



Occlusal Sealant Success Over Ten Years in a Private Practice: Comparing Longevity of Sealants Placed by Dentists, Hygienists, and Assistants

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Abstract

Purpose: The purpose of this 10-year, retrospective, cohort study was to evaluate the success of permanent molar sealants by comparing the effectiveness of sealants placed by dentists, dental hygienists, and dental assistants in a private dental practice, with all operators using an identical, standardized, application technique and 4-handed dentistry.

Methods: From 810 patient records that met entry criteria, the long-term follow-up records of 3,194 permanent first molars were evaluated. Data were collected and evaluated by survival analyses methods for: (1) time to first failure (caries or restoration of the sealed surface); (2) fluoride history; (3) caries experience; (4) operator type; (5) behavior at sealant placement; (6) tooth type; (7) age at placement; and (8) patient gender.

Results: Cumulative survival probability for 10 years in this practice was 87%, using Kaplan Meier analyses. The factors associated with an increased risk of failure included: (1) age ($P < .001$); (2) dmft ($P < .003$); (3) no fluoride ($P < .001$); (4) dentist ($P < .001$); and (5) registered dental assistant ($P < .001$). While all operator groups had success rates equal to or exceeding previous studies, dentists and registered dental assistants showed 3 times and 2 times the risk of failure, respectively, compared to the registered dental hygienists. The no-fluoride group showed almost twice the risk of failure as compared to the optimal fluoride group. Behavior showed a slightly higher risk of failure that approached significance. Age and dmft were highly significant, with slight increased risk of failure. Supplemental fluoride showed a protective effect, but this was marginally significant. Gender and tooth-type were not significant in this model. Major variations in success rates were observed in the dental assistant group, with 2 individuals accounting for most of the failures.

Conclusions: This study supports delegation of sealant delivery to auxiliaries, since dental assistants and dental hygienists were equal to or better than the dentists in long-term sealant effectiveness. (*Pediatr Dent.* 2004;26:426-432)

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Pits and fissures account for 88% of childhood caries in populations with overall low caries risk.^{1,2} Despite proven effectiveness of sealants in protecting caries-susceptible surfaces, sealant usage is not widespread. According to the NHANES III 1988-1991 survey, less than 20% of 5- to 17-year-old children had sealants placed on their permanent dentition.¹ With the improvement of materials, employing careful case selection and excellent

application technique and follow-up care, it has been reported that caries protection approaches 100% in pits and fissures in which sealant has been retained.³⁻⁸

The efficacy of sealants depends on many factors. There are controlled factors such as isolation, use of bonding agent, enameloplasty, and maintenance that may affect sealant retention.^{4-6,9} Factors such as the number of carious lesions present, fluoride exposure, diet, oral hygiene,

age, and patient behavior may contribute to sealant success,⁵ in addition to providing criterion for sealant usage.¹⁰

While many studies have focused on sealant effectiveness based on material type and controlled manipulative variables, the literature is limited regarding the effect various operator groups have on the efficacy of sealants. The length of studies ranged from 1 to 5 years, and the type of material and patient age were the controlling variables with the most influence.^{8,11-16} In 1986, Ooi and Tan compared a dentist with a dental assistant and did not find a significant difference between the 2 operators, although there was a statistical significance between the 2 types of sealants used.¹⁴ In a 1992 study comparing dental assistants to dental hygienists, Foreman and Matis found dental assistants to have a significantly better success rate than dental hygienists.¹⁶ Studies evaluating only dental assistants and only dental hygienists verified similar success rates to studies with dentists applying sealants.^{13,17}

The literature supports the delegation of sealant application to qualified personnel. In 1993, Foreman surveyed pediatric dentists nationwide and found that delegation of sealants was positively correlated to sealant usage.³⁰ As delegation increased, the quantity of sealants and its efficiency in larger practices also increased.

In 2000, Dennison et al recommended that sealants should be placed in higher risk groups, applied diligently, and maintained properly to be effective.³¹ Even with the present caries decline, 20% of the population has 80% of the disease.¹⁸ Studies have confirmed that children from lower socioeconomic populations are at higher risk for dental disease.¹⁹ In a 2001 study that evaluated sealant utilization in a Medicaid population, Dasanayake et al found the utilization rate to be low (5% per year).²⁹ To optimize sealants' effects and increase sealant utilization to 50% of children, in accordance with the US Public Health Service Healthy People 2000/2010 recommendation, delegating to dental auxiliaries may allow dentists to expand dental services to patients in need.

Therefore, the purpose of this study was to evaluate treatment outcomes over an extended time period on sealed permanent first molars in children between 5 and 16 years of age who have been treated in a private dental practice. The main objective was to evaluate the sealant success rates, comparing provider types—dentists, registered dental hygienists, and registered dental assistants—while controlling for patient variables previously shown to alter success rates: (1) gender; (2) age; (3) fluoride exposure; (4) behavior; and (5) previous caries activity.

Methods

Data collection

A retrospective cohort review of records of patients treated with pit and fissure sealants in a private pediatric dental office in Mankato, Minn, was completed on April 29, 2001. Subjects were selected following procedures ap-

proved by the University of Michigan Institutional Review Board for oversight of human subjects in research, as part of a study from the University of Michigan.

Approximately 6,000 records were reviewed, accounting for all active patients treated in the pediatric dental office between January 1987 and October 2000. The selection criteria for study case entry were:

1. fully erupted permanent first molars treated with occlusal pit and fissure sealants;
2. patients treated between 5 and 16 years of age;
3. patients treated between January 1987 and October 2000;
4. no caries or previous restorations on the sealed teeth;
5. patients who returned for at least one follow-up appointment at least 6 months after initial placement.

Upon review of these records, 810 patient records met the criteria for inclusion in this study. The remaining were excluded due to various reasons:

1. enamel or dental defects existed;
2. sealant placement was in the operating room;
3. banded molars;
4. insufficient data;
5. insufficient follow-up (patients treated with sealants who did not return for at least one visit at least 6 months after treatment).

Protocol for sealant technique

All sealants placed by all operators in this study followed standardized procedures, defined by the single practice setting treatment team, and followed accepted protocols as published by manufacturers:

1. cotton roll isolation;
2. 15-second phosphoric acid gel etch;
3. 5- to 10-second rinse;
4. air dry;
5. application of sealant (Fluroshield VLC, LD Caulk, Milford, Delaware, or Ultraseal, Ultradent Products Inc, South Jordan, Utah);
6. 30-second light cure.

The time allotted for every provider in placing only sealants on individual patients was 30 minutes. Prior to acid etch, minimal enameloplasty was used on each tooth by the supervising dentist using a one-quarter round bur in high speed with a light brushing motion in the pits and fissures in order to cleanse the enamel in the fissures. The application of a bonding agent was part of the standard protocol (3M Scotch Bond Multi-Purpose Dental Adhesive, or 3M Single Bond Dental Adhesive, 3M, Irving, Calif). Placement of bonding agent prior to sealant application was as follows:

1. Once the surface had been cleaned, etched, rinsed, and dried, a layer of bonding agent was applied to the surface with a hand-held brush.
2. The bonding agent was then air-thinned across the surface.
3. The sealant was immediately applied over the bonding agent layer.

- Both materials were photo-cured together in one curing cycle of 30 seconds (3M Visilux II with periodic light-output maintenance, or 3M XL 3000 with a self-contained light tester, 3M, Senau, Germany).

Moisture control was carefully maintained by way of accepted cotton roll isolation procedures, and a chairside assistant was provided for every operator placing sealants. In Minnesota, dentists, registered dental hygienists, and registered dental assistants can place sealants.²⁸

From the selected group of patients, 3,194 permanent first molars were treated with pit and fissure sealants. The historical information collected from the records consisted of: (1) teeth treated; (2) date of initial placement of sealant; (3) operator who placed the sealant; and (4) patient gender and birthdate. Clinical follow-up results of each tooth, fluoride exposure, previous caries experience, and patient behavior were coded for data input and recorded in a specially prepared form.

Data management

Potential risk factors thought to influence sealant success or failure were tested in this study.³² They included:

- patient characteristics (gender, age, behavior, previous caries experience, fluoride exposure);
- tooth characteristics (tooth type);
- treatment variables (sealants placed by dentists, dental assistants, or dental hygienists).

Previously published criteria were used for scoring behavior¹³ and previous caries experience.^{24, 25} Some of the predictive factors were dichotomized to simplify analyses.

Behavior problem was defined as any chart documentation relating to difficulties in sealant placement such as “difficult isolation, wet isolation, uncooperative, gag reflex, vomiting, or crying.” Behavior ratings were dichotomized to ideal—“excellent, good” or absence of any documentation (score=0) or any documented problem in treatment during sealant placement (score=1).

Previous caries experience was categorized into “no caries” (score=0) and “caries activity” (score=1). Fluoride ratings were categorized according to the patient’s community water supply: (1) optimal fluoride (score=3); (2) suboptimal with supplementation (score=2); or (3) suboptimal without supplementation (score=1).

The placement of sealants by individual operators was scored into 1 of 3 groups: (1) dentist; (2) registered dental assistant (RDA); or (3) registered dental hygienist (RDH). There were 4 dentists, 10 RDA’s, and 3 RDH’s evaluated in this study. A sealant analysis began at the initial placement and was followed at subsequent follow-up appointments that were documented in the record on a 6-month interval. Radiographic and clinical diagnostic criteria were used to detect caries in this dental office. Clinical examination consisted of: (1) visual detection; (2) color; and (3) sharp explorer. Radiographic examination used the classical detection method and was compared to clinical findings for final diagnosis.

Final sealant status and associated survival times in days were considered as follows:

A. Status censored:

- If a sealant was placed and the site was sound at the last examination, as evidenced in the chart, survival time was calculated by subtraction of the patients last visit date from the date the sealant was placed.
- Because of proximal caries, if a sealant was placed and, subsequently, a restoration or caries was indicated on the occlusal surface, this was not considered a failure. Survival time was calculated to the date of the noted restoration, as aforementioned.
- If the buccal or lingual surface on a previously sealed tooth had caries, this also was not considered a failure of the occlusal sealant. Survival time was calculated as aforementioned.

- #### B. Status failed, if the sealant was recorded as decayed or restored on the occlusal surface. Survival time was calculated by subtracting the date when the situation was first detected from the date when the sealant was placed.

Statistical methods

Analyses were performed by Statistical Product and Service Solution (SPSS) software (version 10.0 for Windows, SPSS International, Chicago, Ill) and S-Plus (Statistical Sciences, Seattle, Wash). Times to first occlusal sealant failure were analyzed by survival analysis methods, including Kaplan-Meier (KM) estimates and Cox regression models (SPSS version 10.0, and S-Plus).

Variables that were not significant in the Cox regression were eliminated from the model. All categorical variables were tested for proportional hazards (PH), an assumption of the Cox model, by plotting the log (-log [KM] estimation) vs log (fail time) for each level of the variable. Parallelism of the lines for each level showed the PH assumption to be upheld in all cases.

Results

Taking into consideration the varying follow-up length for each tooth (Table 1), Kaplan-Meier survival analysis was used to estimate the probability of sealant success (Figure 1). The estimated survival probability for 1 year approached 100%, while the cumulative survival probability for 10 years was 87%. The mean survival time for sealants placed in this study was 5 years. When considering operator type, dentists and RDAs had a mean survival time of 3.45 years and 3.65 years, respectively, whereas RDHs had a mean survival time of 7.71 years.

Kaplan-Meier survival curves were graphed showing rates of failure related to operator type, gender, age, behavior, dmft, and fluoride. A representative graph for differences attributable to operator type is shown in Figure 1. The *P* values presented are from Cox regression

Table 1. Length of Follow-up and Occlusal Sealant Failures in Each Time Interval

Time	6 mos	1 y	2 y	3 y	4 y	5 y	6 y	7 y	8 y	9 y	10 y	Total
No. of sealants followed	70	125	72	77	63	64	94	67	81	54	43	810
% of total sealants	9	15	9	9	8	8	12	8	10	7	5	100
Cumulative follow-up %	9	24	33	42	50	58	70	78	88	95	100	100
No. of failures	0	1	2	4	3	11	5	4	3	1	3	37
% of total failures	0	3	5	11	8	30	13	11	8	2	8	100

models with treatment and other covariates. Survival curves for the 2 genders do not differ. Survival curves for RDAs differed from the other operator types. RDAs showed increased risk of failure in occlusal sealants compared with the RDHs ($P=.015$), whereas dentists did not differ significantly from the dental hygienists ($P=.073$).

Subjects with nonfluoridated water showed an increased tendency for risk of failure in occlusal sealants compared with the fluoridated and the supplemented-fluoride groups, but it was not significant ($P=.054$). The dmft group showed increased risk of occlusal sealant failure ($P<.001$). Patients with less-than-ideal behavior showed increased risk of failure in occlusal sealants ($P=.042$).

Cox regression models allowed the authors to test the relationship of sealant treatment failures to different variables such as gender, age, operator type, behavior, dmft, and fluoride exposure. A robust variance adjustment was used with S-Plus to correct for the clustering of teeth in individuals. Each tooth was analyzed while controlling for gender, age, operator type, behavior, fluoride exposure, and previous caries experience using a Cox Proportional Hazards model. The total number of teeth scored with occlusal sealants in this model was 3,194—with 1,603 being maxillary and 1,591 being mandibular permanent first molars.

Factors that influenced the time to first occlusal failure are summarized in Table 2, in the form of hazard ratios and P values for each variable. These hazard ratios reflect varying hazards associated with that individual factor when all other variables are controlled. Hazard ratios higher than 1.0 indicate a detrimental effect on time to first occlusal failure, whereas hazard ratios lower than 1.0 indicate a protective effect. Bold numbers indicate factors with significant effects.

The factors that showed an increased risk of failure included: (1) age ($P<.001$); (2) dmft ($P<.003$); (3) no fluoride ($P<.001$); (4) dentist ($P<.001$); and (5) RDA ($P<.001$). Dentists and RDAs showed 3 times and 2 times the risk of failure, respectively, compared to the RDHs. The no-fluoride group showed almost twice the risk of failure compared to the optimal fluoride group. Age and dmft were highly significant, with slight increased risk of failure. Supplemental fluoride and behavior showed a strong trend in the data approaching significance. Gender and tooth-type were not significant in this model.

The RDAs were the only providers to show a significant difference within the group. Table 3 shows specifics of number of sealants placed and number of failures by each of the providers in the dental assistant group. Large variation exists in failure rates by individual, with providers no. 1 and no. 5 showing over 20% failure of their sealants, while provider no. 9—having provided the largest number of sealants in the study—showed a failure rate of less than 2%.

Discussion

The primary objective of this study was to evaluate the value of delegating duties to auxiliary personnel. The use of dental hygiene/dental assistant teams in sealant placement has been recommended in the public health settings.²⁰ By evaluating data from a private pediatric dental office, the authors presented evidence that a similar approach could work in private dental offices. The analyses reported in this study included data from sealants that have been followed-up for up to 10 years. According to the *ADA Survey of Legal Provisions for Delegating Expanded Functions to Chairside Assistants and Dental Hygienists*, placement of sealants by RDAs in Minnesota started in 1993.²⁸ Therefore, the length of follow-up on their sealants was shorter in this study.

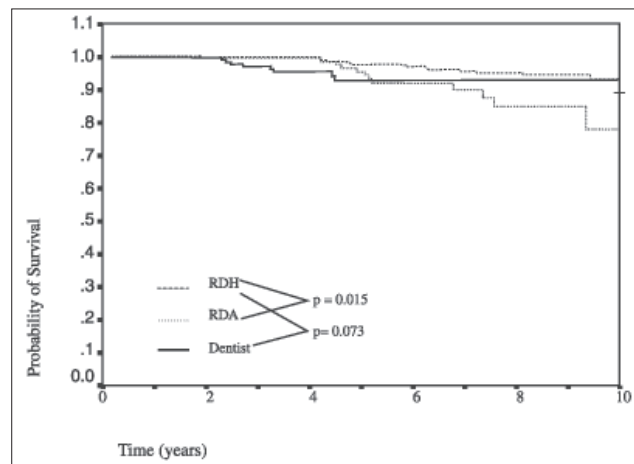


Figure 1. K-M survival plot for sealants analyzed by operator type. Each line represents the cumulative survival of sealants placed by 1 of the 3 operator groups. Changes from the initial 1.0 success level show failures as they occurred in time.

Table 2. Effects of Patient, Tooth, and Treatment Variables on Sealant Failure*†

	Variables	P value	Hazard ratio
Patient variables	Age (5-9 y vs 10-16 y)	<.001	1.346
	Gender (male vs female)	.180	.945
	Behavior (nonideal vs ideal)	.059	1.211
	dmft (caries vs no caries)	<.003	1.037
	Fluoride (F) exposure		
	No F vs optimal F	<.001	1.959
	Supplemented F vs optimal F	.065	.868
Tooth variables	Tooth type		
	No. 3 vs no. 30	.530	1.010
	No. 14 vs no. 30	.430	1.009
	No. 19 vs no. 30	.860	.998
Treatment variables			
	Sealant placed by dentists vs RDH	<.001	4.182
	Sealant placed by RDAs vs RDHs	<.001	3.267

*Cox Proportional Hazards model of 3,194 occlusal sealants.

†**Bold** numbers are hazard ratios significantly different ($P < .05$) from 1.0.

Ratios >1 indicate increased risk of failure, while ratios <1 indicate a protective effect.

Nonetheless, the survival analyses corrects for various follow-up duration, and the mean survival rate is still valid.

This study represents the first long-term investigation of third-generation, fluoride-releasing sealants and the first study that highlights the technique sensitivity of the procedure relative to various provider groups. Significant differences among dental provider groups were found after statistically accounting for the influence of gender, age, previous caries experience, behavior, and fluoride exposure.

The overall sealant success rate in this study was comparable to previous studies.²¹⁻²³ Using caries or restoration as failure criteria, the average yearly failure rates in this study were from 1% to 10%, which is similar to or slightly better than those reported in the literature. The mean survival time in this study was 5 years. The cumulative survival probability for 10 years was 87%. The RDH group showed significantly better results than the dentists and RDA group. All groups, however, demonstrated success higher than that reported in previous investigations.

Upon examining for interoperator differences in the RDA group, one individual had more than half the failures. When this individual was removed from the analysis, the RDA group demonstrated no significant difference from the RDH group. This indicates that all operators are effective in applying sealants, although individual differences in operators exist and must be considered in all training and delegation of duties.

The variables with a large impact on sealant effectiveness were: (1) operator type; (2) previous dmft of the subject; (3) age; and (4) fluoride exposure. In contrast, gender, tooth type, and behavior did not have a significant

effect. In the present study, previous caries activity was related to high risk of sealant failure in all 3 provider groups. This finding agrees with those in earlier sealant investigations in which previous caries experience was shown to decrease effectiveness.^{24,25} This study provides evidence-based data to verify the importance of caries activity on sealant survival and the need to vigilantly maintain sealants on patients who are at high risk for caries.

Inherent problems of retrospective studies were apparent in this study. There was no control for the exposure. The aim of this study was to evaluate the treatment effect of sealants placed by various operator groups. Therefore, patients who had

sealants placed were chosen. The exposure had already occurred before the study began. The investigators looked only at available records for sealed permanent molars that could be categorized according to the operator type who placed them. No documentation was evident in the charts between 2 different sealants that were used, however. Both were visible light activated (third generation) sealants. Finally, subsequent restoration or caries were documented. However, there were 4 dentists without calibration for caries diagnosis.

The authors assumed that all restorations were placed on true carious lesions and that the success rate was measured according to prevention of future restoration. If the sealed surface was not restored, the authors assumed the sealant was intact on that surface until the last visit.

One of this study's strengths is that all sealants were placed under ideal dental office conditions in the same office using a uniform protocol. Prior to each sealant placement, a supervising dentist used a one-quarter round bur in a high-speed handpiece to lightly clean the fissures. All operators followed the same protocol for sealant placement, and all had a chairside assistant. It is the authors' belief that a chairside assistant for each provider, regardless of operator type, is critical for sealant success in order to achieve adequate isolation, efficient placement, and effective patient behavior management.

In the present study, a one-quarter round bur in a highspeed handpiece was used to cleanse and remove debris from the occlusal fissures of the permanent first molars, representing a minimal enameloplasty method. To date, there are few in vivo studies on the enameloplasty technique prior

to sealant placement, regardless of whether the technique was minimal, as in this study, or more extensive. A school-based clinical study was conducted on the 12-month retention of sealants on children in grades 1 to 4 using air abrasion vs acid-etching of the enamel.³⁸ The acid-etch technique was found to be superior to the air-abrasion technique in buccal and lingual fissures, but there was no significant difference in occlusal sealant retention between the 2 techniques.

The authors suggested that air abrasion, in conjunction with acid etching of the enamel, may enhance sealant retention. Enameloplasty is not routinely done in private practices,²⁶ but is commonly employed.²⁷ It has been shown to increase sealant penetration⁶ and retention⁴ in vitro, but the long-term effects of cutting enamel have not been studied. This study's success rates are similar to or better than previous sealant studies, which indicate that the technique may not cause the reduced enamel to be at risk for caries while the sealant is retained. More data in a controlled environment is needed, however, to support this claim.

Comparing this study's results, in which a chairside assistant was used with each provider, to other practices that do not routinely use chairside assistants for sealant application can provide useful knowledge about the value of 4-handed dentistry in sealant placement. Future prospective studies on the effect of enameloplasty prior to sealant placement are necessary to verify the technique already used by some dentists in clinical practice.^{26,27}

Data from the present study confirm high sealant success rates for each provider group, even with significant differences found among the various provider groups. Interoperator differences were found within the RDA group only. Two individuals from the RDA group showed a high hazard for failure. When those individuals were removed from the statistical model, differences among operators disappeared. Therefore, individual operator rather than provider type is highly sensitive to sealant success or failure.

Conclusions

In a private practice setting using caries or restoration as the criteria for sealant failure and with all providers using an identical sealant protocol with 4-handed techniques:

1. All operator groups had sealant success consistent with similar studies in the literature, although the enameloplasty technique was not documented in those studies.

Table 3. Number of Occlusal Sealant Failures for Each RDA

RDA	No. of sealants placed	No. of failures	Failure as a % of sealants placed per operator	% of total no. of failures
1	30	7	23	54
2	18	2	11	15
3	1	0	0	0
4	13	0	0	0
5	9	2	22	15
6	1	0	0	0
7	39	0	0	0
8	8	0	0	0
9	117	2	2	15
10	42	0	0	0
Total	278	13	58	100

2. The risk for sealant failure was significantly lower in sealants placed by RDHs compared to those placed by dentists or RDAs (HR=0.50, $P<.05$).
3. Previous caries experience at time of sealant placement ($P<.003$) and no fluoride exposure at placement ($P<.001$) were highly correlated to increased sealant failure. Interoperator differences within the dental assistant group were detected and highlight the need for continued training and re-evaluation of technical competency of all who apply sealants.

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