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Preventive Resin Restorations and Sealants in Light of Current Evidence

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The 1970s were years of huge potential for change in clinical dentistry, particularly in the fields of preventive dentistry, operative dentistry, and clinical orthodontics. These three disciplines were particularly fertile areas for the application of benefits of the acid-etch technique developed by Buonocore [1]. Nevertheless, change in clinical procedures does not occur easily, and the benefits wrought by the landmark work of Buonocore were adopted painfully slowly into daily clinical dental practice.

In the mid-1960s, Buonocore and others [2–4] published interesting reports on the potential use of the acid-etch technique as a caries-preventive measure that came to be known as the pit and fissure sealant technique. This procedure was introduced commercially in 1971 by the L.D. Caulk Company (Milford, Delaware) when the first ultraviolet-light-cured pit and fissure sealant, Nuva-Seal, was launched in February of that year. In subsequent months and years, several other manufacturers introduced their own sealants, primarily of the autocuring type. The technique was the subject of many laboratory and clinical trials that were generally positive in terms of retention and caries prevention [5]. Nevertheless, the profession was reluctant to adopt this procedure, and in 2005, the pit and fissure sealant is perhaps the most tested yet most underused technique in clinical preventive dentistry [6–8]. Buonocore's work had an even greater potential for impact on clinical restorative dentistry than on preventive dentistry, as Buonocore himself had predicted in his seminal article in 1955 [1]. These changes quickly followed the introduction of pit and fissure sealant as a preventive procedure.

G.V. Black is the father of operative dentistry. His work on dental amalgam and on systematizing the classification of cavity preparations was of immense impact in operative dentistry for most of the last century. His work was regarded with almost biblical reverence by teachers of operative

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dentistry at schools of dentistry around the world. When the acid-etch technique made possible an alternative minimally-invasive option for the treatment of small or incipient pit and fissure carious lesions, a technique that came to be known as the preventive resin restoration (PRR), it was met with skepticism at best, and outright hostility at worst, in the operative and pediatric dentistry departments of many universities. I can remember in 1982 when the Department of Operative Dentistry at the University of Connecticut was teaching the PRR while the Department of Pediatric Dentistry at the same school continued to teach the Class I amalgam for incipient lesions in the pit and fissure surfaces of posterior teeth. This conflict within institutions is common when new technology is assessed in different ways by different faculty. In orthodontics, the benefits of bonding brackets were more readily apparent, and the transition from cementing bands to bonding brackets occurred more smoothly [9].

Pit and fissure sealants and preventive resin restoration

The PRR was born of the clinical experience with sealants in the early 1970s. I was fortunate to spend 6 weeks with Harald Ulvestad and Björn Zachrisson in 1971 at the University of Oslo, Norway, after graduation from the University of Minnesota School of Dentistry. These enthusiastic and distinguished colleagues stimulated thoughts that, combined with clinical experiences with sealants in subsequent years, led to the development of the PRR from 1972 to 1975.

Zachrisson was the pioneer in adopting the acid-etch technique to bonding brackets in orthodontics, and Ulvestad was contemplating using a diluted-composite material as a more wear-resistant sealant option [10]. The use of sealants preventively was clearly beneficial as shown by the early work of Cueto and Buonocore [4], which has been supported by hundreds of subsequent studies and reams of reports. The dilemma of having to prepare the significantly invasive Class I amalgam preparation for teeth deemed inappropriate for sealants because of an incipient lesion led to the thought that a more conservative option must be found. The Class I amalgam preparation is designed to accommodate the strength deficiencies of the amalgam material; therefore, tooth preparations are always made into the dentinal layer rather than leaving some enamel, even if the caries is in enamel only. The reason is that amalgam is a brittle material and weak in a thin layer. Vital tooth structure is removed simply to provide strength for the restorative material. Similarly, the Class I amalgam requires "extension for prevention," which removes adjacent noncarious pits and fissures in a preventive move to limit the chances of an additional caries attack on the adjacent surfaces.

The chasm between the beneficial effects of a noninvasive sealant and the extensively invasive Class I amalgam preparation (at least when compared with the sealant) was huge in microscopic terms. Cutting through enamel into dentin can be the first step in the eventual crowning or loss of the tooth. Losing the enamel link between cusps makes the cusps susceptible to movement during mastication. This microscopic movement leads to cracks in the adjacent enamel. These cracks propagate over time, and, eventually, a cusp fractures, leading to a more radical operative procedure. The life cycle of the first permanent molar, that is, the cycle of restoration and re-restoration, is one that is set up soon after eruption of the tooth if conventional Black cavity preparations are used [11]. Perhaps the greatest service any dentist can provide to a patient is preventing any restorative treatment to the first permanent molars. The acid-etch technique and the new bondable materials provided a minimally-invasive option that theretofore had not been possible. The concept of Black's cavity preparation rules for the Class I amalgam were made obsolete by the ability to change cavity preparations for incipient pit and fissure lesions from the complex rules of Black, that accommodated amalgam's deficiencies, to simply the removal of diseased tooth structure. The practice of extension for prevention became anathema to PRR cavity preparation with the advent of the acid-etch technique and bonded materials. Nevertheless, many years passed before the PRR was completely accepted by clinicians and dental schools as the preferred treatment option for incipient posterior carious lesions.

The first publication on the PRR used the term *sealant-restorations* [12] for the minimally invasive procedure and was the result of the first years of research into a less destructive Class I restorative procedure. The technique was titled "sealant-restoration," because it was a restoration using sealant as an integral part of the procedure (distinguishing it from a conventional preventive sealant in that carious tooth structure was removed). Thereafter, the term *preventive resin restoration* was used [13,14] because it was thought that the term *sealant-restoration* was somewhat oxymoronic (as, perhaps, some would say of the term *PRR*). The term was not meant to confine the category to resin restorative materials but used merely to indicate that this was a new concept using available bondable materials that was restorative while preventive (in terms of minimal amounts of tooth reduction and the use of a preventive material as an integral component of the procedure). The major benefit of the procedure was the minimally-invasive effect of cavity preparations that abandoned Black's principles and removed only diseased tooth structure while using Buonocore's acid-etch principles and Bowen's work in the development of resin materials [15]. The PRR was not well received by the adherents of Black's principles. Three-year results were published in the *Journal of the American Dental Association* [16] only after the author appealed a reviewer's decision to reject the article because, "Everyone knows that composites cannot work in the posterior." Nevertheless, the PRR as a minimally-invasive procedure has stood the test of time, and the basic philosophy of conservation of tooth structure for maintenance of the inherent strength of the tooth remains unchallenged today.

The original three types of PRR (type A, B, and C) from 1977 were modified slightly and updated in 1985 [17] with the definition of types 1, 2, and 3 PRR. Of the different types, the type 3 PRR is the one that is accepted as the generic PRR. The other two types are basically variants that comprise exploratory preparations that do not penetrate enamel and that use a pit and fissure sealant as the material of choice (type 1). The type 2 PRR involves a restorative procedure in which replacement of the tooth structure and sealing of adjacent unprepared pits and fissures is accomplished using a diluted composite resin or, as it would be called today, a flowable resin composite. Until recently, any use of a diluted composite or a flowable resin composite has been somewhat of a compromise in the two needs (restorative and preventive) for a PRR. In the restorative component, a flowable resin composite compared with a full-strength posterior composite will have less filler load (and thus less strength). In the preventive component, the flowable resin composite, being more highly filled than a sealant, will lose some of the penetration effect of the sealant. Penetration of a sealant into pits and fissures is a crucial aspect of success [18]. Because penetration is inversely proportional to the viscosity of the material being used, a flowable material compromises the PRR when compared with the type 3 version using the two materials—the posterior composite for the replacement of lost tooth structure, and the sealant as a preventive material placed over the composite and into adjacent unprepared pits and fissures.

In the type 3 PRR, two materials are used—one to restore and one to prevent future caries. Both materials are used in their primary roles as restorative and preventive materials; therefore, there is no compromise of function of the two materials. Recent developments in flowable materials seem to be heading in the direction of greater strength, but the penetration of the material in its role as a pit and fissure sealant in a PRR is still of concern. Use of a self-etching adhesive (SEA) before a wear-resistant flowable material could be the treatment of choice in the future.

When use of the PRR was first documented, there was concern about etching dentin. Subsequently, the total etch technique and SEAs have become available whereby the etching step is combined with the application of a primer and an adhesive. Although full documentation of the new adhesives remains to be completed, if it is assumed that the new materials will be successful, the type 3 PRR would be performed as follows:

1. Isolate the tooth with a rubber dam. Anesthesia is generally preferable unless the extent of the caries is known to be minimal, and the patient, in the operator’s experience, will be comfortable without anesthesia.
2. Using the smallest bur possible (the 003 or 1/16th bur from Brasseler [Savannah, Georgia] is an example of the smallest ultra-small round bur), the fissures are cleaned and carious areas confirmed. Although other tapered burs and diamonds may work well, it is more difficult to get access to caries (eg, along the dentino-enamel junction under an enamel margin)

with a tapered bur, and the deeper the preparation gets, the wider it becomes when a tapered bur is used. This effect is not true with a round bur.

3. The carious tooth structure is removed with the small round bur, going up in size of the bur as necessary for removal of all decayed tooth structure. Other burs are available, and some operators may prefer to use air abrasion for this step. Although access openings are kept as small as possible, carious tooth structure must be removed carefully along the dentino-enamel junction, which may be difficult to access without increasing the cavity opening. Once all carious tooth structure has been removed and any fissures that may be suspicious for carious activity have been explored, the restoration can commence.
4. A contemporary SEA material is applied into and around the cavity preparation, including areas where the sealant layer will be applied, and is then dried or thinned thoroughly, followed by light-curing, depending on the manufacturer's instructions. The restorative resin composite is applied with an applicator of choice. These small preparations can trap air bubbles unless one operates with care and applies small amounts of material. The SEA materials are new and as a category require further testing in the laboratory and in clinical trials before they can obviate the need for a separate etching step using phosphoric acid.
5. Once the areas where tooth structure has been removed are restored with composite material (or a material of choice) and light-cured, the sealant layer is applied. The sealant layer is designed to fill in any voids or gaps in the restorative material while acting as a sealant over cleaned or untouched adjacent pits and fissures. The sealant layer, as the restorative layer, does not have to be a light-cured version of resin, and autocured material is equally, or perhaps more, effective.
6. The rubber dam is removed, and occlusion is checked. Although an unfilled sealant will be quickly ground into occlusion, if the underlying composite is too high, it will result in discomfort for the patient if the occlusal interference is not adjusted. It is not a problem if this occlusal adjustment removes the sealant over part of the composite, because the two layers will have bonded together completely.

Recent work on PRRs and other minimally-invasive procedures has been enlightening. In a systematic review of available evidence, McComb [19] reported generally favorable outcomes for the PRR, whereas the evidence revealed "low effectiveness for 'tunnel' restorations." Tunnel restorations are also an attempt to conserve tooth structure, in this case, for interproximal lesions, but the literature is equivocal, and the clinical procedure is of questionable general use. A more realistic conservative class II procedure is the conservative proximal slot preparation, which McComb reports as having "supportive results" [19].

Feigal [20] reported that PRRs had a proven record but were susceptible to failure as the overlying sealant failed. McCombe noted that, "The weak link in the latter [PRR] is the overlying fissure sealant, which requires adequate ongoing maintenance" [19]. Generally, a properly placed type 3 PRR using a posterior composite as the restorative material and a sealant as the preventive component on top of the restorative material (placed into unprepared but etched pits and fissures) will show wear of the sealant layer first. Nevertheless, wear or loss of the sealant should not necessarily constitute "failure" of the PRR. Although the sealant should be replaced in the event of loss, as is true in any area where sealant is applied and the caries susceptibility is significant, if there is no immediate danger of caries from the loss, the restorative material used should function adequately for many years before resurfacing may be required.

Lyons [21] from the Ministry of Health in New Zealand reported that, "Preventive resin restorations should be placed to restore deep pits and fissures with incipient caries or developmental defects in primary and permanent teeth." The PRR has become accepted on a global basis as the technique of choice for minimally invasive treatment of incipient or small carious lesions in pit and fissure surfaces.

The use of fluoride-releasing materials such as glass-ionomer cements has been suggested and attempted over the years for sealant application and in minimally-invasive procedures such as atraumatic restorative treatment (ART). ART has been proposed as a minimal intervention technique to manage dental caries. It is mainly performed in third-world countries or areas where there may not be electricity or other staples of optimal treatment on a regular basis. Glass-ionomer cements have been used extensively in ART. The results generally cannot be compared with the outcome of PRR or sealant treatment in the United States or Europe where application conditions are generally ideal. A recent study in Tunisia reported that less than half of the ART restorations survived 3 years, with slightly more than half of the glass-ionomer sealants surviving after 3 years [22].

An extensive review of the literature in 1996 on glass-ionomer sealants was not encouraging in terms of retention but somewhat more positive for caries prevention. As of 1996, the published literature indicated that retention for resin-based sealants was better than for glass-ionomer sealants, but the differences in caries prevention remained equivocal [23]. A more recent clinical evaluation confirmed the previous review. It reported that the retention rates of the glass-ionomer materials (including one resin-modified glass-ionomer material) were low [24]. In another study, the retention and the caries-preventive effect of a glass-ionomer developed for fissure sealing (Fuji III) and a chemically-polymerized, resin-based fissure sealant (Delton) were compared. After 3 years, the glass-ionomer sealant had poorer retention and less of a caries-protective effect than the resin-based sealant [25].

Although the ART approach has been shown to be beneficial in improving the oral health of many patients in developing countries [26], I believe that ART should be more realistically termed a *caries control* *treatment* (CCT). ART is supposedly atraumatic (without use of anesthesia) because the caries is removed with a spoon excavator (presumably until the patient winces); however, the lack of "trauma" is inherently difficult to define and even harder to measure. Because ART is not a definitive restorative treatment, the "A" and the "R" are, in my opinion, misplaced terms. No attempt is made to remove all of the caries, and glass-ionomer restorative material is then applied, sometimes with finger pressure. Exactly how researchers have defined "success" for ART varies considerably, and the process cannot be compared with how researchers evaluate more conventional restorative procedures (such as using United States Public Health Service criteria). Success in an ART study can mean that most of the restorative material is still present without attention to marginal degradation or the color of the restorative material being factored into the results. The results must be evaluated in the context of the study criteria, and it is doubtful, in my opinion, whether ART can be useful in most first-world countries except in certain pockets of populations. Nevertheless, in countries where ART has been tested, the adherents are enthusiastic about its effects on the oral health of the patients treated. As a caries control technique, ART appears to be a valuable tool in fighting caries in any area where the disease is rampant.

Although sealants were a necessary step in the development of minimally-invasive restorative procedures such as the PRR, they now face some criticism from those who think of "hidden caries" as a new phenomenon somehow associated with the increased use of fluoride. The argument is that, in this modern age, the use of fluorides has strengthened the enamel of many people to the point where enamel can withstand the ravages of caries attacking the underlying dentin for some time without collapsing (the cariogenic bacteria having entered through an almost invisible pinpoint pit or fissure). As a result, it is argued that placing a sealant is dangerous, because it could lead to progression of the carious lesion under the sealant, which would block (because many sealants are opaque) the view of the underlying lesion progressing. Indeed, the theme of hidden caries is discussed in more detail elsewhere in this issue. The concept of hidden caries is not a new phenomenon and was noted in a book published in 1890 entitled, *The Diseases of Children's Teeth, Their Prevention and Treatment*. The author notes that, "it is not uncommon to find, in preparing a cavity for filling, that a comparatively small hole in the enamel leads down to a large unexpected, or at all events previously unknown, excavation in the dentine" [27]. I have no reason to believe that this is the first reference to hidden caries, but it does document that hidden caries is not a recent phenomenon. To use the "recent" development of hidden caries as a reason to question the advisability of applying sealant as a preventive material is, in my opinion, a fallacy.

A recent extensive review of the sealant literature [18] encompassing almost 1500 references concluded that pit and fissure sealants are well documented in terms of successful retention and caries prevention. In addition, the effect of the application of sealant over carious lesions is documented.

Summary

My task for this issue was to discuss pit and fissure sealants and the PRR in light of current thinking. It seems clear that both procedures are valid, acceptable, and recommendable treatments—one preventive and the other a combination of preventive and restorative treatment. Pit and fissure sealant should be a treatment option provided to all children at the age immediately after eruption of the posterior teeth, particularly but not exclusively, the permanent teeth. Although there are some children who will not benefit from sealants (those lucky few who will remain caries-free throughout life), most others will benefit greatly from the prevention of pit and fissure caries. This benefit is well-documented in the peer-reviewed literature. The PRR is a minimally-invasive procedure that should be the treatment of choice for small carious lesions in posterior teeth. The Class I amalgam should not be placed as a first-time restorative material to treat incipient or small carious lesions under any circumstances. The amount of tooth structure removal necessary for a class I Black preparation, which requires sufficient depth of amalgam and extension for prevention, is so much greater than the PRR approach that it renders the Class I amalgam an unacceptable treatment when minimally-invasive options are available.

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