EFFECT OF THE METHYL METHACRYLATE-TRIBUTYLBORANE SEALANT IN PREVENTING OCCLUSAL CARIES

BY

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ABSTRACT

A newly developed pit and fissure sealant, named Enamite, was studied technologically and clinically. Major ingredients of the sealant are a solution of 3% 2-hydroxy-3-β-naphthoxypropyl methacrylate in methyl methacrylate and poly (methyl methacrylate) powder, using tributylborane as an initiator. In comparison with other commercially available sealants, Enamite showed much greater adhesiveness to enamel, which was confirmed by scanning electron microscopic observations.

The sealant was applied to 161 first molars in 99 children, aged 6-8 years, to determine the caries preventive as well as the caries retardation effect. Among the treated teeth, 98 were intact and the remaining had incipient caries. The right side teeth of each subject was assigned to the test side and the other side served as a control. Each child was evaluated every 6 months by clinical exploration and bite-wing X-ray survey. At the final examination, the electric conductivity test was also used for the caries detection.

After 2 years the sealant was effective in preventing 57.1% of the occlusal caries on treated compared with control teeth. When evaluation was made by including the caries retardation effect—teeth initially carious but remaining sealed after 2 years were counted as effective—, the sealant was effective in preventing or retarding 96.3% of the occlusal caries.

INTRODUCTION

In a recent publication1) we reported that examinations after one year revealed that the sealing of pits and fissures of 82 human primary molars with an adhesive resin of methyl methacrylate-tributylborane system had resulted in 50.3% reduction of dental caries incidence.

This report presents technological characteristics of the adhesive resin, of which adhesive strength was enhanced by replacing HPPM (2-hydroxy-3-phenoxypropyl methacrylate) with HNPM (2-hydroxy-3-β-naphthoxypropyl methacrylate) in MMA (methyl methacrylate), and protective effects for the occlusal surfaces of first permanent molars examined for 2 years.

MATERIAL AND TECHNOLOGY

Major ingredients of the adhesive sealant are a solution of 3% HNPM in MMA and poly (methyl methacrylate) powder, using TBB (tributylborane) as an initiator (Fig. 1).

The measurement of adhesive strengths between 60% phosphoric acid-etched bovine enamel surface and PMMA round

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stick joined by the adhesive sealants showed the highest values in this newly
developed adhesive sealant, as shown in
Table 1. The adhesive sealant showed ac-
ceptable adhesive strength even after one-
month storage in 37°C water, or 2-hr per-
colation test of alternative immersion in

\[
\begin{align*}
\text{CH}_3 \\
\text{CH}_2=\text{C} \\
\text{COO-CH}_3 \\
\text{MMA} \\
\text{CH}_3 \\
\text{CH}_2=\text{C} \\
\text{COO-C-H}_2-\text{CH}-\text{CH}_2-O- \\
\text{OH} \\
\text{HNPM} \\
\text{CH}_2\text{CH}_2\text{CH}_3 \\
\text{CH}_3(\text{CH}_2)_3\text{CH}_2\text{C}=\text{B-CH}_2(\text{CH}_2)_2\text{CH}_3 \\
\text{TBB}
\end{align*}
\]

Fig. 1. Chemical formulas of MMA, HNPM, and TBB derivative.

0.2% fuchsin solutions at 4°C and 60°C for
1 min, while other commercially available
materials showed significant decrease of
the adhesive strength under these condi-
tions. This was confirmed by scanning
electron micrographic observations.

Fig. 2 shows the so-called tagging effect
of the sealant into the surface enamel
etched for 30 sec by 60% phosphoric acid
before application of the sealant, and Fig.
3 shows the reverse side of the applied
sealant. The specimen was prepared by
complete removal of tooth substance by

<table>
<thead>
<tr>
<th>Sealants</th>
<th>Time in 37°C water</th>
<th>After 2 hr percolation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>24 hr</td>
<td>1 week</td>
</tr>
<tr>
<td>Enamite</td>
<td>60</td>
<td>55</td>
</tr>
<tr>
<td>Nuva Seal</td>
<td>40</td>
<td>30</td>
</tr>
<tr>
<td>Directon S.</td>
<td>30</td>
<td>30</td>
</tr>
</tbody>
</table>

* Mean values of 15 tests

Fig. 2. SEM picture showing the tagging effect of the sealant into
the surface enamel (×5000) (A. Ishizaki, 1973)
PREVENTING OCCLUSAL CARIES

Prophylaxis with brush corn and dental floss
↓
Rubber dam application
↓
Drying with ethanol and compressed air
↓
Etching with 60% H₃PO₄ for 30 sec
↓
Washing with water spray
↓
Drying with compressed air
↓
Application of the sealant with fine brush
↓
Removal of rubber dam

Fig. 4. Application procedure of the sealant

acid application. The stability of adhesion with surface enamel was confirmed by several other in vitro studies²,³).

APPLICATION PROCEDURE AND EVALUATION METHOD

The scheme of application procedure is shown in Fig. 4. Firstly, oral prophylaxis should be given; rubber dam is applied using #14A clamp. Occlusal surface is dried by compressed air, and the site to be sealed by the sealant is etched with 60% phosphoric acid for 30 sec. The acid is washed out completely with a water spray, the occlusal surface is dried again, and the sealant is applied by a fine brush. The sealant drying takes about 5 to 6 min from mixing these agents. Finally, the rubber dam is removed and the patient is asked not to take any thing for 30 min to secure adhesion of the sealant. Fig. 5 shows the armamentarium of this procedure and Fig. 6 shows application technique of the sealant. In this particular case, a dye was added to the polymer for clear demonstration of the sealant, but commercially available material named Enamite is white. The sealed occlusal surface of upper first permanent molar is shown in Fig. 7. By using the afore-mentioned application procedure,
Fig. 5. Armamentarium of the MMA-TBB system sealant

Fig. 6. Application technique of the sealant

Fig. 7. Sealed occlusal surface of upper first permanent molar with MMA-TBB system sealant
the adhesive sealant was applied to 161 first permanent molars in 99 school children, aged 6 to 8, to evaluate the caries preventive as well as the caries retardation effects of this sealant.

Among the treated teeth, 98 were intact and the remaining teeth were having incipient carious lesions, but they were also subjected for exploring the possible caries retardation effect of the sealant application to the incipient carious pits and fissures. The right side teeth of each subject was assigned to the test side and the other side served as a control. Table 2 shows the initial stage of the caries experience of the subjected teeth.

Each child was recalled and evaluated every 6 months by clinical exploration for occlusal caries detection and bite-wing X-ray survey for proximal caries detection and for examining the extent of carious lesions. At the final examination, the electric conductivity test was also used for the caries detection. Compatibility of the clinically classified degrees of carious lesion and the resistance values read on the so-called Caries Meter was confirmed beforehand. When we define that intact or completely sealed teeth and C₀ teeth, that means teeth having a sticky fissure, should show a resistance value of over 600 kΩ, C₁ between 250 and 600 kΩ, and C₂ less than 250 kΩ, the rates of coincidence between clinical exploration and electric conductivity test were respectively 100% for the intact or completely sealed teeth, 69.5% for C₀, only 14% with wide variation for C₁, and 80% for C₂ teeth. From these results, the teeth showing the resistance of over 600 kΩ was classified into intact or completely sealed.

RESULTS AND DISCUSSION

When the two-year DF (decayed and filled teeth) increment of test side was compared with the control, caries reduction rate was calculated to be 57.1% as shown in Table 3. It should be mentioned that these data are not the true two-year follow-up, and some first permanent molars which became eligible for the sealant application or for control during the first 1.5 years were added to the subjects. At 12-month and 18-month observations, the sealant was supplementally applied to the teeth whose sealant was thought to have fallen off totally or partially, and these occlusal surface still being intact or incipient carious. When these teeth showed resistance of over 600 kΩ at the final examination, such teeth were defined as "reversal". These "reversals" were classified into the sealed teeth in Table 3. Table 4-a and -b show how respective intact, C₀, and C₁ teeth were protected by application of the sealant from extension of carious lesion. As mentioned before, "reversal" means that the occlusal surfaces remained sealed at the

<table>
<thead>
<tr>
<th>No. teeth examined</th>
<th>Intact or sealed teeth</th>
<th>No. DF teeth</th>
<th>DF increment (%)</th>
<th>Caries reduction (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test side</td>
<td>100</td>
<td>68</td>
<td>82</td>
<td>32.0</td>
</tr>
<tr>
<td>Control side</td>
<td>118</td>
<td>90</td>
<td>88</td>
<td>74.6</td>
</tr>
</tbody>
</table>

Table 2. Dental Caries Experience of First Permanent Molars at Baseline
Table 4a. Caries Extension for 2 years (Test side)

<table>
<thead>
<tr>
<th>Baseline</th>
<th>I (100)</th>
<th>C₀ (39)</th>
<th>C₁ (25)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 yrs. S (I)</td>
<td>46</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>S (Re)</td>
<td>22</td>
<td>22</td>
<td>8</td>
</tr>
<tr>
<td>DF</td>
<td>32</td>
<td>17</td>
<td>17</td>
</tr>
</tbody>
</table>

I=intact, S=sealed, Re=reversal

Table 4b. Caries Extension for 2 years (Control side)

<table>
<thead>
<tr>
<th>Baseline</th>
<th>I (118)</th>
<th>C₀ (20)</th>
<th>C₁ (13)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 yrs.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I</td>
<td>30</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>C₀</td>
<td>24</td>
<td>2</td>
<td>-</td>
</tr>
<tr>
<td>C₁~</td>
<td>23</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>F</td>
<td>41</td>
<td>13</td>
<td>11</td>
</tr>
</tbody>
</table>

end of two-year observation, even though they received supplemental application of the sealant in the process of two years of trailing.

The sealant was applied even to the incipient carious occlusal surface in order to test the possibility of caries retardation by the sealant application, since it is rather difficult to restore successfully such occlusal incipient caries by the conventional restorative techniques even when it is found at its earliest stage of carious development, as many clinicians realize it.

Respective 68% and 56.4% of intact and C₀ teeth remained sealed, while only 32% of C₁ teeth remained sealed as shown in Table 4a. This would indicate that caries retardation effect of the sealant could be expected in cases of the so-called sticky fissure stage or when the electric resistance value remains over 600 kΩ, but not for more extensive caries, possibly because of reduction of the tagging effect. The caries extension of the control side during 2 years of observation was obviously as much as average Japanese children of this age group, which is shown in Table 4-b.

Table 5. Caries Reduction including Caries Retardation Effect

<table>
<thead>
<tr>
<th>Baseline</th>
<th>2-year DF rates</th>
<th>DF increment</th>
<th>DF reduction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(%)</td>
<td>(%)</td>
<td>(%)</td>
</tr>
<tr>
<td>Test side</td>
<td>39.1</td>
<td>40.2</td>
<td>2.7</td>
</tr>
<tr>
<td>Control side</td>
<td>21.4</td>
<td>80.1</td>
<td>73.3</td>
</tr>
<tr>
<td></td>
<td>96.3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

When the intact sealed teeth were combined with all reversal teeth, then the DF incremental rate of test side was only 2.7%, whereas that of the control side was 73.3% (Table 5). In other words, the sealant was effective in preventing or retarding 96.3% of the occlusal caries of the first permanent molars for 2 years, when the careful follow-up examinations and supplemental application of the sealant are given after the sealant application.

CONCLUSION

1) In comparison with other commercially available sealants, the newly developed MMA-TBB system sealant showed a much greater adhesiveness to enamel, which was confirmed by scanning electron micrographic observations.

2) After a two-year observation, the sealant was effective in preventing 57.1% of the occlusal caries on the sealed first permanent molars, compared with control teeth.

3) When the intact sealed teeth were combined with all reversal teeth for the evaluation, the sealant was effective in preventing or retarding 96.3% of the occlusal carious lesion of first permanent molars.

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REFERENCES


