

Have Recent Advances in Adhesives and Materials Dictated a Change in Sealant Protocols?

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ABSTRACT

With the constant evolution in new materials and techniques, the dental clinician needs to evaluate the integration of these changes into everyday practice. In the area of dental sealants, new glass ionomers, polyacid modified resin composites, flowable composites, composite sealants, and the new self-etching adhesives have been introduced to increase the predictability and caries reduction, of sealing the pits and fissures of occlusal surfaces of teeth. An overview and evaluation of the current literature will help the clinician choose a clinical protocol based on the evidence. This article suggests a current protocol based on the evidence to date.

Decisions regarding prevention and treatment of dental caries lesions forming in enamel pits and fissures can be challenging because of factors such as the “hidden caries” phenomenon, types of materials to use, methods of bonding restorative materials, and concerns for conserving tooth structure.¹ Pit and fissures are only 12.5% of the

tooth surfaces, yet they now account for 88 % of caries in children,² which is significantly higher than in 1973, when Ripa observed 50% caries.³ The overall annual attack rate for caries for all occlusal first permanent molar surfaces is 5.9% per year, while the approximal surfaces is 1.3% in a representative group of children, seven to fifteen years of

age.⁴ The efficacy of resin based sealants has been well documented over the years since the introduction of the ability to etch enamel and effectively bond to the surface by Buonocore.^{5,6} When evaluating treatment outcome trees for continuously enrolled 6-year old children who routinely used Medicaid dental services, Bhuridej et al found that sealed molars were less likely to receive further restorative treatment than were non-sealed molars (13 versus 29 percent).⁷

In an evaluation of published studies of parallel group and split mouth study designs, Uribe found that with 5-10 year old children, resin-based sealants resulted in caries reductions which ranged from 86% at 12 months to 57% at 48-54 months.⁸ One of the highest retention rates recorded at two years, with no new pit and fissure caries was for UltraSeal XT at

96.3% by Boksmen et al.⁹ Simonson has published a 10 year study on a single application of sealant with a 57% complete retention rate,¹⁰ and a 15 year study showing a 74% caries free status of sealed surfaces.¹¹ There is a variation in retention based on tooth type and position. Retention in premolars is higher than molars¹² and sealants placed in maxillary pit and fissures last longer than mandibular occlusals.¹³ In an excellent review of the literature (1,465 references) Simonsen states that “it has been documented for decades that sealants are safe, effective and underused”, and that “the profession has not embraced the procedure to the extent that available scientific data would expect”.¹⁴

Liebenberg stated that “fissure sealants are anything but effective unless applied with diligence and with due regard for appropriate case selection”, and in the same editorial was quick to point out that “a step in the right direction would be for clinicians to acknowledge that the difficulties begin with the investigation and diagnosis of the occlusal surfaces of teeth and the proper application of sealants is extremely difficult and often impossible”.¹⁵ Clinically, even with the aid of bite-wing radiographs, it is often extremely difficult if not impossible, to diagnose pit and fissure decay. Clinicians have usually relied on radiographs, the tactile feel of a sharp explorer in the occlusal grooves, and visual stain or discoloration of the enamel to decide whether treatment is necessary. However it is unfortunate that at the stage when an explorer finally detects an occlusal catch, the degree and extent of demineralization and compromised tooth structure is already far advanced.¹⁶

Laser-based fluorescence (Diagnodent — Kavvo) can be used for indication of decalcified carious

areas in pits and fissures.¹⁷ An excellent paper by Young discusses the merging of strategies for caries detection and modern caries management.¹⁸ Emerging technologies in this area include non-intrusive, non-contacting frequency-domain photothermal radiometry and frequency-domain luminescence.¹⁹ It remains to be seen whether these methods of detection become the norm. Even though a recent article by Kidd states that “there is little evidence that infected dentine must be removed prior to sealing a tooth”²⁰ and that caries do not progress under an intact sealant,²¹ it has never been a clinical protocol to knowingly seal carious pit and fissures. Dentin lesions should be restored preferably by the use of minimal intervention techniques like the preventive resin restoration.²²

In the last few years, the dental profession has been inundated with claims and counter claims utilizing new materials and techniques for the placement of dental sealants. Glass ionomer materials, and resin modified glass ionomers have been recommended for use. A sealant material containing amorphous calcium phosphate has recently been introduced that is claimed will have retention equivalent to any of the resin-based pit and fissure sealants. But when asked by the author for verification, no clinical trials are available for this product. The evolution of self-etch adhesives, which differ with multiple step and single step techniques, have lead manufacturers to indicate this adhesive for use with dental sealants. “When only one in five dental products live up to manufacturers claims, what you don’t know will hurt you and your patients” is a statement from CRA in 2006.²³ As well “there is currently no requirement for the presentation of clinical data before marketing an adhesive bonding agent”.²⁴ So where do we really stand at this time with our dif-

ferential choice for materials and techniques for sealant placement?

GLASS IONOMERS

Glass ionomers, which are a mixture of a polyacrylic acid and fluoro-aluminum silicate glass, bond to tooth structure with ionic bonds, but without the use of an acid etch technique.²⁵ The interest in the development of glass ionomers as pit and fissure sealants can be attributed directly to the release of fluoride into the adjacent tooth structure.²⁶ However the ionic bond of glass ionomers to enamel is much less than typical resin based sealants²⁷ and because of this and the brittle nature of the material, clinical retention rates of glass ionomer used as fissure sealants is extremely low.²⁸

In a study by the author, the retention rate of Fuji III sealant (GC) after six months was only 2% for Alpha or full retention with 94% of the samples totally lost.²⁹ Other authors report 1.2% retention after five years,³⁰ and 4% after three years³¹ for glass ionomers used as sealants. However although there is agreement that the retention rates of these glass ionomer sealants is low, there is no agreement on the potential caries reduction long term, of the fluoride released into the enamel and the pit and fissure area.³² Poulsen et al. state that “the glass-ionomer sealant tested in the present study had poorer retention and less caries protective effect than the resin-based sealant used³³ and re-iterated the superiority of composite sealants in reducing the risk of developing caries in an article in 2006.³⁴ In a randomized controlled trial Chadwick et al. found no evidence that the intervention as used (glass ionomer sealant) in the trial had any effect on caries incidence and stated that the glass ionomer cannot be recommended as a clinical procedure.³⁵ Caries reduction after the physi-

cal loss of the material has been attributed to fluoride uptake by the enamel or remnants of the glass ionomer in the fissure defects. In a study of 100 six to eight year olds with 400 glass ionomer sealants over a period of 36 months, Pereira found a 56% lower incidence of caries than the control group.³¹ Similarly Beiruti found “that the caries-preventive effect of high-viscosity glass ionomer sealants, placed using the ART procedure, was between 3.1 and 4.5 times higher than that of composite resin sealants after 5 years.”³⁶

Isolation of newly erupting teeth is an extremely difficult, if not impossible technique to accomplish. Moisture contamination of any type will lead to failure of the classical composite resin sealant material but minor moisture contamination does not prevent the formation of ionic bonds by glass ionomer cement. In his article on “surface protection for newly erupting first molars” Antonson suggests that a glass ionomer could be a “transitional sealant” that can be applied to newly erupting teeth and maintained throughout the eruptive process. Once effective isolation can be achieved, a permanent resin-based composite could be applied.³⁷ Similarly others have suggested the use of glass ionomer sealants when isolation is difficult to achieve in high risk patients.^{38,39}

POLYACID-MODIFIED RESIN COMPOSITES

The fluoride release of the polyacid-modified resins is much less than that of glass ionomers.⁴⁰ With non invasive techniques of placement, retention is low, with reports of total retention of 3.4% after six years,⁴¹ and 5% after forty eight months.⁴² The bond strength of non-rinse application to enamel is extremely weak.⁴³ The use of an invasive technique increases the retention rate of

these materials due to mechanical retention. However the marginal integrity is poor after 12 months⁴⁴ and there is marked occlusal wear.⁴⁵ Current research cannot support the use of polyacid-modified resin composites for use as pit and fissure sealants.

FLOWABLE COMPOSITES

Flowable composites, a dilute formulation of composite resin, have been evaluated as potential alternatives to the classic pit and fissure sealant. They range in filler loading by weight from 45% (Renamel Flowable Microfil — Cosmedent) to 70% (Matrixx Flow — Discus, Point 4 Flowable — sds/Kerr, Renamel De-Mark — Cosmedent). By volume the range is from 32% (AeliteFlo LV — Bisco) to 51% (Flow-It! — Pentron). Because of these differences in formulation the actual flow or rheology of these materials varies drastically. In a comparative test, Reality has rated the flow of these materials from 5 (no flow) to 0 (maximum flow).⁴⁶ In these tests Palifique Estelite LV (HF — Tokuyama/J. Morita USA) and Permaflo (Ultradent), had maximum flow of 0. Most of the flowables had low flow measurements of 4-5. This inherent characteristic of flow or lack thereof, and the ability to wet the surface, i.e. penetrate into the pit and fissure morphology, will significantly affect retention rates and clinical performance. It is therefore not surprising that clinical studies on flowable composites vary in their conclusions.

Autio-Gold when looking at a medium-filled (46%- volume) flowable found that “it did not perform better in retention rate and caries increment when compared to an unfilled sealant”.⁴⁷ In a study on the performance of classical sealants, flowable composites and flowable compomers Duangthip found that “the classical sealants showed significantly

lower microleakage than flowable composites”.⁴⁸ However a study comparing flowable to a resin-modified glass ionomer and compomer found that the flowable performed with better retention.⁴⁹ This, from the above discussion of the inherent lack of retention of glass ionomer materials, should not be a surprise. Clinically, the practitioner usually does not know where on the scale of flow, their material is likely to be, and therefore flowables can not be recommended for routine use in pit and fissure sealing.

COMPOSITE SEALANTS

In a special report detailing product use in 2005, CRA in their segment on preventive dentistry stated that 73% of respondents to their survey used sealants “routinely,” with the sealant brand most used as UltraSeal (Ultradent) at 42%.⁵⁰ Reality in their ratings of sealants list the highest filler rate by weight at 58% (UltraSeal XT — Ultradent) and the lowest at 6% (Clinpro Sealant — 3M/Espe).⁵¹ However, the filler loading does not correspond to the flow of the materials mentioned in rating of their top seven products. The highest flow was for the UltraSeal XT at 0.5 (0 = high flow and 5 = low flow), and the lowest was for Delton FS+ (Dentsply Professional) and EcuSeal (DMG/Zenith) at 2.5.

The lowest filled sealant did not have the highest flow. For UltraSeal XT plus “the main advantages over other sealants were a combination of convenient delivery system, excellent flow, fluoride release and white colour to facilitate monitoring of retention”.⁵² The presence of fluoride in a sealant, allows for the sealant fluoride to be “recharged” with topical 1.23% acidulated phosphate fluoride gel. In a study by Steinmetz, Helioseal F and UltraSeal XT released significant amounts of fluoride after the recharging process.⁵³

In a study looking at microleakage comparing a filled sealant with a drying agent (UltraSeal XT — Ultradent), a filled sealant (Prismashield — Caulk/Dentsply) and an unfilled sealant (Delton — Dentsply Professional), UltraSeal XT showed significantly less microleakage than the other two sealants.⁵⁴ This finding was verified by Lee, who in his study, evaluated the microleakage of three sealants, showing that UltraSeal XT had a significant difference in microleakage.⁵⁵ PrimaDry (Ultradent) a 99% ethyl alcohol and 1% bonding resin used with the UltraSeal XT enhances the sealant's penetration into the pits and fissures.⁵⁶ The high viscosity sealants (Prismashield — Caulk/Dentsply and Concise — 3M/Espe) do not penetrate enough to ensure that acid-etched enamel is infiltrated sufficiently by the sealant to insure good marginal seals.⁵⁷ In studies on the retention of sealants, UltraSeal XT has one of the highest two year retention rates for a fluoride-containing sealant ever recorded at 96.3%.⁹

SELF-ETCHING ADHESIVES

As mentioned earlier, the work by Buonocore on etching enamel with phosphoric acid paved the way for much of the adhesive dentistry we practice today. We know that acid etching of enamel with phosphoric acid is very predictable and uniform in the etching effect on enamel²² with high bond strengths as a result. In relationship to the penetration of etching agents and its influence on sealant penetration into fissures, a surfactant containing etchant (like UltraEtch — Ultradent) can completely penetrate into fissures, resulting in an increased retentive and wettable surface, which significantly increases sealant penetration into deep fissures.⁵⁸

With the advent of self-etching adhesives, these products are now being evaluated for use in multi-

ple bonding applications, with some being recommended for use by their manufacturers for use with sealants. The self-etching or 6th and 7th generation bonding agents as they are commonly referred to, vary in the number of steps required to use them,⁵⁹ filler weight,⁵⁹ acidity,⁶⁰ depth of etch on enamel,⁶¹ bond strength⁶⁰ and compatibility with dual-cure and self-cure composites.⁶² It can therefore be expected that the research that is published for using the self-etching adhesives can be for or against its use. When looking at two two-bottle, two all-in-one self-etching adhesives and one total etch control, Perdigao found that the field-emission scanning electron microscope revealed a deep interprismatic etching pattern for the total-etch adhesive, whereas the self-etching systems resulted in an etching pattern ranging from absent to moderate.⁶³

When evaluating microleakage using self-etching bonding systems Hanning found that the use of self-etching bonding systems, (Clearfil Liner Bond 2 — Kuraray America) cannot be recommended for fissure sealing since the sealing ability is less effective as compared to the conventional acid-etching technique.⁶⁴ However, Tay found that “aggressive self-etch adhesives are potentially useful for bonding to unground enamel such as that present in occlusal fissures, in conjunction with the use of pit-and-fissure sealants”.⁶⁵

A product that has been extensively researched and published in the dental literature is Prompt-L-Pop (3M/Espe). Perry found that the “use of this specific acidic resin primer in lieu of conventional acid etching (whether cured prior or subsequent to sealant placement) demonstrated greater incidence of microleakage and would not be advocated over traditional etching procedures.⁶⁶ “A logistic regression model at the

person level demonstrated that the phosphoric acid technique was six times as likely to have retention of all the sealed tooth surfaces as those sealed with Prompt-L-Pop when looking at twelve month data for a school-based sealant program.⁶⁷ However, a study by Perdigao looking at methodologies of application and curing of the sealant material found that the highest mean bond strengths were obtained when Adper Prompt L-Pop was applied in two layers and light-cured prior to the insertion of Clinpro Sealant (3M/Espe). Application of one layer of Adper Prompt L-Pop co-cured with the sealant resulted in bond strengths similar to those obtained with phosphoric acid etching.⁶⁸ This is the clinical protocol suggested by the manufacturer as a time saving procedure, decreasing the application time from 3.1 minutes to 1.8 minutes.^{69,70}

The two layer/light-cure/application technique resulted in a bond strength of 22.7 MPA and the single coat/co-cured technique resulted in a bond strength of 18 MPA.⁷¹ When looking at a small sample of 10 in each category, Peutzfeldt states that “the self-etching adhesive studied seems an attractive alternative to the acid-etch technique for sealant application in young children where simplifications in the clinical techniques are warranted.”⁷²

CONCLUSION

Based on the above discussion and research literature some conclusions can be drawn:

- 1) The use of a glass ionomer sealant can be viewed as an interim prophylactic step when isolation is impossible to achieve and the caries risk (and oral hygiene compliance) warrants early intervention.
- 2) The sealant UltraSeal XT has the highest current usage and

highest retention rates recorded for a dental sealant

3) Due to the variation in pH of the self-etch adhesives, only those with a low enough pH to etch unground enamel sufficiently may show some promise.

4) Alternative methodologies using self-etch adhesives need further study to unequivocally prove that their retention rates and caries reduction equals or is superior to current total etch techniques. **OH**

Disclosure

Dr. Len Boksman is an Adjunct Clinical Professor at the Schulich School of Medicine and Dentistry in London Ontario, and is a paid consultant to Clinical Research Dental Supplies and Services Inc, London, Ontario, with the title of Director of Clinical Affairs.

Oral Health welcomes this original article.

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