Dental sealant longevity in a cohort of young U.S. naval personnel

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Dental sealants have been shown to be effective in preventing occlusal caries in children and adolescents.[1-7] However, despite endorsement by the American Dental Association and more than 25 years of availability, dental sealant use in the United States remains low. According to data from the Third National Health and Nutrition Examination Survey (NHANES III), less than 19 percent of children 5 to 17 years of age had at least one sealed permanent tooth. The mean number of sealed teeth per person examined was 0.8, though the average number sealed teeth among those who had received dental sealants was 4.1.[8] Among adults, the number of people who had received sealants was even lower. The NHANES III survey revealed that only 5 percent of 18- to 24-year-olds and 2 percent of 25- to 39-year-olds had dental sealants.[9]

A large number of young naval personnel have caries-susceptible teeth that may benefit from the placement of dental sealants.

Rationale for dental sealant placement in adults. Dental caries, occlusal caries in particular, has been regarded as a childhood condition. However, with the well-documented decline in childhood dental caries prevalence and incidence over the past 30 years, children now reach adulthood with fewer carious and restored teeth.[10-12] Because preventive therapies have slowed the caries process, the expression of dental caries now appears to be delayed into early adulthood. Moreover, contrary to previously held beliefs, a tooth's susceptibility to dental caries does not necessarily decrease with posteruptive age. Several studies

ABSTRACT

Background. The U.S. Navy emphasizes caries prevention and encourages the placement of dental sealants on the caries-susceptible teeth of patients at risk of developing caries. The authors analyzed dental records to assess the longevity of dental sealants placed in naval personnel.

Methods. A cluster sample of dental records from 1,123 personnel who entered naval service in 1997 was drawn from eight Navy dental treatment facilities. The authors determined the number of sealants provided, the number of sealants that failed over the observation period (1997-2001), the dates of sealant failure and the longevity of sealants placed during and after recruit training.

Results. A total of 319 personnel received sealants during their first two years of service. The authors evaluated 1,467 sealed teeth. They followed the sealants for an average of 35 months. They noted 179 sealant failures in 102 subjects; 69 previously sealed teeth required sealant replacement, and 110 sealed teeth required restoration of the occlusal surface. Among those sealants that failed, the mean length of time from placement to failure was 26 months. Sealant failure rates were significantly higher among subjects at moderate risk or high risk of developing caries than among subjects at low risk.

Conclusions. After an average of 35 months, 87.8 percent of the sealants placed in this population were retained and functional. Subjects who were at moderate or high risk of developing caries demonstrated significantly higher sealant failure rates than those at low risk of developing caries.

Clinical Implications. Dental sealants can be retained successfully in adults. They should be considered a viable treatment alternative for adult patients who are susceptible to caries; however, patients at elevated risk of developing caries may require more frequent re-evaluation and maintenance to achieve maximum benefit.

Key Words. Dental sealants; caries; caries risk; adults.

TABLE 1

U.S. NAVY DENTAL CORPS CARIES RISK ASSESSMENT CRITERIA.*

CARIES RISK STATUS	CRITERIA
Low	No cavitated or active carious lesions No incipient occlusal or interproximal lesions Less than four cervical decalcifications or white-spot lesions
Moderate	One to three cavitated or active carious lesions One or more incipient occlusal or interproximal lesions Four or more cervical decalcifications or white-spot lesions
High	Four or more active cavitated or active carious lesions

* Source: Chief, U.S. Navy Dental Corps.[23]

have suggested that posterior teeth may remain susceptible to caries for many years, perhaps indefinitely, after eruption[13-17] and that caries activity may continue well into and throughout the adult years.[18-21] These studies demonstrate that dental caries increasingly is becoming a problem for adults.[12,18,22]

Dental sealant placement in the U.S. Navy. The U.S. Navy dental care system emphasizes caries prevention and encourages the placement of dental sealants in the posterior teeth of caries-susceptible personnel. Dentists perform a caries risk assessment[23] for each recruit at his or her initial dental examination, and they indicate treatment for teeth that may benefit from dental sealants. They re-evaluate caries risk at each subsequent required annual dental examination. Dentists classify patients as being at low, moderate or high risk of developing caries according to the presence or absence of cavitated or active carious lesions, incipient occlusal or interproximal lesions and cervical, smooth surface decalcifications or white-spot lesions[24-30] (Table 1). All patients at moderate or high risk of developing caries receive professional fluoride treatments. They also receive standardized educational presentations regarding the caries disease process and their role in maintaining adequate oral health care regimens and controlling fermentable carbohydrate consumption. Dental personnel place sealants in pits and fissures that exhibit incipient or questionable caries and in noncarious pits and fissures that exhibit morphological characteristics that may increase caries risk.[31,32]

The U.S. Navy Dental Corps takes great effort to provide caries-preventive therapies to personnel as early as possible in their Navy careers. Dental sealants usually are placed during the initial eight-week recruit training period. However, because of recruits' demanding schedules and the need to prioritize other more urgent restorative needs, treatment for many teeth indicated for dental sealants must be deferred.

Neither the longevity of sealants placed in this environment nor their effectiveness in preventing dental caries in a cohort of young naval personnel has been evaluated. Therefore, we conducted a study to determine

- the longevity of dental sealants placed in young naval recruits;
- if the longevity of sealants placed during recruit training differs from the longevity of those placed after recruit training;
- if the longevity of dental sealants differs based on sex, ethnicity, tobacco-use status or initial caries risk status.

SUBJECTS AND METHODS

Sampling method. We selected a random sample of eight U.S. Navy dental treatment facilities (DTFs) located in the continental United States. We did not include very small clinics in the sampling frame because of cost-benefit considerations, and we subdivided very large clinics into smaller units that could be selected independently. All personnel who entered naval service during 1997 and whose dental records were maintained at the eight randomly selected DTFs were eligible for inclusion into the study. Naval Institute for Dental and Biomedical Research (NIDBR) personnel (J.W.S., K.E.D. and R.L.A.) traveled to the eight DTFs between February and November 2001, identified potential subjects, and located and digitized the subjects' dental records. To ensure the subjects' anonymity, personnel masked all subject identifiers during the record digitization process.

Variables for analysis. We reviewed the dental records of 1,123 subjects to determine the

date of initial entry into the Navy, the number and location of sealants placed in each subject, the dates of sealant placement, the dates of sealant failure and the date of the last required annual dental examination. We defined the longevity of sealants that remained functional as the period between the date of sealant placement and the date of the last required annual dental examination. We defined a sealant failure as the loss of all or part of the sealant, as indicated by the need for replacement or the diagnosis of caries that required restoration of the occlusal surface. We excluded from this investigation sealed teeth that required subsequent restoration owing to proximal caries. We defined the longevity of sealants before failure as the period between the date of sealant placement and either the date of sealant failure diagnosis or the date of sealant replacement or restoration of the occlusal surface.

A greater proportion of subjects at moderate or high risk of developing caries than of subjects at low risk of developing caries received sealants.

We categorized time of sealant placement as during recruit training or after recruit training. We classified all sealants placed within eight weeks of the subjects' in-processing date as during recruit training and all other sealants as after recruit training. We did not include sealants placed after 1999 in this study, to ensure at least six months of follow-up for all sealants evaluated. We recorded subjects' tobacco use at entry into the Navy based on the results of a questionnaire recruits completed at the initial dental examination. We determined sex, age at entry into the Navy and race from the subjects' in-processing records.

The institutional review board of NIDBR, Great Lakes, Ill., reviewed and approved our research protocol.

Statistical analysis. We analyzed data to determine the percentage of sealant failures; the longevity of sealants before failure; the differences in sealant longevity related to race, sex, tobacco-use status and initial caries risk status; and the differences in sealant longevity related to time of placement (during recruit training versus after recruit training).

Unless otherwise noted, we based the demographic descriptions and descriptions of outcomes in terms of percentages, means, correlation coefficients and survival on the sealant event as the unit of analysis. For the statistical tests, however, we used methodology to properly account for the nesting, or grouping, of sealants within subjects' mouths. Using statistical software, we tested failure rates using a generalized estimating equation approach for correlated binomial data, with subjects as a "repeated" variable using an exchangeable covariance structure. We treated sex, race, age at entry and tobacco-use status as "class" variables. Using another statistical software package, we tested the effect of sealant placement during recruit training versus after recruit training using a fixed-effects, partial-likelihood Cox proportional hazards regression model to control for differences in the observation period with the robust sandwich estimate of the covariance matrix used to adjust for nesting of sealants within subjects. We set the α level of error for all statistical analyses at .05.

RESULTS

Records revealed that the 1,123 subjects in this cohort had an average age at entry into the Navy of 20 years (range, 17-34). The majority of subjects was white (75 percent, based on data available for 1,082 subjects) and male (85 percent) and did not use tobacco products at the time of entry into the Navy (69 percent, based on data available for 969 subjects). Of those personnel receiving sealants, 72 percent were white, 85 percent were male, and 68 percent did not use any tobacco product at the time of entry into the Navy. Of those personnel not receiving sealants, 76 percent were white, 85 percent were male, and 69 percent did not use any tobacco product at the time of entry into the Navy. Analysis of the demographic data revealed no significant differences in race, sex or tobacco-use status between those who did and did not receive sealants (χ^2, all $P > .18$).

The proportions of subjects categorized as being at low, moderate or high risk of developing caries were 41.9 percent, 34.2 percent and 23.9 percent, respectively (Table 2). Sealant placement was significantly related to caries risk status (χ^2, $P = .009$); a greater proportion of subjects at moderate (34.8 percent) or high (29.1 percent) risk of developing caries than of subjects at low (22.8 percent) risk of developing caries received sealants.

Dental personnel placed 1,467 sealants on non-third molar posterior teeth in 319 (28.4 percent)

TABLE 2

SEALANT PLACEMENT BY INITIAL CARIES RISK STATUS (N = 1,123 SUBJECTS).

SUBJECTS	INITIAL CARIES RISK STATUS (N [%])		
	Low	Moderate	High
All Subjects	470 (41.9)	385 (34.2)	268 (23.9)
Subjects Receiving Sealants	107 (22.8)	134 (34.8)	78 (29.1)
Subjects Not Receiving Sealants	363 (77.2)	251 (65.2)	190 (70.9)

TABLE 3

SEALANT FAILURES BY SUBJECTS' RACE, SEX AND TOBACCO USE.

SEALANTS	RACE		SEX		TOBACCO-USE STATUS	
	White	Other	Male	Female	User	Nonuser
No. Placed	999	424	1,248	219	451	807
No. Failed (%)	123 (12.3)	51 (12.0)	157 (12.6)	22 (10.0)	58 (12.9)	93 (11.5)

of the 1,123 subjects during their first two years of military service (1997-1999) (mean = 4.6 sealants per subject). The average length of follow-up was 35 months (range, six-50 months). We noted 179 (12.2 percent) sealant failures in 102 subjects; 69 (4.7 percent) needed sealant replacement, and 110 (7.5 percent) required restoration. The range was one to four sealant failures per subject. Among those sealants that failed, the average length of time between sealant placement and failure was 26 months (range, two weeks-50 months); 47 (3.2 percent) of 1,467 failures occurred during the first 12 months, 42 (3.0 percent) of the remaining 1,420 failures occurred between months 13 and 24, 49 (3.6 percent) of the remaining 1,378 failures occurred between months 25 and 36, and 41 (3.1 percent) of the remaining 1,329 failures occurred between months 37 and 50. Of the 110 sealed teeth that later required restoration due to occlusal caries, the caries rate mirrored the overall sealant failure rate: 29 teeth (2.0 percent) were restored during the first 12 months, 34 (2.3 percent) were restored during months 13 through 24, 29 (2.0 percent) were restored during months 25 through 36, and 18 (1.2 percent) were restored during months 37 through 50. We found no significant differences in the percentage of sealant failures based on race, sex or tobacco-use status (Table 3).

Dental personnel placed 707 (48.2 percent) sealants during recruit training and 760 (51.8 percent) sealants after recruit training. A greater proportion of sealants placed during recruit training failed (16 percent) compared with those placed after recruit training (8.7 percent) (Table 4). However, because subjects who were at moderate or high risk of developing caries were given priority for treatment during recruit training, dentists placed more sealants in those subjects during recruit training (n = 476, 66.1 percent) than after recruit training (n = 395, 52 percent). In addition, owing to the methodology of this study, the length of follow-up for sealants placed after recruit training was shorter than that for sealants placed during recruit training. Recruit training lasts only eight weeks, but it often is many months after recruit training before additional treatment can be provided to Navy personnel. To address this inequality in length of follow-up, we used the fixed-effects, partial-likelihood Cox proportional hazards regression model to control for differences in time of observation. This analysis revealed no statistically significant difference between the failure rates of sealants placed during recruit training and those placed after recruit training ($P = .97$). We performed a simple life table analysis, which estimated that 90 percent of sealants would survive 36 months.

Sealant failures increased with increasing caries risk, regardless of the time of sealant placement (Table 4). When we combined data for sealants placed during and after recruit training, sealant failure rates among subjects at low, moderate or high risk of developing caries were 8.1 percent, 13.9 percent and 17.8 percent, respectively. Odds ratio calculations (Table 5) revealed that the likelihood of sealant failure was nearly twice as high among subjects at moderate or high risk of developing caries as among subjects at low

TABLE 4

SEALANT FAILURES BY INITIAL CARIES RISK STATUS AND TIME OF PLACEMENT.

SEALANTS	INITIAL CARIES RISK STATUS											
	During Recruit Training				After Recruit Training				All Sealants			
	Low	Moderate	High	Total	Low	Moderate	High	Total	Low	Moderate	High	Total
Placed	231	329	147	707	365	295	100	760	596	624	247	1,467
Failed (%)	29 (12.6)	53 (16.1)	31 (21.1)	113 (16.0)	19 (5.2)	34 (11.5)	13 (13.0)	66 (8.7)	48 (8.1)	87 (13.9)	44 (17.8)	179 (12.2)

TABLE 5

ODDS OF SEALANT FAILURE BY CARIES RISK STATUS.*

CARIES RISK STATUS	ODDS RATIO	95% CONFIDENCE INTERVAL	*P* VALUE†
Low Versus Moderate	1.69	0.97 to 2.94	.070
Low Versus High	1.54	1.15 to 2.13	.020
Moderate Versus High	1.44	0.82 to 2.55	.240
Low Versus Moderate and High	1.90	1.13 to 3.21	.014

* Odds ratios were estimated using generalized estimating equation (GEE) for correlated binomial data.
† Type 3 GEE χ^2.

risk of developing caries.

DISCUSSION

To our knowledge, this is the first longitudinal evaluation of dental sealants placed in an entirely adult population. The 87.8 percent sealant retention rate we observed in this study compares favorably with that reported in other studies.[5,6,33,34] This finding is noteworthy, considering that this was not a controlled clinical trial and that sealants had been placed under nonstandardized conditions by a large number of practitioners with varying experience levels.

Previous reports[16,35,36] have suggested that the need for sealants among the U.S. military population ranges from less than 1 to more than 47 percent. Those studies, however, relied on subjective criteria and practitioners' clinical judgment in determining patients' needs for sealants. In those studies, practitioners recommended sealants primarily for patients without caries. U.S. Navy guidelines[23] establish caries risk based on standardized criteria. Sealants are indicated for patients at moderate or high risk of developing caries (that is, those with clinical signs of caries activity). The 1994-95 Tri-Service Comprehensive Oral Health Survey[37] reported that 79 percent of recruits and 45 percent of nonrecruit active duty personnel needed one or more restorations.[38,39] If the current caries risk assessment guidelines were applied to these prevalence data, dental personnel would assign all of these patients to either the moderate or high caries risk group and reasonably could expect these patients to require sealants.

The subsequent caries incidence among sealed teeth (110/1,467 = 7.5 percent) in our study is similar to that reported in other studies. Heller and colleagues[40] compared the five-year caries rates of initially sound and initially incipient molar surfaces among elementary school children in Michigan. For initially sound surfaces, the caries rates were 8.1 percent for sealed surfaces and 12.5 percent for nonsealed surfaces. For initially incipient surfaces, caries rates were 10.8 percent for sealed surfaces and 51.8 percent for nonsealed surfaces. Another study[41] reported three-year caries rates among U.S. Navy personnel of 1.2 percent and 5.3 percent for sealed and nonsealed teeth, respectively; however, dental personnel placed sealants primarily in patients without caries, rather than patients with caries. Several studies[7,40,42-46] have suggested that sealants are more clinically effective and cost-effective when they are limited to patients with restorations, incipient caries or other factors placing them at high risk of developing caries.

One possible limitation of our study may be the lack of documentation regarding partial retention

of sealants. Even partially retained sealants may provide caries-preventive effects. Simonsen[5] reported no caries in any permanent molar surfaces that exhibited partial sealant retention 15 years after the initial sealant placement. However, because our study was a retrospective review of dental treatment records, in most cases, it was impossible to determine whether sealants were partially or completely lost before retreatment. Therefore, we defined any documented resealing of an occlusal surface as a failure of the first sealant. It is possible that some of these resealed surfaces did, indeed, possess sufficient sealant to remain effective. Our results, then, may reflect an overestimation of true or complete sealant failure. On the other hand, we believe it is safe to assume that there were likely just as many undocumented partially lost sealants that were not resealed and, thus, counted as fully retained.

Another potential limitation of our study is the possible disparity between the actual time of sealant failure and the detection of the failure. In the Navy dental care system, as in the typical private practice setting, patients are not appointed for the express purpose of monitoring sealant retention. Dentists evaluated sealants during scheduled appointments for other treatment or, at a minimum, at the patient's required annual dental examination. Therefore, detection of sealant failures tends to cluster around the examination dates (at 12, 24, 36 and 48 months in our study), although the sealant failures may have occurred earlier. This is a limitation common to virtually any retrospective epidemiologic study, and it tends to overestimate restoration longevity. However, given the exceedingly favorable long-term retention of sealants reported in previous studies,[4,5,34] a slight discrepancy in the time of failure of a small number of restorations seems to be of minor concern. In our study, among the sealants that failed, the average time to failure was 26 months. A mean of 12 months or less would suggest the possibility that a majority of sealant failures occurred within the first few weeks or months after placement. The most probable cause for such early failures is improper placement technique.[5] Our data, however, suggest a different pattern. Failures were distributed fairly evenly (3.0-3.6 percent per year) over the observation period, which compares favorably with the 5 to 10 percent annual failure rates reported by Feigal.[47]

Perhaps the most important finding of our study is the dramatic increase in sealant failures with increasing caries risk status. This is consistent with other epidemiologic findings for this population. Compared with subjects who were caries-free at entry into the U.S. Navy, those who were caries-active at the beginning of their training period even after receiving complete restorative treatment, required more restorations (1.2 versus 1.9, respectively)[48] and were twice as likely to experience a restorative or endodontically related dental emergency[49] during their first four years of military service.

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Our data do not reveal whether sealants failed due to the development of occlusal caries peripheral to otherwise intact sealant margins, or whether carious lesions developed after sealant loss or failure. However, because sealant retention generally is equated with sealant efficacy,[5,6] we may speculate that carious lesions developed subsequent to sealant failure and that there are factors in patients at high risk of developing caries that predispose their sealants to early failure. While further study is needed to delineate these factors, it is apparent that patients at high risk of developing caries require more frequent re-evaluation to maximize the benefits of preventive therapies.

CONCLUSIONS

Our study revealed that a large number of young naval personnel have caries-susceptible teeth that may benefit from the placement of dental sealants. After an average follow-up of 35 months, 87.8 percent of the dental sealants placed in this population were retained. Sealant failure rates did not differ by sex, race, tobacco-use status at entry into the Navy or time of placement (during or after recruit training). However, we found that initial caries risk status was associated with sealant failure and that subjects at moderate or high risk of developing caries exhibited increased sealant failure rates. The caries incidence (7.5 percent) in sealed teeth compares favorably with results from other studies, even though the majority of subjects in our study was classified as being at moderate or high risk of

developing caries.

These results suggest that dental sealants can be retained successfully in adults and should be considered as a viable treatment alternative for adult patients who are susceptible to caries. However, further study is required to determine the reasons and possible remedies for increased sealant failure among patients at moderate or high risk of developing caries, and to determine the clinical and cost-effectiveness of caries prevention by sealant placement on young adults entering the U.S. Navy. ■

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