A comparison of the effects of toothbrushing and handpiece prophylaxis on retention of sealants

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ABSTRACT

Background. Tooth surface cleaning before acid etching is considered to be an important step in the retention of resin-based pit-and-fissure sealants.

Methods. The authors reviewed and summarized instructions for cleaning tooth surfaces from five manufacturers of 10 unfilled resin-based sealants marketed in the United States. The authors also searched electronic databases for studies that directly compared the effects of different surface-cleaning methods on sealant retention and for systematic reviews of the effectiveness of sealants. They explored the association between surface-cleaning methods and sealant retention in the studies included in the systematic reviews. They calculated the summary weighted retention rates for studies that used either a handpiece or toothbrush prophylaxis.

Results. All of the sealant manufacturers' instructions for use (IFU) recommended cleaning the tooth before acid etching. None of the IFU directly stated that a handpiece was required to perform the cleaning, but five IFU implied the use of handpiece prophylaxis. None of the IFU recommended surface-altering procedures in caries-free teeth. Direct evidence from two clinical trials showed no difference in complete sealant retention between surfaces cleaned mechanically with pumice or prophylaxis paste and those cleaned with air-water syringe or dry toothbrushing. Indirect evidence from 10 studies found that weighted summary retention by year after sealant placement in studies that used toothbrush prophylaxis was greater than or equivalent to values for studies that used handpiece prophylaxis.

Conclusions. Levels of sealant retention after surface cleaning with toothbrush prophylaxis were at least as high as those associated with handpiece prophylaxis.

Clinical Implications. This finding may translate into lower resource costs for sealant placement.

Key Words. Dental sealants; pit-and-fissure sealants; acid etching; dental prophylaxis; toothbrush cleaning; dental cleaning.

JADA 2009;140(1):38-46.

In the placement of pit-and-fissure sealants, a clean tooth surface facilitates direct contact between acid etchant and enamel. The etched enamel, in turn, provides microporosities into which resin-based material flows to form a mechanical bond that retains the sealant against the tooth surface.[1] Pumice prophylaxis by means of a rubber cup or rotary brush on a slow-speed handpiece has been a method commonly used for surface cleaning before acid etching.[2] Other methods, however, have been used in clinical care settings and school programs. For example, in 2001, 45 and 15 percent of pediatric dentists reported using pumice or paste and a rotary cup or brush, respectively, for surface cleaning teeth during sealant placement.[3] Thirteen percent reported using a toothbrush, and 11 percent reported using nothing, which we presume was with the use of the air-water syringe. Toothbrush prophylaxis commonly is used in school-based dental sealant (SBDS) programs to clean the tooth before etching the enamel surface.[4-8]

Recent evidence-based clinical recommendations for use of pit-and-fissure sealants did not specifically address surface-cleaning methods,

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although supporting information acknowledged that manufacturers' sealant placement instructions should be consulted and that a surface-cleaning step typically is included in these instructions.[9] Concurrent with the development of clinical recommendations by the American Dental Association, the Centers for Disease Control and Prevention (CDC) convened a work group of experts to examine the available information and update recommendations related to specific practices in SBDS programs. SBDS programs typically are found in schools that serve children from low-income families, and they focus primarily on sealing occlusal surfaces of permanent molars—the teeth that are most susceptible to dental caries.[10,11] As part of the CDC's review, the work group considered the effectiveness of placement techniques, such as surface-cleaning methods and manufacturers' instructions for use (IFU).

In this article, we describe surface-cleaning methods recommended by manufacturers for unfilled resin-based sealants before acid etching, as well as the findings of clinical studies that compared sealant retention by surface-cleaning methods. Because there are few clinical studies that directly compare surface-cleaning methods and sealant outcomes, we also examined studies included in systematic reviews of sealant effectiveness. These studies typically contain detailed descriptions of surface-cleaning and placement procedures and provide indirect evidence about the association between cleaning methods and sealant outcomes.

METHODS

We reviewed and summarized surface-cleaning methods detailed in IFU for unfilled sealant materials marketed in the United States by five manufacturers. We focused our review of IFU on unfilled sealants because they do not require occlusal adjustment and, thus, are used most commonly in school programs.

We searched electronic databases for clinical studies published in English during the period of 1966 through 2006 that directly compared results for the retention or effectiveness of resin-based sealants after different surface-cleaning procedures. For our search of the PubMed database, we used the following search strategy: "Pit and Fissure Sealants"[Mesh] AND (cleaning[Text Word] OR prophylaxis[Text Word]) AND ("humans"[MeSH Terms] AND English[lang] AND (Clinical Trial[ptyp] OR Randomized Controlled Trial[ptyp])). We used similar parameters when we searched The Cochrane Library database. The searches yielded 25 articles representing 21 unique studies. Two of the authors (S.K.G. and S.O.G.) screened titles and abstracts and excluded 19 of the 21 studies because they were not about resin-based sealants or did not directly compare the cleaning methods used before placement.[12-30] One author (S.K.G.) abstracted the two remaining studies.[5,31]

Because our literature review yielded only two comparative clinical studies, we also searched the literature for systematic reviews of the effectiveness of sealants. From the studies included in these reviews, we documented surface-cleaning methods and sealant outcomes and, thus, generated indirect evidence about the relationship between surface-cleaning methods and sealant retention. We searched PubMed and The Cochrane Library for reviews that were published in English between 1990 and 2006. We identified four systematic reviews, which included 35 unique studies.[32-35] One author (S.K.G.) screened these studies and excluded 24 of the 35 studies for the following reasons: was not published in English,[36] had no concurrent comparison group,[37] involved the use of ultraviolet light–polymerized resin-based sealant material (that is, first-generation material),[13,38-50] contained insufficient information to estimate both the percentage of sealants that were fully retained on permanent first molars by year since placement and the standard errors (SE) of those estimates,[51-54] involved the use of mechanical preparation such as enameloplasty or fissureotomy before sealant placement,[55] or involved the repair or reapplication of lost or fractured sealant material.[56-58]

For 11 of the 35 studies that met our inclusion criteria,[6,7,59-67] one author (S.K.G.) documented the study designs, methods of cleaning and preparing the surface, retention of the sealant over time and other descriptive data. If adequate detail about surface-cleaning methods was not provided, we contacted the study's authors to verify information about how they conducted the study.

The main outcome measure in our analysis of indirect evidence was the percentage of sealants fully retained on the occlusal pits and fissures of

ABBREVIATION KEY. CDC: Centers for Disease Control and Prevention. **IFU:** Instructions for use. **M1:** Permanent first molar. **NR:** Not reported. **SBDS:** School-based dental sealant.

first permanent molars at annual follow-up examinations. We chose retention instead of effectiveness as the outcome because retention would be less affected by potential confounders such as differences in caries risk among the sample populations of multiple studies. We assumed a binomial distribution in calculating the SE of the retention rate:

$$SE = \sqrt{\frac{\text{retention} \times (1 - \text{retention})}{n}}$$

For each of the five years after sealant placement, we calculated a summary retention rate separately for the studies that used the same type of surface-cleaning method (for example, handpiece or toothbrush prophylaxis). We weighted the studies by the reciprocal of their squared SE. We deemed summary retention rates by cleaning method significantly different if the 95 percent confidence intervals (rounded up to two decimal points) did not overlap.

RESULTS

Manufacturers' IFU. We identified 10 unfilled sealant products from five manufacturers. The IFU for all 10 products directed the operator to clean the tooth surface before acid etching (Table 1). In Table 1, each manufacturer is designated by a letter, and the unfilled sealant products manufactured by the same company are numbered. For example, A-1, A-2 and A-3 are three unfilled sealants from the same manufacturer. None of the IFU directly stated that a handpiece was required to perform the cleaning. However, the use of pumice, prophylaxis paste or prophylaxis brush was included in the IFU for five products, implying handpiece use. Language in the IFU for the other five products was nonspecific. The IFU for seven products indicated that use of fluoride-containing or oil-containing pastes be avoided. None of the IFU specifically directed the operator to perform enameloplasty, fissureotomy, air abrasion or air polishing to clean the tooth surface before placing the sealant. The IFU for one product, however, directed the operator to remove minimal caries with a small round bur in a slow-speed handpiece after surface cleaning.

Direct evidence. From the literature search, we identified two clinical trials that directly compared surface-cleaning methods.[5,31] Investigators in these studies found no difference in complete retention of sealants between surfaces that were cleaned mechanically with pumice and those that were cleaned by means of an air-water spray and running a sharp probe along the fissures. Both studies reported retention rates greater than 96 percent at one year after placement for all surface-cleaning methods (Table 2, page 42).

Indirect evidence. Eleven of 35 studies from four systematic reviews of the effectiveness of sealants met our initial criteria.[6,7,59-67] We were unable to determine definitively the surface-cleaning method used in one study[66] and excluded the study from our analysis. Handpiece prophylaxis with a rubber cup or rotary brush was used in eight studies, and toothbrush prophylaxis was used in two studies (Table 3, page 43). Of those studies using handpiece prophylaxis, four used pumice and four used prophylaxis paste. Of the latter four studies, three specifically stated that the paste did not contain fluoride, and one did not specify if the paste contained fluoride. Only one of the four studies using prophylaxis paste indicated that the paste was oil-free.[61] No studies stated if there was fluoride or oil in the pumice. Of the two studies using toothbrush prophylaxis, patients (under the supervision of an operator) brushed their own teeth—in one study with fluoride-containing toothpaste, and in the other with a dentifrice without fluoride. We observed no difference in reported retention of sealants between these two studies (Table 4, page 44).

From the 10 selected studies, we generated weighted summary measures of complete retention (percentage) for sealants (Table 4). Because of notably low retention rates for one operator in a study that used handpiece prophylaxis,[65] we excluded that operator's results. By not including the findings from this operator, our findings were biased toward handpiece prophylaxis' being more effective. Weighted summary retention by year after sealant placement for studies that used toothbrush prophylaxis was either greater than or equivalent to values for studies that used handpiece prophylaxis (Table 4). The summary retention rate for studies using toothbrush prophylaxis was higher at year one compared with studies using handpiece prophylaxis, and we observed no differences in summary retention between the two cleaning methods at years two through five (Table 4).

DISCUSSION

We found that the five manufacturers of the unfilled resin-based sealants marketed in the United States that we included in our review

instructed the operator to clean the surface before performing acid etching and placing the sealant material. IFU for five of the products included in our limited review did not specify a particular cleaning method, thus allowing operators to use their professional judgment. Some IFU stated that additives, such as fluoride or oil, should be avoided. In 1982, Gwinnett[68] noted that there were no studies that contraindicated the use of fluoride-containing prophylaxis paste for cleaning the tooth surface before etching. Recommendations in sealants' IFU to avoid fluoride might be based on older in vitro or laboratory studies that found exposure of enamel to topical fluorides inhibited acid etching and reduced the bond strength of early sealant products.[69-71] More recent clinical[72,73] and in vitro[74-78] studies suggest that exposure of teeth to various topical fluoride treatments or fluoride-containing prophylaxis paste before sealant placement does not decrease retention or bond strength. Similarly, we found no difference in sealant retention between two studies that used toothpaste with and without fluoride before sealant placement.[6,7]

TABLE 1

Sealant manufacturers' instructions for surface preparation.

MANUFACTURER-PRODUCT	CLEANING IMPLEMENT	CLEANING MATERIAL	CLEANING METHOD
A-1	Prophylaxis brush	Pumice and water, no commercial prophylaxis pastes (fluoride or oil additives interfere with etching)	Handpiece not specifically stated in IFU* but implied through recommended use of prophylaxis brush
A-2	Prophylaxis brush	Pumice and water, no commercial prophylaxis pastes (fluoride or oil additives interfere with etching)	Handpiece not specifically stated in IFU but implied through recommended use of prophylaxis brush
A-3	Not stated	Not stated	Nonspecific; IFU do not state or imply use of handpiece or prophylaxis paste
B-1	Not stated	Prophylaxis paste (nonfluoride, oil-free) or pumice and water	Handpiece not specifically stated in IFU but implied through recommended use of prophylaxis and prophylaxis paste
B-2	Not stated	Prophylaxis paste (nonfluoride, oil-free) or pumice and water	Handpiece not specifically stated in IFU but implied through recommended use of prophylaxis and prophylaxis paste
C-1	Not stated	Paste (nonfluoride, oil-free)	Nonspecific; IFU do not state or imply use of handpiece and description of paste is nonspecific
C-2	Not stated	Paste (nonfluoride oil-free)	Nonspecific; IFU do not state or imply use of handpiece and description of paste is nonspecific
D-1	Not stated	Not stated	Nonspecific; IFU do not state or imply use of handpiece or prophylaxis paste.
D-2	Not stated	Not stated	Nonspecific; IFU do not state or imply use of handpiece or prophylaxis paste
E-1	Not stated	Prophylaxis paste (nonfluoride oil-free)	Handpiece not specifically stated in IFU but implied through recommended use of prophylaxis paste; minimal caries removed with small round bur in slow speed handpiece

* Instructions for use.

In our literature search, we found only two published clinical studies that directly compared sealant retention by surface-cleaning methods,[5,31] but our findings are consistent with those of a recent systematic review of retention of resin-based sealants,[79] which was published after we began our analysis. The systematic review also reported no difference for the study by Donnan and Ball,[31] which compared handpiece cleaning to no cleaning beyond an air-water spray and running a sharp probe along the fissures, and for the study by Gillcrist and colleagues,[5] which compared handpiece cleaning (with fluoride-containing paste) to dry toothbrush cleaning provided by the operator.

Although the studies that we evaluated from systematic reviews did not directly compare surface-cleaning methods, they provided suffi-

TABLE 2

Sealant retention rate, by clinical studies that compared surface-cleaning methods.

STUDY	SURFACE-CLEANING METHOD	RETENTION RATE (%)	
		Six Months	12 months
Gillcrist and Colleagues[5]	Handpiece, prophylaxis brush, fluoride prophylaxis paste	NR*	97.6
	Dry toothbrushing by operator	NR	99.2
Donnan and Ball[31]	Handpiece, prophylaxis brush, pumice	98.3	96.6
	Sharp probe along fissures, forceful water spray	98.3	97.3

* NR: Not reported.

ciently detailed information about cleaning methods and retention to allow us to conduct a weighted bivariate analysis. Based on the summary retention data we examined, it appears that sealant retention was the same or higher when teeth were cleaned with a toothbrush rather than with a handpiece. For this group of studies that we included in our review, we found that sealant retention was higher in studies using toothbrush prophylaxis at one year. In years two through five, however, toothbrush and handpiece cleaning had similar percentages of sealant retention. We excluded one study[66] from our analysis because the surface-cleaning method was not specifically described. The article stated that tooth surfaces "received careful mechanical cleaning," a phrase that may suggest the use of a handpiece. When we included the findings from this study in our analysis along with the other studies using handpiece prophylaxis, we found that the summary retention was higher in studies using toothbrush prophylaxis at both year one and year two. Retention data for the excluded study were not reported after two years; therefore, our summary retention did not change for years three through five.

Toothbrushing differs from other cleaning methods—such as handpiece prophylaxis, air-polishing or use of an explorer—because either the patient or the provider can do it. In our literature review, we did not identify any studies that compared sealant retention when the operator brushed the patient's teeth versus when the patient brushed his or her own teeth. In both studies that we included in our indirect analysis to generate summary retention findings, a toothbrush was used to clean the surface. Patients (that is, children) brushed their teeth with a dentifrice while supervised by an operator. Summary retention data reported in our study for both handpiece and toothbrush cleaning (for example, 85 percent or higher at one year) are consistent with estimates of sealant retention reported in comprehensive reviews of the literature.[32,80] In addition, toothbrushing can be performed with or without toothpaste or other dentifrice. Retention data at one year for toothbrushing with toothpaste was similar to reported retention for dry toothbrushing in the clinical study by Gillcrist and colleagues[5]; summary retention was higher than 94 percent for both methods.

The surface-cleaning method also was included in a recent multivariate analysis exploring four-handed delivery and retention of resin-based sealants.[81] In that analysis, Griffin and colleagues[81] found that retention was lower when surfaces were cleaned with a handpiece before placement. It is possible that some prophylaxis pastes marketed in the 1970s and 1980s contained oils or other substances that interfered with bonding. It also is possible that residual paste or pumice within pits and fissures after prophylaxis and etching could reduce retention of sealants.

Consistent with general manufacturers' IFU, all studies included in our analyses cleaned the tooth surface before acid etching, either with a handpiece, toothbrush or air-water spray. In the earliest sealant studies, Buonocore and colleagues[82-84] and Cueto and Buonocore[85] used a pumice handpiece prophylaxis to provide a clean enamel surface for etching. Donnan and Ball[31] suggested that the scientific justification for the handpiece prophylaxis before acid etching may rest on a study by Miura and colleagues.[86] The latter study reported that pumice prophylaxis improved bond strength for orthodontic brackets on smooth surfaces of premolars that were subsequently extracted and evaluated via scanning electron microscope. The authors concluded that the "greatest adhesion was achieved when both polishing and acid etching were carried out."[86] The relevance of these findings to application of sealants to occlusal pits and fissures is unclear, however, because the materials and methods used in that study—use of 70 percent ethyl alcohol before and after prophylaxis, application of a

TABLE 3

Cleaning method descriptions and summary measures of resin-based sealant retention, by study.

STUDY	YEAR STUDY BEGAN	AGE OF SUBJECTS (YEARS)*	DESIGN	TOOTH	PAIRS OF TEETH OR SITES (NO.)	FOLLOW-UP (NO. OF MONTHS)	COMPLETE RETENTION (%)	MATERIAL	SURFACE PREPARATION
Charbeneau and Dennison[59]	1975	5-8	Half-mouth	M1†	229 202 186 193 185	0 12 24 36 48	100 79 71 61 52	Autocure	Handpiece, rubber cup, prophylaxis paste without fluoride
Erdogan and Alaçam[60]	1982	8-10	Half-mouth	M1	170 118 102 96	0 12 18 54	100 77 73 74	Autocure	Handpiece, prophylaxis brush, pumice
Gibson and Colleagues[61]	1975	6-10	Half-mouth	M1	425 393 352 337 330 331	0 12 24 36 48 60	100 89 86 75 68 67	Autocure	Handpiece, rubber cup, prophylaxis paste without fluoride
Houpt and Shey[6]	1976	6-10	Half-mouth	M1	205 186 175 164 162 125	0 12 24 36 48 60	100 94 88 83 73 67	Autocure	Toothbrush—child brushed with fluoride-containing toothpaste under supervision of dentist
Hunter[62]	NR‡	5-8	Half-mouth	M1	575 509	0 36	100 73	Autocure	Handpiece, rubber cup, prophylaxis paste without fluoride
McCune and Colleagues[63]	1975	6-9	Half-mouth	M1	318 275 252 272	0 12 24 36	100 92 89 87	Autocure	Handpiece, prophylaxis brush, pumice
Mertz-Fairhurst and Colleagues[7]	1975	6-8	Half-mouth§	M1	NR 239 233 201 168	0 12 24 36 54	100 94 84 80 71	Autocure	Toothbrush—child brushed own teeth with dentifrice without fluoride under supervision of dentist
Poulsen and Colleagues[64]	1995	7	Comparison	M1	NR NR NR 206	0 12 24 36	100 85 80 74	Autocure	Handpiece, prophylaxis brush, pumice
Rock and Bradnock[65] (Operafor 2)	1974	6-7	Half-mouth	M1	NR 130 109 111	0 12 24 36	100 68 63	Autocure	Handpiece, rotary brush, prophylaxis paste (fluoride status unknown)
Vrbič[67]	1979	6.8	Half-mouth	M1	413 373 293	0 24 60	100 86 52	Autocure	Handpiece, prophylaxis brush, pumice

* Studies may have included other age groups, but we limited our review to 5- to 10-year-olds.
† M1: Permanent first molars. Studies may have examined primary teeth or other permanent teeth, but we limited our analysis to permanent first molars.
‡ NR: Not reported.
§ First-generation sealant on one side of mouth and second-generation sealant on the other one-half. Values for first-generation sealant not included in table.

silane coupling agent and placement of sealant material on smooth surfaces—are not common elements of pit-and-fissure sealant placement.

Our study had some limitations. In our review of the literature, we found only two direct comparative studies of surface cleaning methods. In our analysis of studies included in systematic reviews of effectiveness, we found only two

TABLE 4

Percentage of sealants completely retained, by year since placement and cleaning method.

STUDY	COMPLETE RETENTION (% [95% CONFIDENCE INTERVAL])				
	Year One	Year Two	Year Three	Year Four	Year Five
Toothbrush Prophylaxis					
Houpt and Shey[6]	94 (91-97)	88 (84-92)	83 (78-88) (33 months)	73 (67-79)	67 (60-74)
Mertz-Fairhurst and colleagues[7]	95 (92-97)	84 (79-89)	80 (76-84)	NR*	71 (65-78) (54 months)
SUMMARY RETENTION	**94 (92-96)**	**86 (83-89)**	**82 (78-85)**	**73 (67-79)**	**69 (64-74)**
Handpiece Prophylaxis					
Charbeneau and Dennison[59]	79 (74-85)	71 (64-77)	61 (54-68)	52 (45-60)	NR
Erdogan and Alaçam[60]	77 (70-85)	74 (65-82)	NR	NR	74 (65-83) (54 months)
Gibson and colleagues[61]	90 (87-93)	86 (82-89)	75 (70-79)	68 (63-73)	67 (62-72)
Hunter[62]	NR	NR	73 (69-77)	NR	NR
McCune and colleagues[63]	92 (88-95)	89 (85-93)	88 (84-91)	NR	NR
Poulsen and colleagues[64]	NR	NR	74 (68-80)	NR	NR
Rock and Bradnock[65] (Operator 2†)	75 (67-82)	68 (59-77)	63 (54-72)	NR	NR
Vrbič[67]	NR	86 (82-90)	NR	NR	(46-58)
SUMMARY RETENTION	**87 (85-89)**	**84 (82-86)**	**76 (74-78)**	**63 (59-67)**	**63 (59-66)**

* NR: Not reported.
† Results from operator 1 excluded, owing to notably low results.

studies that used toothbrush prophylaxis. Our analysis of studies from systematic reviews was observational and limited to bivariate analysis. Our findings may be subject to recall bias because we contacted authors to obtain additional information if adequate data were not included in their studies. Because the studies in the systematic reviews were not designed to compare sealant outcomes by surface-cleaning method directly, the association between retention and an explanatory variable might have been due to another variable that was omitted. Although the possibility of confounding remains, a recent multivariate analysis found that toothbrush prophylaxis was associated with higher sealant retention than was handpiece prophylaxis.[81]

We limited our search for indirect evidence to studies in the existing systematic reviews of sealant effectiveness.[32-35] These studies already had met specific rules for study design, conduct and measurement established for each systematic review. In the absence of published comparative studies, our less resource-intensive method to identify and screen potential studies is attractive because it is an efficient method of collecting data from well-conducted studies. We minimized bias because the authors of the original systematic reviews determined the universe of studies. Although only one author screened these studies for our review, the inclusion and exclusion criteria in our analysis were objective and were specified before we screened available studies.

CONCLUSIONS

The results of our comparative tooth cleaning analysis indicate that retention of sealants after a supervised toothbrush cleaning by the patient was at least as high as those associated with a traditional handpiece prophylaxis. Our findings may translate into lower costs for materials, equipment and personnel. ■

Disclosure. None of the authors reported any disclosures.

The findings and conclusions of this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention.

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