Bull. Tokyo Med. Dent. Univ., 23: 149-155, 1976,

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

BY

Ikuo OHMORI,*1 Kazuyoshi KIKUCHI,*1 Eiichi MASUHARA,*1
Nobuo NAKABAYASHI*2 and Shinsuke TANAKA*3

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 micrographic 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 assinged 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 publication[1] 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

*1 大森郁朗，菊池一嘉: Department of Pedodontics (Chief: Prof. I. OHMORI), Tsurumi University School of Dental Medicine

*2 増原英一，中林宣男: Division of Organic Materials (Chief: Prof. E. MASUHARA), Institute for Medical and Dental Engineering, Tokyo Medical and Dental University

*3 田中晋介: Mochida Pharmaceutical Co., Ltd., Material Laboratory

Received for publication, May 10, 1976.

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 acceptable adhesive strength even after one-month storage in 37° water, or 2-hr percolation test of alternative immersion in 0.2% fuchsin solutions at 4° and 60° for 1 min, while other commercially available materials showed significant decrease of the adhesive strength under these conditions. This was confirmed by scanning electron micrographic observations.

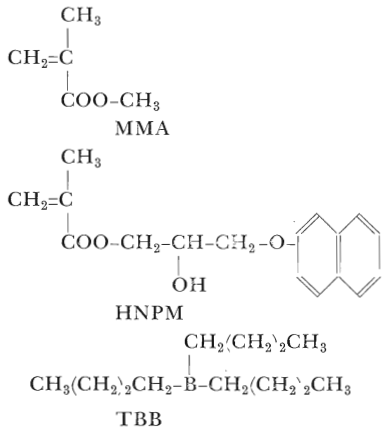

Fig. 1. Chemical formulas of MMA, HNPM, and TBB derivative.

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 1. Adhesiveness* to Bovine Enamel (kg/cm²)

Sealants	Time in 37°C water			After 2 hr percolation
	24 hr	1 week	1 mo.	
Enamite	60	55	55	50
Nuva Seal[4]	40	30	25	20
Directon S.	30	30	25	15

* Mean values of 15 tests

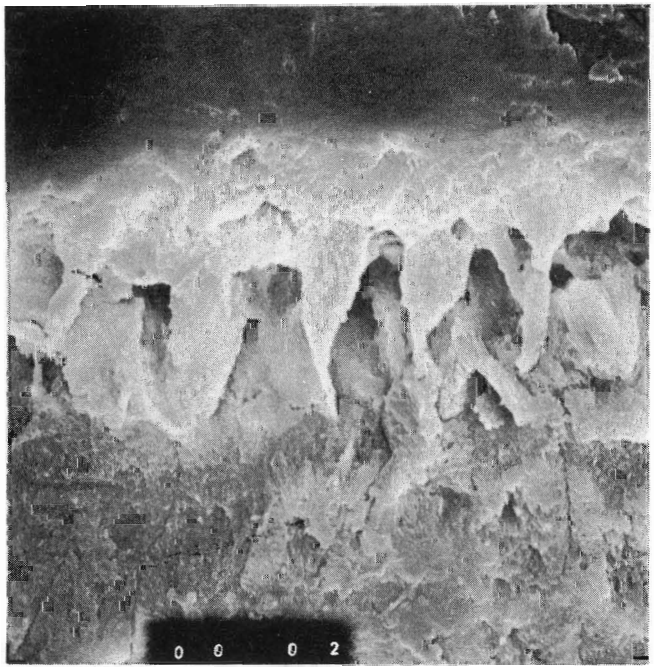

Fig. 2. SEM picture showing the tagging effect of the sealant into the surface enamel (×5000) (A. Ishizaki, 1973)

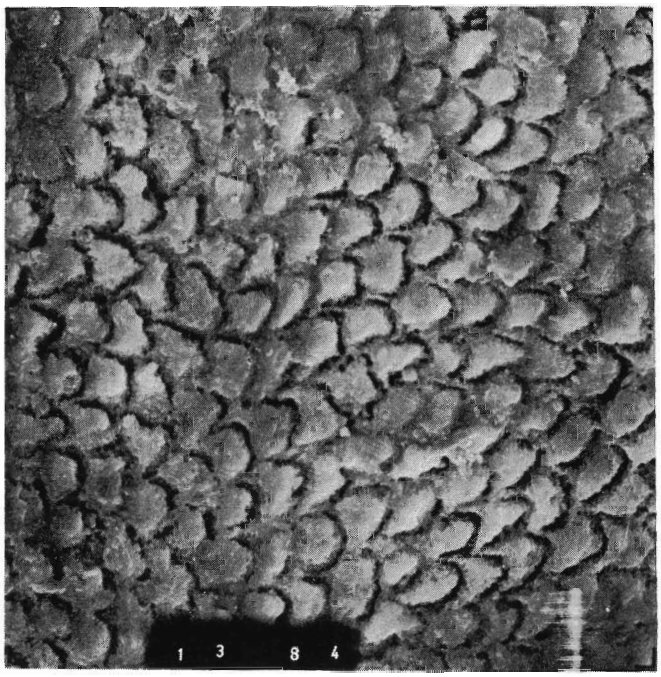

Fig. 3. SEM picture showing the reverse side of the applied sealant fitting the acid-etched enamel surface (×1000)

Prophylaxis with brush corn and dental floss
⇓
Rubber dam application
⇓
Drying with ethanol and compressed air
⇓
Etching with 60% H_3PO_4 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 studies[2,3].

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,

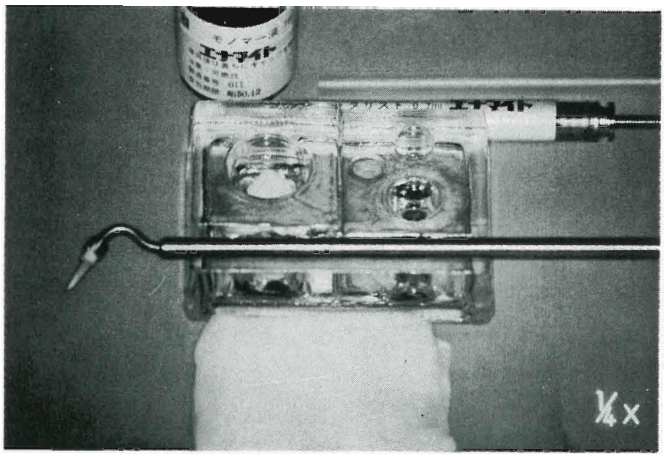

Fig. 5. Armamentarium of the MMA-TBB system sealant

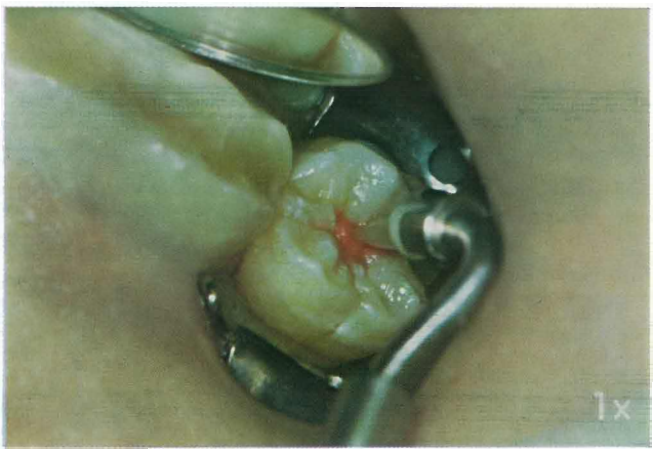

Fig. 6. Application technique of the sealant

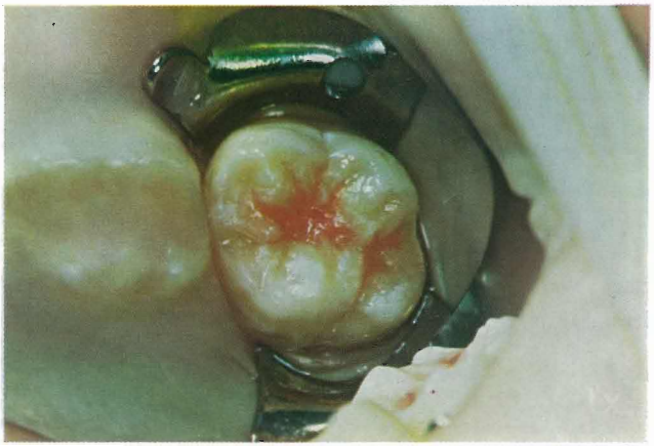

Fig. 7. Sealed occlusal surface of upper first permanent molar with MMA-TBB system sealant

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[5,6] 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[7] was confirmed beforehand. When we define that intact or completely sealed teeth and C_0 teeth, that means teeth having a sticky fissure, should show a resistance value of over 600 kΩ, C_1 between 250 and 600 kΩ, and C_2 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 C_0, only 14% with wide variation for C_1, and 80% for C_2 teeth. From these results, the teeth showing the resistance of over 600 kΩ was classified into intact or completely sealed.

Table 2. Dental Caries Experience of First Permanent Molars at Baseline

	No. teeth examined	Intact teeth	DF teeth	DF rates (%)
Test side	161	98	63	39.1
Control side	154	121	33	21.4

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, C_0, and C_1 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 3. DF increments and Caries Reduction

	No. teeth examined	Intact or sealed teeth	No. DF teeth	DF increment (%)	Caries reduction (%)
Test side	100	68	32	32.0	57.1
Control side	118	30	88	74.6	

Table 4a. Caries Extension for 2 years (Test side)

Baseline / 2 yrs.	I (100)	C_0 (39)	C_1 (25)
S (I)	46	—	—
S (Re)	22	22	8
DF	32	17	17

I=intact, S=sealed, Re=reversal

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

Baseline / 2 yrs.	I (118)	C_0 (20)	C_1 (13)
I	30	—	—
C_0	24	2	—
C_1～	23	5	2
F	41	13	11

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 C_0 teeth remained sealed, while only 32% of C_1 teeth remained sealed as shown in Table 4-a. 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

	Baseline DF rates (%)	2-year DF rates (%)	DF increment (%)	DF reduction (%)
Test side	39.1	40.2	2.7	96.3
Control side	21.4	80.1	73.3	

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.

Grateful acknowledgment is made of the participation in this study of the staff of Nagatacho Primary School, Chiyoda-ku, Tokyo (Principal: Mr. Toshiro Sato, School Nurse: Mrs. Hiro Yoda) and the staff of Department of Pedodontics, Tsurumi Uni-

versity, School of Dental Medicine for their earnest cooperation.

This paper was read before 24th General Meeting of the Japanese Society for Dental Health (October 11, 1975), 40th General Meeting of Japan Stomatological Society (November 8, 1975), and 54th General Session of International Association for Dental Research (March 27, 1976).

References

1) Ohmori, I., *et al.*: Caries prevention of primary teeth by the MMA-TBB sealant, *Jpn. J. Pedodontics*, 13 (1): 12–22, 1975 (in Japanese).
2) Masuhara, E., *et al.*: The application of acrylic resins of TBB activator system in early treatment and prevention of dental caries, Reports of Inst. for Med. Dent. Eng. Tokyo M. & D. Univ., 6: 76–81, 1972.
3) Nakabayashi, N., *et al.*: Development of pit and fissure sealant with MMA-TBB system resin. Paper read before the Society of Biomaterial Symposium, Philadelphia, 1976.
4) Buonocore, M. G.: Caries prevention in pits and fissures sealed with an adhesive resin polymerized by ultraviolet light; a two-year study of a single adhesive application, *J.A.D.A.*, 82 (5): 1090–93, 1971.
5) Mayuzumi, Y.: A method of diagnosing incipient caries in pits and fissures by measuring electric resistance, *Jpn. J. Conservative Dent.*, 7 (1): 50–69, 1964 (in Japanese).
6) Kawaguchi, Y., *et al.*: Relationship between the electrical resistance and the extent of enamel caries in pits and fissures, *Jpn. J. Conservative Dent.*, 14 (2): 242–53, 1972 (in Japanese).
7) Matsumoto, H., *et al.*: The study of electrical diagnosis of dental caries (Caries Meter), *Jpn. J. Conservative Dent.*, 17 (2): 290–303, 1974 (in Japanese).