECTS & METHODS**

For the transmission study, a total of 338 pregnant women was screened. Altogether, 195 women showed high levels of MS in their saliva (CFU ≥ 10⁵/mL) and were invited to participate in the study. Of them, 120 were
randomly assigned to the xylitol gum group, 32 to the chlorhexidine (CHX) treatment group, and 36 to the fluoride group. In addition, seven mothers who reported use of xylitol chewing gum on a daily basis were assigned to the xylitol group. The children of these seven mothers were first excluded in all analyses in the present study; however, in no way did these children differ from the other children in the xylitol groups at any annual examination. Therefore, they were included in all the results. For the details of the study design, see Söderling et al. (2000).

The mothers started using xylitol chewing gum three months after the birth of the baby, and the use of xylitol was discontinued 24 months after the delivery. The chewing gum contained xylitol as the only sweetener (65% w/w), and the average daily dose of xylitol was 6 to 7 g, with an average consumption frequency of four times per day. The mothers in the CHX group received a total of three chlorhexidine varnish (EC40®, Certichem, Nijmegen, The Netherlands) treatments, and the mothers in the fluoride group three fluoride varnish (Duraphat®, Rhone-Poulenc Rorer, GmbH, Köln, Germany) treatments, i.e., 6, 12, and 18 months after the delivery of the child. The children themselves were not treated with any prophylactic measure before the age of 2 years. All the children, regardless of the study group and regardless of the possible caries risk, got an oral health care program which has been routinely given to children under 5 years of age in the Finnish public health care system, including regular examinations, advice on diet, oral hygiene and use of fluorides, and, where necessary, restorative treatment. Until the children were 2 years old, all mothers in the fluoride and CHX groups followed the given instructions and did not use xylitol chewing gum. When the children were four, all the mothers were interviewed on post-intervention use of xylitol chewing gum. All together, 35% of the mothers in the xylitol and CHX groups and 16% in the fluoride group reported that they were currently daily users of xylitol-containing chewing gum. These differences were statistically non-significant.

All together, 164 children—103 from the xylitol group, 28 from the CHX group, and 33 from the fluoride group—were available for both clinical and microbiological examinations at the age of 2 years, while 143 children, 73.3% of the original 195 mother-child pairs, were available when the children were 5 years old. The main reason for the loss of subjects was that they moved away from the area. For the present study, the teeth of the children were examined annually for possible dental decay, starting at the age of one year, by eight experienced clinicians who routinely cared for these children. The same dentist carried out all dental examinations, saliva and plaque collections, and varnish treatments of the mothers throughout the study. Thus, each child was examined by only one dentist. All the examiners were blinded throughout the study with regard to the MS colonization of the child. The examiners were not blinded as to the mother's group during the first two annual examinations when the children were 1 and 2 years of age but were blinded during the clinical examinations of the child at the ages of 3, 4, and 5 years.

The clinical caries examinations took place in a fully equipped dental chair with good illumination. Dental caries was registered according to the WHO criteria (1979), and the teeth were examined by means of a sharp explorer, fiber optic transillumination (FOTI), and mouth mirror. The clinical examinations were carried out as part of routine practice for all children at the Ylivieska Health Care Center. The only exception was that all the examinations of these children were carried out at 12-month intervals, and not at individualized intervals. No x-rays were taken. For the analyses, only lesions extending to the dentin, and fillings, were included. As described earlier, the study had been accepted by the Ethical Committee of the Ylivieska Health Care Center, and all the participating mothers also accepted the study (Söderling et al., 2000).

We used the life table method in estimating the survival times, measured according to the age of the child at the first observed caries attack. The Cox relative hazard model was used to test the group differences and the effect of MS colonization in children at the age of 2 years on the survival times. The differences in dmF figures among the xylitol, CHX, and fluoride groups at the age of 5 years were tested with Student's t test. The analyses were carried out by means of the Statistica (1991) program.

RESULTS
The association between MS colonization in children at the age of 2 years and the first caries attack in the primary
dentition was clear and systematic. The first caries attacks occurred later in all the non-colonized groups than in the corresponding colonized groups. The risk ratio between the children colonized and those non-colonized with MS at the age of 2 years was 3.60 (95% CI, 1.99-6.49; Beta coefficient, 1.28; SE 0.300; df = 1; p < 0.001). The applied treatment as such had no additional explanatory power. The differences in risk between the chlorhexidine and the xylitol groups (RR = 1.39; 95% CI, 0.69-2.79), as well as between the fluoride and the xylitol groups (RR = 1.27; 95% CI, 0.65-2.47), were not statistically significant (Cox relative hazard model) (Table 1, Fig. 1).

The subjects not colonized with MS at the age of 2 years showed less total caries experience (dmf) at all annual examinations than the colonized children in all groups (Table 2). At the age of 5 years, the xylitol group showed significantly less total caries experience than both the CHX and the fluoride groups (p < 0.001) (Table 2). The caries reduction, measured with the dmf index, was 71% between the xylitol and the fluoride groups, and 74% between the xylitol and the CHX groups. The difference between the CHX and the fluoride group was not statistically significant.

**DISCUSSION**

The result that, regardless of the treatment group, the children who were not colonized by MS at the age of 2 years showed less caries at all annual examinations than the children colonized with MS is in good agreement with results of earlier studies: if no early MS colonization, then less decay (Alaluusua and Renkonen, 1983; Köhler and Andréen, 1994). Mothers' habitual xylitol consumption during the tooth eruption of their children successfully reduced the mother-child transmission of MS (Söderling et al., 2000), which further resulted in reduced dental decay in their children's primary dentition. The superiority of xylitol in caries prevention when compared with fluoride and CHX was, therefore, based on its superior ability to prevent MS colonization. One suggested explanatory mechanism for the favorable results with xylitol is that the adhesive properties of the MS bacteria have been altered as a result of regular use of xylitol chewing gum in such a way that the MS bacteria can no longer tightly grip tooth surfaces but are easily flushed away by saliva (Söderling et al., 1991; Trahan et al., 1992).

**Table 2. Annual Mean dmf Figures in the Xylitol, Chlorhexidine, and Fluoride Groups**

<table>
<thead>
<tr>
<th>Group</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>n</td>
<td>Mean</td>
</tr>
<tr>
<td>Xylitol, all</td>
<td>0.02</td>
<td>0.20</td>
<td>103</td>
<td>0.17</td>
</tr>
<tr>
<td>aMS-</td>
<td>0.00</td>
<td>0.00</td>
<td>93</td>
<td>0.09</td>
</tr>
<tr>
<td>bMS+</td>
<td>0.20</td>
<td>0.63</td>
<td>10</td>
<td>1.00</td>
</tr>
<tr>
<td>Chlorhexidine, all</td>
<td>0.21</td>
<td>0.83</td>
<td>28</td>
<td>0.77</td>
</tr>
<tr>
<td>MS-</td>
<td>0.00</td>
<td>0.00</td>
<td>20</td>
<td>0.06</td>
</tr>
<tr>
<td>MS+</td>
<td>0.75</td>
<td>1.49</td>
<td>8</td>
<td>2.38</td>
</tr>
<tr>
<td>Fluoride, all</td>
<td>0.21</td>
<td>0.70</td>
<td>33</td>
<td>0.55</td>
</tr>
<tr>
<td>MS-</td>
<td>0.00</td>
<td>0.00</td>
<td>17</td>
<td>0.41</td>
</tr>
<tr>
<td>MS+</td>
<td>0.44</td>
<td>0.96</td>
<td>16</td>
<td>0.69</td>
</tr>
<tr>
<td>Total n</td>
<td>164</td>
<td></td>
<td>156</td>
<td></td>
</tr>
</tbody>
</table>

a MS = MS not detected in children at the age of 2 years.

b MS+ = MS detected in children at the age of 2 years.

c The group differs significantly from the chlorhexidine and fluoride groups, p < 0.001.
Fluoride varnish treatment is known not to reduce MS
counts in saliva (Schaeken et al., 1991). The result with CHX
treatment was, however, weaker than we expected. There are
two possible explanations for this observation. First, the loss
of subjects during the follow-up from 2 to 5 years was similar
in the xylitol and the fluoride groups but not in the CHX
group, where all withdrawals took place in the subgroup
without MS colonization at the age of 2 years (Table 2). This
asymmetry alone explains the higher average caries experience
in the total CHX group compared with the total fluoride group.
Second, we treated the mothers at six-month intervals. A
higher frequency of treatments might have improved the
results, but this would also have increased the number of visits
to dental clinics. Due to the small sample size, no definite
conclusions can be drawn from the results with CHX in the
present study.

It is a well-known fact that caries registrations show
considerable variation among examiners. For practical
reasons, it was not possible in the present study to organize
inter- and intra-examiner analyses. All eight examiners,
however, were experienced clinicians who had been earlier
calibrated, and their inter- and intra-examiner variations had
been analyzed in association with an earlier xylitol study at
the same health care center (Isokangas et al., 1988). It could
be suspected that some of the examiners may have registered
dental decay in a biased manner, because they knew the
mother-child pair group until the child was 2 years of age,
and they could thus have also remembered the group during
later examinations. There are some factors, however, that
make this assumption rather improbable. First, the study was
blind with regard to MS colonization. It is not possible, in a
clinical examination, to see with the naked eye whether the
child is colonized with MS. Second, many of the children
were colonized at the later clinical examinations, but nobody
knew which ones. The bacteriological analyses were carried
out at the University of Turku, at a distance of 600 km away
from Ylivieska, after the clinical examinations, by means of
a blind study design by a laboratory worker who was not
aware of the study design and had no information on the
outcome of the clinical caries examinations. The results at
every examination were similar in all non-colonized groups
but showed a systematic and logical difference between the
colonized and non-colonized children in caries figures
within all study groups (Tables 1, 2). In our opinion, it
would be impossible to get these kinds of results in a blind
study without true differences between and among the
groups. In addition, this was the first-ever mother-child
transmission study with xylitol. Therefore, none of the
examiners or researchers had any clues as to the possible
outcome of the study.

Despite decreased caries occurrence figures in almost all
industrialized countries during the last 20 years, we still lack
effective methods to prevent early childhood caries, and new
approaches are needed (Horowitz, 1998). Our study was the
first attempt to prevent the transmission of MS by maternal use
of xylitol. The effect of maternal use of xylitol on the
occurrence of caries in their children's primary dentition in the
present study was superior to that obtained with bi-annual use
of chlorhexidine or fluoride varnish treatments of the mothers'
dentition. Our study suggests that intervention against oral MS
colonization may lead to better caries prevention than the
traditional preventive measures concentrating on increasing the
resistance of the teeth but leaving the cariogenic micro-
organisms alone.

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Nijmegen, The Netherlands.

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establishment and dental caries experience in children from 2 to 4

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