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The American Academy of Pediatric Dentistry
Volume 7 Number 1

Occlusal wear of four pit and fissure sealants over two years

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Abstract

Four different commercially available sealants were placed in caries-free permanent premolars and molars for a total of 381 teeth in 53 young participants. The volumetric loss of sealant material was evaluated over a two-year period using a tooth replica technique previously published. The pattern of progressive sealant loss was similar for all materials and for molars and premolars.

Approximately 50% of the applied sealant volume was lost after one month, which was the first sampling interval. Subsequent loss occurred at a reduced rate. At the end of two years, the overall mean sealant loss was approximately 75%. There were no consistent statistically significant differences between materials regarding volumetric loss when expressed as a percentage of applied sealant volume.

The introduction of pit and fissure sealants in occlusal caries prevention initially was received with enthusiasm by the dental profession. However, widespread use of sealants in clinical practice never materialized,[1] partly because of early conflicting results regarding their physicochemical and retentive properties, and partly because of behavioral and social factors. A comprehensive survey by Gift et al. in 1974 showed that more than 62% of U.S. dentists did not utilize fissure sealants in their private dental practices.[2] Recent studies have indicated that fissure sealant utilization remains at a low level.[3-5]

One concern of the practicing dentist regarding sealants is their clinical longevity. Bulk loss of sealant due to inadequate retention to the surface enamel is a result of imperfect enamel preparation and material manipulation. Data regarding the clinical wear characteristics of various sealant formulations is sparse. It is known that wear is the result of a combination of factors including fracture and loss of filler particles, loss of resin matrix, failure of the matrix through cracking, and exposure of entrapped bubbles of air, but there is little laboratory or clinical data to identify what components of the resin impact favorably on its wear characteristics.[6] Laboratory data from abrasion wear studies, or from investigations into possible relationships between certain physical and chemical characteristics and wear in vitro[7-23] have been inconclusive and highly dependent on test methods used.[16,24,25]

Some initial wear of the sealant is desirable, as it helps reestablish proper occlusion. Concerns have been raised regarding possible deleterious effects on the TMJ apparatus from the increase in vertical dimensions due to sealants but there are no reports in the literature of untoward side effects.

The most commonly used method in evaluating the clinical performance of pit and fissure sealants is visual-tactile examination, whereby the sealant is recorded as intact, partially lost, or completely lost. However, these methods are subjective and not discriminate enough to evaluate differences in wear resistance among different sealant materials. Photometric[26] and scanning electron microscopy[27] of tooth replica models also have been employed. While these two methods are useful aids in determining the extent and location of sealant coverage after a period of clinical use, neither allows quantification of sealant loss.

The volumetric assessment method used in this study has been described in a previous report.[28] Using a tooth replica technique, the progressive volumetric loss of sealant material can be determined objectively and accurately. This technique has been shown to be sufficiently sensitive to discern minor differences in wear resistance among sealants.[29]

Methods and Materials

Fifty-three study subjects, (29 females, 24 males) were selected from 12- to 16-year-old patients seeking comprehensive dental care in the Department of General Dentistry at Eastman Dental Center. All unrestored, caries-free, first and second permanent molars, maxillary first and second premolars, and mandibular second premolars were sealed. Four commercially available sealants were used, each representing a compositional variation of the prevailing sealant type, which is based on the Bis-GMA monomer. The sealant types and their physicochemical characteristics are presented in Table 1. The final study group available for evaluation at the end of the two-year study period consisted of 381 teeth, after elimination of unusable postsealant copings. The unusable copings resulted from technical problems related to the silver plating technique and occurred on a random basis. Since meaningful results were found with the remaining teeth, it was not considered worthwhile to remake silver copings. The distribution of the final study sample by material and tooth type is presented in Table 2.

All sealant applications were performed by one of the authors (ØEJ) according to the manufacturers' suggestions. Care was taken not to carry any sealant material over the height of the cusp inclines.

Treatments were assigned to subjects on a random basis. Each patient received the same sealant material in all quadrants. The use of different sealant materials in the same mouth, while appealing from a theoretical point of view, was rejected, since it was felt that if filled and unfilled sealants are placed opposite each other in the upper and lower jaws, or if one side receives a filled sealant and the other an unfilled sealant, interpretation of the initial wear patterns could be distorted because the different sealants may have different wear characteristics. Furthermore, attempting to achieve complete randomization of the four sealants in the four quadrants within the study group would increase the complexity of the study design, and loss of subjects seriously would have affected the integrity of the randomization.

Measurement of the volume of sealant applied and subsequent sealant loss was done according to the technique described by Handelman et al.[28] with two exceptions. Reprosil[a] vinyl polysioloxane was used as the impression material and Epoxydent[b] epoxy resin was used to fabricate tooth replica dies. Tooth replica dies were fabricated from full-arch impressions taken prior to and again immediately after sealant placement, and at each recall visit. The immediate postsealant impression was taken after thoroughly removing the unpolymerized resin with an alcohol gauze. Silver copings were made by electroplating the immediate postsealant tooth replica die. Then copings partly were embedded in an acrylic block to ease handling.

The volume of applied sealant material and subsequent volumetric sealant loss was determined by placing each die in the silver coping made from the immediate postsealant die and weighing the impression material that filled the void between the die and its respective coping. To ensure that a reproducible force was exerted on each die and coping, the assembly was placed in a modified *C* clamp partly embedded in stone (Fig 1). The screw of the *C* clamp was turned clockwise in contact with the center of the tooth replica die until the spring-supported acrylic disc was level with the stone. After the impression material had set completely, the excess material was removed with the aid of a scalpel. The tooth replica die was removed and the remaining material was weighed. Three measurements were obtained for each tooth replica die at each measuring point. Since the specific gravity of Reprosil® was 1.0, 1 mg of impression material was equivalent to 1 mm^3 of volume. The volumetric assessment was repeated twice for each

[a] The L.D. Caulk Co., Milford, DE.
[b] Oxy Dental Products, Inc., Hillside, NJ.

Table 1. Bis-GMA Type Sealants Used in the Study

Brand Name	*Filler Incorporated*	*Polymerization Method*	*Manufacturer*
Delton®	No	Self	Johnson & Johnson, East Windsor, NJ
Kerr®	Yes	Self	Kerr Mfg. Co., Romulus, MI
Nuva-Cote®	Yes	UV light	The L.D. Caulk Co., Milford, DE
Nuva-Seal®	No	UV light	The L.D. Caulk Co., Milford, DE

TABLE 2. Distribution of Final Study Sample by Material and Teeth

	Premolars						*Molars*								
	Maxillary				Mandibular		Maxillary				Mandibular				
*Tooth No.:	*14*	*15*	*24*	*25*	*35*	*45*	*16*	*17*	*26*	*27*	*36*	*37*	*46*	*47*	
Material															Totals
Delton®	9	6	9	8	9	6	6	4	5	4	5	7	4	5	87
Kerr®	9	10	11	10	9	9	5	5	4	7	4	4	3	8	98
Nuva-Cote®	5	9	7	8	9	6	5	5	4	9	4	5	4	5	85
Nuva-Seal®	10	11	13	14	9	12	3	10	5	9	1	7	2	5	111
Totals	33	36	40	40	36	33	19	24	18	29	14	23	13	23	
						218								163	381

* FDI tooth numbering system.

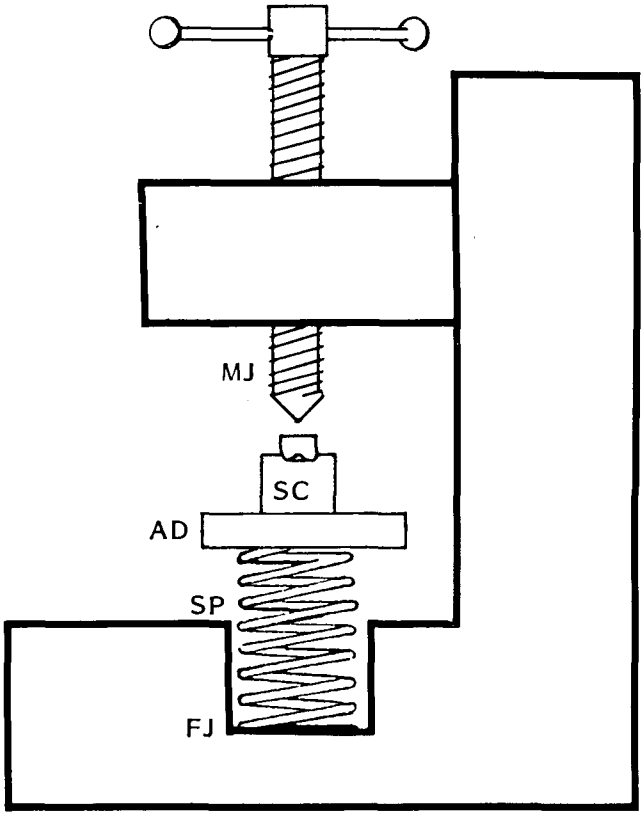

FIG 1. Schematic cross section of apparatus: SC — silver coping; SP — coiled spring; AD — acrylic disc; FJ — fixed jaw plate; MJ — movable jaw.

replica model for a total of three measurements per tooth at each time interval.

The subjects were recalled 1, 6, 12, 18, and 24 months after sealant application. If the sealant was lost and caries developed in the fissures or if the interproximal decay was noted at any of the recalls, the tooth was restored with silver amalgam. If the sealant was clinically undetectable in part of the fissure system and the tooth was judged to be at risk of developing fissure caries, the tooth was resealed. In both cases the teeth were eliminated from the study.

Results

Of the 2,286 potential observations in the study sample, 301 observations (13.2%) were missing. The reasons for missing observations were defects (bubbles, distortions) in the tooth replica models, fracture of the silver coping during the measurement phase (189 observations), missed recall visits (105 observations), or resealing or restoration (16 observations). Although the latter has to be considered a sealant failure, it was not considered to be caused by physiologic wear. The analysis of the 16 missing observations caused by a need for resealing or restoration of the study teeth is presented in Table 3. Since all restored teeth were filled by a dentist other than a member of the study team, it is difficult to judge the criteria that were used, but the numbers were relatively small. The distribution of actual observations within the final study sample by material and tooth type is contained in Table 4. Since the initial analyses indicated that there were no significant differences in wear between maxillary and mandibular teeth, interarch data were collapsed. A univariate analysis to determine the method error for the three replicate measurements yielded a mean coefficient of variation of 16.04 (± .28 S.E.).

The mean volume of applied sealant by tooth type and material is presented in Table 5. As could be expected, the mean volume applied to molars was approximately twice the mean volume applied to premolars.

An analysis of variance was performed to detect statistically significant differences among materials

Table 3. Analysis of Missing Observations Due to Resealing or Restoration of Study Teeth

Pt. No.	*Tooth/ Teeth*	*Time Interval*	*Condition*	*No. of Missed Observations*
01	36,37	18,24 mo.	Presented with fillings at recall	4
17	47	18,24 mo.	Caries in fissure, restored	2
18	26,27	18,24 mo.	Presented with fillings at recall	4
37	37	18,24 mo.	Resealed	2
43	37	18,24 mo.	Resealed	2
51	17,37	24 mo.	#17 resealed, #37 restored	2
			Total	16

Table 4. Distribution of Actual Observations Within Study Sample by Material and Tooth Type

		Baseline	*1 mo.*	*6 mo.*	*12 mo.*	*18 mo.*	*24 mo.*
Delton®	Premolars	47	40	35	35	37	35
	Molars	40	30	33	36	34	33
Kerr®	Premolars	58	53	53	46	48	54
	Molars	40	37	37	35	37	37
Nuva-Cote®	Premolars	44	35	36	31	27	28
	Molars	41	33	33	29	21	24
Nuva-Seal®	Premolars	69	61	62	65	63	53
	Molars	42	37	39	37	39	28
Totals		381	326	328	314	306	292

Table 5. Mean Volume of Applied Sealant by Tooth Type, Location and Material

Material	*Tooth Type*	*Arch*	*N*	*Mean Volume in mm³*	*(± S.E.)*
Delton®	Premolars	Max.	32	8.33	(0.76)
		Mand.	15	8.22	(0.64)
	Molars	Max.	19	12.54	(0.75)
		Mand.	21	14.88	(1.03)
Kerr®	Premolars	Max.	38	6.37	(0.44)
		Mand.	18	5.38	(0.30)
	Molars	Max.	21	12.90	(1.28)
		Mand.	19	15.29	(1.85)
Nuva-Cote®	Premolars	Max.	29	9.01	(0.77)
		Mand.	15	8.33	(0.94)
	Molars	Max.	23	14.07	(1.61)
		Mand.	18	17.52	(1.99)
Nuva-Seal®	Premolars	Max.	48	8.21	(0.75)
		Mand.	21	7.82	(0.98)
	Molars	Max.	27	14.24	(1.04)
		Mand.	15	17.88	(1.78)

regarding the volumes applied. While there were no significant differences for molars, a statistically significant difference was detected for premolars ($p < .003$). Tukey's multiple comparisons test showed that the amount of sealant applied to premolars, using Kerr[c] sealant was significantly lower than the other three brands, which were not significantly different from each other.

In order to eliminate any statistical influence resulting from the differences in applied sealant volumes, an analysis of covariance was used to evaluate subsequent sealant loss, using the applied sealant volume as the covariate. Measurements within subjects' mouths were found to be significant and also were controlled for in the analyses.

Table 6 is a summary of the mean volumetric sealant losses over time by tooth type and material. The data indicated that there was approximately a 50% volumetric loss at the first sampling interval (one month after application). Subsequent sealant loss was progressive but less dramatic. At the end of two years, the overall mean volumetric sealant loss was approximately 75%.

The only values that reached statistical significance at the .05 level using an analysis of covariance were found at the 12 and 18 months sampling intervals for premolars. At these time points there was a statistically significant difference in sealant loss between Delton[d] and Nuva-Seal,[e] as determined by Tukey's multiple comparisons test. No other significant differences were found for the premolars or molars.

In order to visualize the progressive loss for each sealant with time, the amount of remaining sealant volume expressed as a percentage of the amount initially applied was plotted against time lapsed since application (Fig 2). To better compare differences between materials, two additional graphs were constructed, one for each tooth type (Fig 3). The pattern of progressive sealant loss was similar for all materials and for molars and premolars. However, Delton® consistently had the largest percentage of sealant volume left on the occlusal surface.

[c] Kerr Mfg. Co., Romulus, MI.
[d] Johnson & Johnson, East Windsor, NJ.
[e] The L.D. Caulk Co., Milford, DE.

Discussion

The primary objective of this study was to evaluate whether or not pit and fissure sealants of different chemical and physical characteristics exhibit different clinical wear rates. The statistical analyses showed no significant differences in quantitative wear among the four sealants tested, although Delton®, an autopolymerizing unfilled sealant, tended to perform better at all times. This similarity in wear rates between filled and unfilled sealants is contrary to most laboratory wear studies, which suggest that the addition of inorganic filler particles enhances the wear resistance of these materials. Interestingly, a recent article[30] concluded that there was no correlation ($r = .08$) between in vitro and in vivo wear data, supporting the increasingly accepted view that current methods of measuring composite or sealant wear are inadequate predictors of clinical performance.

Specific objective or subjective measures related to occlusal interferences were not undertaken as part of the study, but participants did not report any discomfort related to the TMJ, or any tooth discomfort related to premature occlusal contact at the time of recall visits. The marked loss of sealant during the first month

Table 6. *Volumetric Sealant Loss in mm^3 by Tooth Type and Material*

Material	Tooth Type	Mean Volume Applied (mm^3 ± S.E.)	Sealant Loss (± S.E.) 1 mo.	6 mo.	12 mo.	18 mo.	24 mo.
Delton®	Premolars	8.29(.56)	3.57(.39)	4.49(.52)	4.64(.22)	5.13(.55)	6.13(.68)
	Molars	13.77(.67)	6.87(.60)	7.93(.51)	8.84(.58)	9.11(.61)	9.88(.74)
Kerr®	Premolars	6.06(.32)	3.09(.17)	3.57(.17)	3.76(.19)	4.14(.25)	4.62(.21)
	Molars	14.03(1.11)	7.86(.81)	8.61(.89)	9.47(1.00)	10.50(1.08)	11.53(1.01)
Nuva-Cote®	Premolars	8.78(.59)	5.36(.50)	5.73(.53)	5.59(.46)	6.20(.57)	6.37(.54)
	Molars	15.58(1.27)	7.38(.57)	9.03(.46)	8.91(.67)	9.62(.77)	10.67(.74)
Nuva-Seal®	Premolars	8.09(.60)	4.00(.37)	4.75(.34)	5.45(.53)	5.90(.49)	6.05(.42)
	Molars	15.54(.95)	9.06(.58)	9.66(.56)	10.48(.54)	11.39(.69)	12.06(1.26)

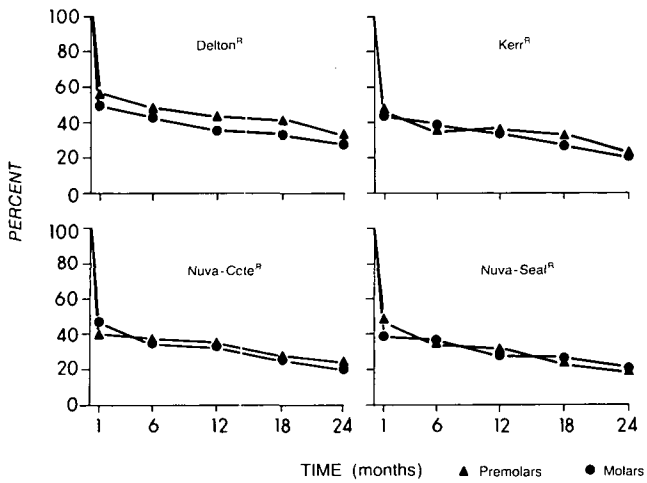

FIG 2. Mean remaining sealant volume, expressed as a percentage of applied sealant volume, as a function of time.

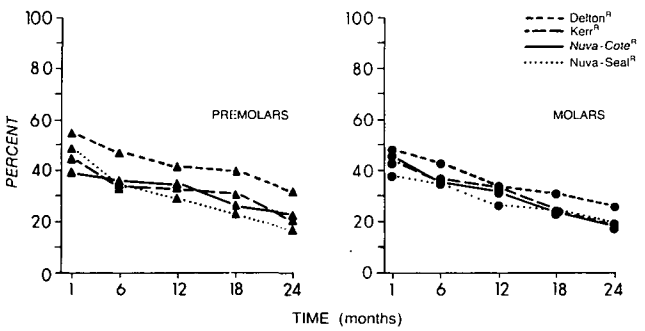

FIG 3. Mean percentage sealant volume remaining, by tooth type.

for all teeth and for all sealant types indicates that the primary accommodation of the oral apparatus to sealant placement is wear of the sealant.

Conclusions

1. There were no statistically significant differences in clinical wear rates between filled and unfilled sealants, or between self-polymerizing and UV-polymerizing sealants. However, Delton,® a self-polymerizing, unfilled sealant, tended to perform better at all times.
2. The amount of sealant applied to molars was approximately twice the amount applied to premolars (approximately 15.0 mm^3 vs 8.0 mm^3, respectively).
3. The greatest amount of sealant loss for both premolars and molars occurred within the first month following sealant application, accounting for more than half of the total sealant loss during the two-year study period.
4. There were no patient complaints of tooth or TMJ sensitivity due to increased vertical dimension of the occlusion after sealant application on the occlusal surfaces of the posterior teeth.
5. During the two-year study period, only 9 of 381 teeth (2.4%) were judged to be at risk or carious by the investigator or by the parents' private dentist, requiring either resealing or restoration at the 18- or 24-month recall intervals.

This study was supported by NIDR grant DE 0542.

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Corrections

The story about Dr. Albert L. Anderson in the last Journal [Pediatr Dent 6:281] incorrectly stated that Dr. Anderson was a member of the original San Diego Stadium Authority and that he served as chairman from 1941-42. In fact, he had just graduated from high school in 1941. He served as chairman of the Stadium Authority in 1981-1982.