How the introduction of the acid-etch technique revolutionized dental practice

Domenick T. Zero, DDS, MS

Over the last 100 hundred years, only a handful of discoveries have revolutionized the practice of dentistry. Without question, the introduction of acid etching to condition the enamel surface as a means of retaining pit-and-fissure sealants—and its much broader impact on the blossoming of restorative and esthetic adhesive dentistry—must be considered to be at the very top of the list. While the potential for dental sealants to prevent pit-and-fissure caries and to inhibit the progression of early caries has yet to be fully realized due to underutilization, sealants have had a major effect in reducing caries prevalence in children,¹ ² especially through school-based programs.³

Dr. Michael Buonocore was not the only one who envisioned the potential of adhesive dentist-
This landmark article by Michael Buonocore\textsuperscript{13} that is the basis of this commentary provided the two-year clinical data documenting the effectiveness of dental sealants following from an earlier publication in JADA that reported the results after one year.\textsuperscript{6} These articles were the first to establish that the combination of acid etching (to condition the tooth surface) and resin polymer was effective in preventing pit-and-fissure caries. The resin formulation involved three parts bisphenol A and glycidyl methacrylate and one part methyl methacrylate monomer. A light-activated catalyst, benzoin methyl ether, was mixed in just before curing with ultraviolet light. In an earlier study, Cueto and Buonocore\textsuperscript{10} used a mixture of methyl 2-cyanoacrylate and siliceous filler material similar to what was used in silicate cements commonly in use in dental practice at that time. Although this was the first pit-and-fissure sealant study using the acid-etch method, the results did not meet Dr. Buonocore’s expectations owing to an unacceptable rate of sealant loss necessitating reapplication every six months. He recognized that for sealants to be broadly adopted, they must be able to provide a substantial reduction in dental caries from a single application and not require frequent repeat applications due to sealant loss. In this landmark article, he\textsuperscript{13} reported almost complete protection against pit-and-fissure caries in permanent teeth (99 percent reduction) and primary teeth (87 percent reduction) over a two-year period after one application in a very high–caries-risk population.

What is most apparent in Dr. Buonocore’s approach to the development of dental sealants was that he combined his knowledge in chemistry, dental materials and clinical dentistry to painstakingly develop an approach that would ultimately lead to the successful dental bonding system for preventing dental caries. His idea to
acid-etch the enamel surface in advance of applying an adhesive material was based on his knowledge that phosphoric acid was used to pre-treat metal surfaces to obtain better adhesion of paint and resin coatings. Furthermore, phosphoric acid was commonly used in phosphate cements, which lessened any clinical safety concerns about using an acid on tooth structure. He made incremental improvements in the method of enamel etching and placing sealants and the materials used that clearly reflected the translation of his laboratory findings into highly innovative clinical applications.

A careful reading of Dr. Buonocore’s landmark article reveals his many findings and insights, most of which have held up more than 40 years later. These include several clinical observations: sealants are better retained and more effective in preventing caries in the permanent dentition than in the primary dentition; occlusal fissures with multiple crevices have the best retention; the presence of resin tags may explain the observed caries protection, even when sealant appear to be lost clinically; and the addition of fluoride to sealant material may provide additional protection. Dr. Buonocore also provided guidance on how to place sealants that have endured the test of time, which included the importance of a properly etched surface with a uniform dull appearance on drying, thoroughly washing the etched tooth surface, preventing saliva contamination after etching and, most importantly, drying the etched tooth surface with warm air that is free of water and oil immediately before sealant application.

Michael Buonocore must be considered one of dentistry’s greatest innovators and visionaries. The conceptual framework that he laid out in his article published in 1955 remains the basis for the use of pit-and-fissure sealants and modern adhesive dentistry, which has not changed much over nearly 60 years:

We foresee that the formation of good bonds, of the sort we have demonstrated, to enamel surfaces open the possibility of successfully sealing pits and fissures for purposes of caries prevention. In addition, good bonding at the enamel cavity margins would protect against secondary or marginal decay.

As noted in the introduction to this article, there was a general understanding at that time that existing restorative materials had limitations owing to their lack of adhesion to tooth structure and that development of materials or ways of conditioning the enamel surface that resulted in the adhesion to the tooth structure would be a major advance for dentistry. This led to the pursuit of different strategies to obtain bonding between restorative materials and tooth structure.

Dr. Buonocore outlined several approaches: developing new materials with adhesive properties; modifying existing materials to make them more adhesive; using coatings with adhesive properties between restorative material and tooth; and altering the tooth surface chemically to permit better adhesion. It was this last approach that he pursued and which started the revolution.

At the time of the first clinical trial, there was not a full understanding of the mechanism behind the remarkable increased adhesion observed both in laboratory studies and clinically. Dr. Buonocore had postulated that this mechanism could be due to several factors: increased surface area for bonding due to acid etching; exposure of the organic matrix for the resin to adhere; the formation of a new surface layer due to precipitation of reaction products to which the acrylic might adhere; etching away of the existing surface layer exposing a more reactive surface; and the creation of an adsorbed layer of highly polar phosphate groups as a result of the acid exposure.

The actual mechanism by which the dramatic increase in bonding occurred was not scientifically resolved until later when Dr. Buonocore, in collaboration with Drs. Matsui and Gwinnett, observed that enamel surfaces etched with phosphoric acid were penetrated by “prism-like” resin tags in comparison with nonconditioned enamel (Figure 2), which exhibited poor bonding and the absence of resin tags. They concluded that enamel bonding was primarily mechanical in nature, where the penetration of the resin in monomer form fills the micropores (interprismatic and intraprismatic spaces) enlarged by acid etching. The resin tags can be readily seen in a scanning electron micrograph of the undersurface of a sealant after the enamel has been partially dissolved by strong acid (Figure 3). They went on to define the characteristics of an ideal material to facilitate bonding, which included wettability and surface tension and the ability to form into an impermeable and abrasion- and bacteria-resistant polymer.

Over the years following Dr. Buonocore’s trailblazing research, there have been efforts by manufacturers, researchers and clinicians to improve on his basic concept. The phosphoric acid concentrate has been reduced from the 50 percent originally used by Dr. Buonocore in his early clinical studies to the 35 percent and 37 percent commonly used today. Acid-conditioning times have been reduced from 60 seconds.
In closing, it’s worthwhile to look at Dr. Buonocore’s contribution to dentistry in light of where we are heading (or should be heading) as a profession. There has been an ongoing debate on how to manage dental caries properly as long as there has been a dental profession. The current controversy centers on the diagnostic threshold of when nonoperative versus operative approach is used to managing noncavitated carious lesions.20 The weight of available evidence is clearly on the side of taking a conservative, nonoperative approach whenever possible in managing noncavitated carious lesions.20 Dr. Handelman along with Dr. Buonocore and others at Eastman were the first to establish that sealants were effective in reducing bacteria’s viability and preventing progression of early carious lesions.19,21,22 These findings have been substantiated by several systemic reviews,3,23 including the evidence-based report of the ADA Council on Scientific Affairs published in JADA.2

On the basis of a 2011 survey,24 U.S. dentists have not yet adopted recommendations to seal noncavitated carious lesions. Many of the issues surrounding the use of sealants to prevent progression of early carious lesions have been with us since the turn of the last century. Thaddeus Hyatt’s25 report, read at a meeting of the New York Academy of Dentistry on Oct. 22, 1925, and the discussion that followed provide some interesting insights into the controversy surrounding the prophylactic odontotomy at that time. Given the thoughtful rationale that he provided in the then prefluoride, presealant era, I believe it’s safe to assume that Dr. Hyatt would have fully embraced the use of dental sealants for the prevention of caries in clinically sound teeth and the sealing of teeth with noncavitated carious lesions without operatively altering tooth structure in light of the current discussion.

In closing, it’s worthwhile to look at Dr. Buonocore’s contribution to dentistry in light of where we are heading (or should be heading) as a profession. There has been an ongoing debate on how to manage dental caries properly as long as there has been a dental profession. The current controversy centers on the diagnostic threshold of when nonoperative versus operative approach is used to managing noncavitated carious lesions.20 The weight of available evidence is clearly on the side of taking a conservative, nonoperative approach whenever possible in managing noncavitated carious lesions. Dr. Handelman along with Dr. Buonocore and others at Eastman were the first to establish that sealants were effective in reducing bacteria’s viability and preventing progression of early carious lesions.19,21,22 These findings have been substantiated by several systemic reviews,3,23 including the evidence-based report of the ADA Council on Scientific Affairs published in JADA.2

On the basis of a 2011 survey,24 U.S. dentists have not yet adopted recommendations to seal noncavitated carious lesions. Many of the issues surrounding the use of sealants to prevent progression of early carious lesions have been with us since the turn of the last century. Thaddeus Hyatt’s25 report, read at a meeting of the New York Academy of Dentistry on Oct. 22, 1925, and the discussion that followed provide some interesting insights into the controversy surrounding the prophylactic odontotomy at that time. Given the thoughtful rationale that he provided in the then prefluoride, presealant era, I believe it’s safe to assume that Dr. Hyatt would have fully embraced the use of dental sealants for the prevention of caries in clinically sound teeth and the sealing of teeth with noncavitated carious lesions without operatively altering tooth structure in light of the current discussion.
current scientific evidence. Maybe it’s time for our component dental societies to rekindle this kind of debate among their members.

Dr. Zero is the director, Oral Health Research Institute, and a professor, Department of Preventive and Community Dentistry, School of Dentistry, Indiana University, 415 Lansing St., Indianapolis, Ind. 46202-2876, e-mail dzero@iu.edu. Address reprint requests to Dr. Zero.


Introducing Sensodyne® Repair & Protect toothpaste

Our new layer of protection for dentin hypersensitivity

Sensodyne® Repair & Protect toothpaste builds a robust reparative layer over and within dentin tubules.1,2 The layer begins to form from the first use, and provides proven, lasting protection from dentin hypersensitivity.1,2,3

Think beyond pain relief and recommend Sensodyne® Repair & Protect toothpaste.

† with twice daily brushing.

References:

© 2013 GlaxoSmithKline Consumer Healthcare