Evaluation of pumice, fissure enameloplasty and air abrasion on sealant microleakage

Julie A. Blackwood, DDS, MS Diane C. Dilley, DDS Michael W. Roberts, DDS, MScD Edward J. Swift, Jr, DMD, MS

Dr. Blackwood was a resident, University of North Carolina, Chapel Hill, NC and is now in private practice, New Hanover Community Health Center, Wilmington, NC; Dr. Dilley is associate professor, and Dr. Roberts is professor and chair, Department of Pediatric Dentistry; Dr. Swift is associate professor and chair, Department of Operative Dentistry, School of Dentistry, University of North Carolina, Chapel Hill, NC. Correspond with Dr. Blackwood at julie_blackwood@dentistry.unc.edu

Abstract

Purpose: The purpose of this in vitro study was to evaluate microleakage of pit and fissure sealants after using three different pit and fissure preparation techniques: (1) traditional pumice prophylaxis and acid etching, (2) fissure enameloplasty and acid etching and (3) air abrasion and acid etching.

Methods: Sixty extracted third molars with no clinical evidence of caries were randomly divided into 3 groups of 20 each. Teeth were prepared using 1 of 3 occlusal surface treatments prior to placement of Delton® opaque light-cured sealant. The teeth were thermocycled between 5±2°C and 55±2°C for 500 cycles with a dwell time of 30 seconds and then stored in 0.9% normal saline. All teeth were sealed apically and coated within 1.5 mm of the sealant margin with two layers of nail varnish. The teeth were immersed in a 1% solution of methylene blue for 24 hours to allow dye penetration into possible gaps between enamel and sealant. Three buccolingual cuts parallel to the long axis of the tooth were made yielding 4 sections and 6 surfaces per tooth for analysis. The surfaces were scored 0 to 3 for extent of microleakage using a binocular microscope at 25X magnification.

Results: Kruskal-Wallis and *t* tests revealed no significant difference in microleakage between the 3 fissure preparation methods prior to sealant placement.

Conclusions: Neither air abrasion nor enameloplasty followed by acid etching produced significantly less microleakage than the traditional pumice prophylaxis with acid etching technique.*(Pediatr Dent 24:199-203, 2002)*

KEYWORDS: SEALANTS, MICROLEAKAGE, AIR ABRASION, ENAMELOPLASTY

Received July 2, 2001 Revision Accepted March 5, 2002

Sealing pits and fissures in teeth is a widely advocated preventive technique. A nagging issue is identification of the ideal regimen for placement of sealants to maximize retention and prevent microleakage. Inhibiting marginal leakage is important for sealant success because the seepage of bacteria beneath a sealant may support caries initiation and progression.[1,2] There is no clear consensus relative to the best method of cleaning pits and fissures prior to applying etchant and sealant. Salivary pellicles, organic debris and handpiece lubricating oil have all been identified as potential contaminants of the tooth surface that may lead to marginal leakage or loss of the sealant.[3] Removal of enamel surface contaminants and obtaining a properly acid-etched surface prior to sealant placement are important factors for successful retention and caries prevention.[3,4]

The pumice prophylaxis and acid-etch technique is still considered by most clinicians the standard for cleaning fissures prior to sealant application. This typically involves a prophylaxis with an aqueous slurry of pumice, acid etching for 60 seconds and rinsing for a minimum of 10 seconds. Ripa[5] concluded in a comprehensive review of sealants that there was insufficient evidence to warrant changes in the traditionally recommended pumice procedure. However, it has also been shown that cleaning the fissures with flour of pumice using rotary instruments in a slow-speed handpiece followed by etching does not remove all of the pellicle and debris.[6]

More recently, alternative methods such as bur preparation and air abrasion have been proposed to better clean pits and fissures of debris. Enameloplasty, or fissure enlargement with a bur, has been advocated as a technique that enhances retention by allowing deeper penetration of etchant and sealant and increasing surface area for bonding.[7] Air abrasion has also been suggested as a pretreatment method to mechanically roughen enamel in a conservative and time-efficient manner and remove residual organic material

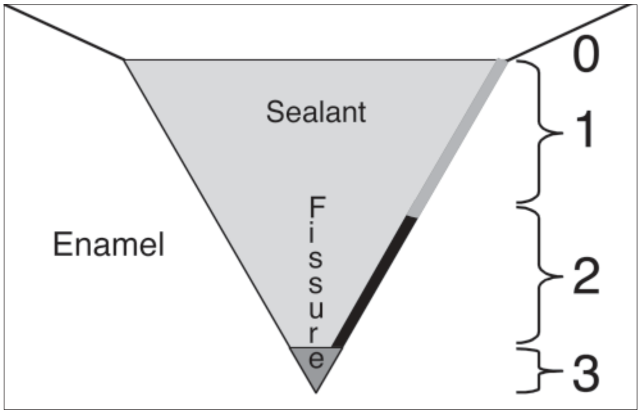

Fig 1. Schematic diagram for dye penetration scoring as described in text

in the fissures to aid in sealant bonding.[8] However, marginal leakage studies have shown that air abrasion alone is not as effective as air abrasion coupled with acid etching in preventing microleakage.[9-13]

Researchers have used dye penetration to evaluate potential sealant leakage and the susceptibility of a tooth to caries.[13] Conflicting results have been reported by the few studies comparing microleakage of sealants prepared by traditional pumice and etch to those prepared by bur or air abrasion coupled with acid etching.[12,14-16] Therefore, the search continues for the most effective enamel surface preparation to enhance sealant integrity.

The aim of this in vitro study was to compare the microleakage of pit and fissure sealants after using three different preparation techniques: (1) traditional pumice prophylaxis and acid etching, (2) fissure enameloplasty and acid etching and (3) air abrasion and acid etching.

Methods

Sixty noncarious and unrestored extracted third molars chosen to best represent the anatomy of first permanent molars (30 mandibular and 30 maxillary) were stored and refrigerated in 0.1% chloramine. For group allocation purposes, the teeth were numbered 1 to 60. They were randomly divided into 3 groups of 20 each, with 10 maxillary and 10 mandibular teeth per group. The treatment groups were prepared as follows:

Group 1: Traditional pumice prophylaxis and acid etching. All fissures were cleaned for 15 seconds with an aqueous slurry of 5 g pumice/4 mL water using a disposable rotating bristle brush in a slow-speed, contra-angle handpiece. The teeth were rinsed with air-water spray, dried using compressed air and etched with 37% liquid phosphoric acid for 60 seconds as recommended by the sealant manufacturer (Delton® Opaque, Dentsply Professional, York, PA).

Group 2: Enameloplasty with a carbide fissure bur (Fissurotomy™ Bur #18010, SS White, Ivoclar North America, Inc.) and acid etching. The pits and fissures were prepared with the Fissurotomy™ Bur in a high-speed handpiece using a light "sweeping" motion for 10 seconds according to the manufacturer's directions to minimally open pits and fissures. The teeth were rinsed, dried and etched with 37% liquid phosphoric acid for 60 seconds.

Group 3: Air abrasion and acid etching. The Mach 5.0 air abrasion unit (Kreativ, Inc., San Diego, Calif) was used according to the manufacturer's directions with 27.5 μm aluminum oxide particles for 10 seconds at 40 psi, Micropulse™ mode, and beam intensity of 2 gm/min. The handpiece measured 0.28 mm (0.011 in) in diameter at tip orifice and was held at a distance of 2 to 2.5 mm from the tooth. The occlusal surfaces were rinsed, dried and etched with 37% liquid phosphoric acid for 60 seconds.

An opaque light-cured sealant (Delton® Opaque, Dentsply Professional, York, Pa) was applied to the occlusal pits and fissures of all teeth in accordance with the manufacturer's instructions. The sealant was cured for 15 seconds on "normal" curing mode (400-500 nm) using the Kreativ Kuring Light (Kreativ, Inc., San Diego, Calif) according to the recommendations of the curing light and sealant manufacturers. The polymerizing light was calibrated and verified periodically to ensure constancy of light output power according to the manufacturer's recommendations. Each sealant was checked with an explorer for complete coverage and retention. All sealed teeth were stored in 0.9% normal saline less than 24 hours before thermocycling.

All of the teeth were thermocycled between 5±2°C and 55±2°C for 500 cycles with a dwell time of 30 seconds in each bath and a 30-second dwell time at room temperature between baths (2 min/cycle) followed by storage in 0.9% normal saline. The teeth were dried and the apices sealed with sticky wax. All tooth surfaces were painted within 1.5 mm of the sealant margin with a layer of nail varnish and allowed to dry. A second coat of nail varnish was applied and allowed to dry. The teeth were immersed in a 1% methylene blue solution for 24 hours at 37°C to allow dye penetration into possible gaps between enamel and sealant.

Upon removal from the dye, the teeth were rinsed with distilled water, positioned, and secured on glass slabs using sticky wax prior to sectioning. Three buccolingual sectioning cuts parallel to the long axis of each tooth were made, yielding 4 sections and 6 surfaces per tooth for analysis. A water-cooled 0.3 mm thick diamond wafering blade (Isomet™, Buehler, Lake Bluff, IL) mounted on a high-speed saw was used. The depth of dye penetration was evaluated by a single examiner blinded to the treatment regimen using a binocular microscope at 25X magnification according to the method described by Överbö and Raadal.[17] The scoring method was (Fig 1):

Score 0=no dye penetration
Score 1=dye penetration restricted to the outer half of the sealant
Score 2=dye penetration to the inner half of the sealant
Score 3=dye penetration into underlying fissure

Each surface score was determined by the greatest dye penetration detected on the buccal occlusal and/or lingual occlusal fissure wall. The overall score for each tooth equaled the highest score of the 6 surfaces. Mean microleakage scores and standard errors were calculated for each treatment group.

Microleakage analysis at the section level used *t* tests to statistically examine the significance of the differences of

Table 1. Distribution of Section-Level Microleakage Scores

Method	0	1	2	3	Total
Pumice	85	21	7	7	120
Bur	91	18	5	6	120
Air abrasion	92	19	8	1	120
Total	268	58	20	14	360

Table 2. Mean Microleakage Scores – Section-Level Analysis

Preparation method	n	Treatment group mean	Standard error
Pumice	120	0.467	0.102
Bur	120	0.383	0.099
Air abrasion	120	0.317	0.059
Total	360	0.389	0.052

For all three paired *t* tests, $P>0.2$

average scores between all 3 possible pairwise comparisons (ie, pumice vs air abrasion, pumice vs bur and air abrasion vs bur). The Kruskal-Wallis test was used to statistically analyze for significant differences in microleakage between treatment groups at the tooth level.

Results

Intraexaminer reliability for microleakage scoring was calculated using Kappa statistics prior to actual microleakage evaluation. The calibration was performed by the examiner assessing 45 sections on different days. Reliability for microleakage scoring produced a weighted Kappa of 0.90, indicating good reproducibility.

Section-level analysis

Table 1 shows the microleakage scores according to section-level analysis with 6 surface measurements per tooth totaling 360 scores. Statistical analysis using *t* tests indicated no significant difference between the pumice, enameloplasty, and air-abrasion methods. No leakage (score=0) was found on 268 of 360 surfaces (74%). Dye penetration restricted to the outer half of the sealant (score=1) was noted in 58 of 360 views (16%). Thus, 90% of the sealant sections had minimal to no leakage. The diamond blade was of sufficient thickness (0.3 mm) to prevent adjacent surfaces from being "mirror images" of each other. For example, there were many instances in which one surface displayed microleakage, and the adjacent sectioned surface had no microleakage. The mean microleakage scores for the 3 treatment groups are listed in Table 2.

Tooth-level analysis

The distribution of microleakage scores for all 60 teeth is shown in Table 3, using the worst surface-level leakage score for each tooth. The air abrasion group had the most sealants exhibiting no leakage (score=0) at 35% (7/20), as well as the least number of sealants displaying maximum leakage (score=3) at 5% (1/20). The bur group showed no leakage in 25% (5/20) of sealants. The pumice group had the least number of sealants with no leakage (4/20) and the greatest number of sealants with maximum leakage (4/20). According to the Kruskal-Wallis test, there was no statistically significant difference ($P>0.05$) between the 3 treatment groups represented by the mean microleakage scores in Table 4.

Table 3. Distribution of Tooth-Level Microleakage Scores

Method	0	1	2	3	Total
Pumice	4	7	5	4	20
Bur	5	7	5	3	20
Air abrasion	7	5	7	1	20
Total	16	19	17	8	60

Table 4. Mean Microleakage Scores – Tooth-Level Analysis

Preparation method	n	Minimum	Maximum	Treatment group mean	Standard error
Pumice	20	0	3	1.45	0.235
Bur	20	0	3	1.30	0.231
Air abrasion	20	0	3	1.10	0.216

When all sealants in the 3 groups were considered, 16/60 sealants showed no leakage in any section. Minimal leakage (ie, dye penetration restricted to the outer half of the sealant) was observed in 19/60 sealants. Hence, minimal or no leakage was found in 35/60 (58%) sealants. Maximum microleakage into the depth of the underlying fissure was found in only 8/60 (13%) sealants.

Discussion

A variety of fissure preparation methods have been used prior to sealant placement in an attempt to successfully inhibit microleakage and maximize retention. While sealants have gained acceptance as their retentive and microleakage properties have improved, their clinical success rate still remains less than ideal. A 5% to 10% annual sealant failure rate was reported following analysis of multiple studies.[18] Consequently, the search for alternative preparation methods has continued to be an ongoing challenge.

In the present study, no significant difference in sealant microleakage was found between pumice, bur and air abrasion preparation methods in combination with acid etching. This study's results are supported by those of Mentes and Gencoglu.[12] The 2 studies used the same scoring system by Övrebö and Raadal[17] to analyze dye penetration. The air abrasion/etch group produced the lowest microleakage scores in both studies but not significantly lower than the other 2 treatment methods.

Similar results have been obtained in other microleakage studies. Xalabarde et al[16] demonstrated no significant difference in microleakage when comparing enameloplasty and etch to pumice and etch. They evaluated 2 different types of burs, the Sorensen diamond and 1/4-round carbide, but neither reduced significantly marginal leakage. In a study by

Zyskind et al,[13] the extent of microleakage was comparable between bur and air abrasion preparation methods when acid etch was employed. A recent study by Guirguis et al[10] yielded similar results. The marginal leakage of preventive resin restorations placed in teeth prepared with air abrasion alone was compared to resin restorations placed after bur preparation or air abrasion coupled with acid etching. Significant microleakage was observed in the non-etched, air abraded specimens, while the resins prepared by bur/etch or air abrasion/etch produced similar microleakage results that were significantly less than air abrasion alone.

In contrast, Hatibovic-Kofman et al[15] reported bur preparation with a 1/4-round bur coupled with acid etching to be significantly better at reducing microleakage than pumice and etch. The difference in findings may be due to the use of different burs and preparation depths. They reported opening fissures to an approximate diameter of the 1/4-round bur, whereas this study used a light "sweep" of the grooves trying to remove as little tooth structure as possible. Geiger et al[19] demonstrated that the deeper the level of sealant penetration, the lower the probability of microleakage. The broad range of enameloplasty preparation depths reported by dentists in a 1995 survey of northern California pediatric dentists reinforces the observation that clinicians are not consistent with this technique.[20]

Lending support to this study's findings is an in vitro sealant study by Brown and Barkmeier[21] that found no significant difference in bond strength between air abrasion and acid etch compared to acid etch alone. Similarly, a retention study conducted on extracted molars found that all acid-etched groups, which included a pumice, air abrasion, hydrogen peroxide and acid-etch alone group, generated equivalent mean shear bond strengths.[22] In contrast, Geiger et al[19] demonstrated on extracted molars that sealant retention was significantly improved by bur preparation compared to non-prepared fissures. A 6-year clinical trial by Shapira et al[23] reported sealants prepared by enameloplasty/etch had a significantly higher retention rate than those prepared by pumice/etch on maxillary molars only.

The finding of no significant difference in microleakage between the 3 sealant pretreatment methods has several implications regarding sealant placement. First, it suggests that dentists may be using more aggressive sealant preparation techniques on sound, healthy tooth structure than is necessary. Secondly, air abrasion is not without disadvantages, as it often creates a substantial dust powder in the work area that requires additional time to clean up. Lastly, a dental auxiliary cannot legally perform any type of tooth structure removal, which includes air abrasion and enameloplasty techniques. Therefore, fissure preparation with these 2 procedures requires the dentist's time rather than delegation to dental hygienists or qualified dental assistants.

Circumstances do present where bur or air abrasion preparation is obviously warranted. Suspected carious fissures should be prepared or explored by enameloplasty or air abrasion prior to sealant application to disclose potential caries. However, several studies have provided evidence that inadvertent sealing over carious lesions leads to arrest and not to caries progression.[24-29] The need to routinely air abrade or mechanically prepare fissures prior to sealing is not supported in the literature.

This study's results suggest that the method of pit and fissure cleaning is not the critical step in the sealant technique. It is more likely conditions such as tooth isolation and moisture control, eruption status of tooth, patient cooperation and a proper etch that determine sealant success. This study did not omit acid etching in the air abrasion group because the majority of previous studies have consistently demonstrated that the roughened surface produced by air abrasion alone lacks the seal obtained with acid etching.[9-13, 30] The literature appears to support acid etching as the treatment of choice over air abrasion alone.

The increased enamel resin tag formation that has been observed in SEM studies is one of the main benefits of acid etching.[31-33] Resin tag formation provides micromechanical retention of the sealant to enamel interface and serves as the primary mechanism by which sealants bond to enamel fissures.[34] This study's findings suggest that it makes no difference what type of fissure preparation is used as long as it is followed by acid etching prior to sealant placement.

More recently, the addition of a bonding agent to the traditional sealant technique has shown promising results as a means of improving retention and microleakage. Feigal et al[35] found single-bottle bonding agents to reduce the usual risk of retention failures of occlusal sealants. Another study demonstrated a significant reduction in microleakage when a dentin-bonding agent was applied between a sealant and saliva-contaminated enamel interface.[36] Self-etching adhesive systems have also been developed which may be able to improve and simplify the sealant process further, thus warranting more investigation.

This investigation was performed in vitro using extracted third molars. A controlled clinical trial is needed to further study the 3 preparation methods. Until microleakage and retention studies demonstrate conclusively one preparation method to be more effective than another at enhancing sealant success, it would seem prudent to continue using the traditional pumice and acid-etch technique. Based on the present findings, routine removal of healthy sound tooth structure prior to sealant placement does not seem justified.

Conclusions

1. Neither air abrasion nor enameloplasty followed by acid etching produced significantly less microleakage than the traditional pumice prophylaxis with acid etching technique.
2. This in vitro comparative study suggests that the conventional pumice prophylaxis with acid etching technique should remain the standard of practice for cleaning fissures prior to sealant placement.

References

1. Jensen OE, Handelman SL. Effect of an autopolymerizing sealant on viability of microflora in occlusal dental caries. *Scand J Dent Res.* 1980;88:382-388.
2. Jeronimus DJ, Till MJ, Sveen OB. Reduced viability of microorganisms under dental sealants. *J Dent Child.* 1975;42:275-280.
3. Sheykholeslam Z, Brandt S. Some factors affecting the bonding of orthodontic attachments to tooth surface. *J Clin Orthod.* 1977;11:734-773.
4. Newman GV, Facq JM. The effects of adhesive systems on tooth surfaces. *Am J Orthod.* 1971;59:67-75.
5. Ripa LW. The current status of pit and fissure sealants. A review. *JCDA.* 1985;5:367-380.
6. Burrow MF, Makinson OF, Orth D. Pits and fissures: remnant organic debris after acid-etching. *J Dent Child.* 1990;57:348-351.
7. Garcia-Godoy F, de Araujo FB. Enhancement of fissure sealant penetration and adaptation: The enameloplasty technique. *J Clin Pediatr Dent.* 1994;19:13-18.
8. Goldstein RE, Parkins FM. Air-abrasive technology: its new role in restorative dentistry. *JADA.* 1994;125:551-557.
9. Davis G, Waggoner W, Wilson S, Laurell K. Fissure sealants microleakage: comparison of acid etch versus air abrasion. *Pediatr Dent.* 1996;18:173 [abstract].
10. Guirguis R, Lee J, Conry J. Microleakage evaluation of restorations prepared with air abrasion. *Pediatr Dent.* 1999;21:311-315.
11. Haws SM, Oliveira ML, Vargas MA, Kanellis MJ. Air-abrasion and microleakage of pit and fissure sealants. *J Dent Res.* 1996;75:180 [abstract 1301].
12. Mentes A, Gencoglu N. An in vitro study of microleakage of sealants after mechanical or air abrasion techniques with or without acid-etching. *Eur J Paediatr Dent.* 2000;4:151-156.
13. Zyskind D, Zyskind K, Hirschfeld Z, Fuks AB. Effect of etching on leakage of sealants placed after air abrasion. *Pediatr Dent.* 1998;20:25-27.
14. Chan DCN, Summitt JB, Garcia-Godoy F, Hilton TJ, Chung KH. Evaluation of different methods for cleaning and preparing occlusal fissures. *Operative Dent.* 1999;24:331-336.
15. Hatibovic-Kofman S, Wright GZ, Braverman I. Microleakage of sealants after conventional, bur, and air-abrasion preparation of pits and fissures. *Pediatr Dent.* 1998;20:173-176.
16. Xalabarde A, Garcia-Godoy F, Boj JR, Canalda C. Microleakage of fissure sealants after occlusal enameloplasty and thermocycling. *J Clin Pediatr Dent.* 1998;22:231-235.
17. Övrebö RC, Raadal M. Microleakage in fissures sealed with resin or glass ionomer cement. *Scand J Dent Res.* 1990;98:66-69.
18. Feigal RJ. Sealants and preventive restorations: review of effectiveness and clinical changes for improvement. *Pediatr Dent.* 1998;20:85-92.
19. Geiger SB, Gulayev S, Weiss EI. Improving fissure sealant quality: mechanical preparation and filling level. *J of Dent.* 2000;28:407-412.
20. Halterman CW, Rayman M, Rabbach V. Survey of pediatric dentists concerning dental sealants. *Pediatr Dent.* 1995;17:455-456.
21. Brown JR, Barkmeier WW. A comparison of six enamel treatment procedures for sealant bonding. *Pediatr Dent.* 1996;18:29-31.
22. Ellis RW, Latta MA, Westerman GH. Effect of air abrasion and acid etching on sealant retention: an in vitro study. *Pediatr Dent.* 1999;21:316-319.
23. Shapira J, Eidelman E. Six-year clinical evaluation of fissure sealants placed after mechanical preparation: a matched pair study. *Pediatr Dent.* 1986;8:204-205.
24. Going RE, Loesche WJ, Grainger DA, Syed SA. The viability of *JADA.* 1978;97:455-462.
25. Kramer PF, Zelante F, Simionato MR. The immediate and long-term effects of invasive and noninvasive pit and fissure sealing techniques on the microflora in occlusal fissures of human teeth. *Pediatr Dent.* 1993;16:108-112.
26. Leverett DH, Handelman SL, Brenner CM, Iker HP. Use of sealants in the prevention and early treatment of carious lesions: cost analysis. *JADA.* 1983;106:39-42.
27. Mertz-Fairhurst EJ, Schuster GS, Fairhurst CW. Arresting caries by sealants: results of a clinical study. *JADA.* 1986;112:194-197.
28. Mertz-Fairhurst EJ, Adair SM, Sams DR, et al. Cariostatic and ultraconservative sealed restorations: nine-year results among children and adults. *J Dent Child.* 1995;62:97-107.
29. Swift EJ. The effect of sealants on dental caries: a review. *JADA.* 1988;116:700-704.
30. Eakle WS, Wong J, Huang H. Microleakage with microabrasion versus acid-etched enamel and dentin. *J Dent Res.* 1995;74:31 [abstract 160].
31. Jasmin JR, van Waes H, Vijayaraghavan TV. Scanning electron microscopy study of the fitting surface of fissure sealants. *Pediatr Dent.* 1991;13:370-372.
32. Birkenfeld LH, Schulman A. Enhanced retention of glass-ionomer sealant by enamel etching: A microleakage and scanning electron microscopic study. *Quintessence Int.* 1999;30:712-718.
33. Retief DH. Effect of conditioning the enamel surface with phosphoric acid. *J Dent Res.* 1973;52:333-341.
34. Silverstone LM. Fissure sealants: laboratory studies. *Caries Res.* 1974;8:2-26.
35. Feigal RJ, Musherure P, Gillespie B, Levy-Polack M, Quelhas I, Hebling J. Improved sealant retention with bonding agents: a clinical study of two-bottle and single-bottle systems. *J Dent Res.* 2000;79:1850-1856.
36. Hebling J, Feigal RJ. Use of one-bottle adhesive as an intermediate bonding layer to reduce sealant microleakage on saliva-contaminated enamel. *Am J Dent.* 2000;13:187-191.