Indian Journal of Dental Education
Volume 13 Number 1, January – March 2020
DOI: https://dx.doi.org/10.21088/ijde.0974.6099.13120.2

Etching in Dentistry

Prashanth Kumar Katta

Author's Affiliation: Assistant Professor, Department of Restorative Dental Sciences, King Faisal university, Al Hasa, Kingdom of Saudi Arabia.

Corresponding Author: Prashanth Kumar Katta, Assistant Professor, Department of Restorative Dental Sciences, King Faisal university, Al Hasa, Kingdom of Saudi Arabia.

E-mail: drprashanthmds@gmail.com

Received on 12.11.2019; **Accepted on** 11.12.2019

How to cite this article:
Prashanth Kumar Katta. Etching in Dentistry. Indian J Dent Educ. 2020;13(1):17–20.

Abstract

Etching is not as simple as it sounds. The contribution of good etching process is more important than the best bonding agent because without proper etching even the best bonding agent does not give optimum results. Etching is not confined to ideal enamel or dentin conditions. The substrate can be a young tooth, old tooth or otherwise. This article highlights the differences in enamel and dentin etching and the factors that affect the etching process.

Keywords: Concentration; Dentin; Depth; Enamel; Etching.

Introduction

In the early 1950s, Dr. Michael Buonocore first introduced the idea of acid etching enamel to increase bonding of resin to tooth structure. Retention of dental resin materials is increased significantly by prior treatment of the enamel surfaces with few inorganic acids or chelators.[16]

Acid etch creates microscopic spaces in enamel (increasing surface roughness) into which the bonding agent/adhesive can flow, aiding the bonding process (micromechanical retention). When desiccated, a surface that has been etched appears chalky white or frosted.

Why Etching

Phosphoric acid is used to eliminate the smear layer and demineralize the surface of the dentin. This exposes a network of collagen fibers on the surface. Phosphoric and maleic acid, but also functional monomers of self-etch adhesives such as Phenyl-P, will initially bond to Ca of HAp, but then bond will fail. The negatively loaded phosphate ions (or carboxyl groups for carboxyl-based monomers/acids) will remove the positively loaded (and thus electrostatically attracted) Ca ions from the surface, up to a certain depth depending on the application time.

The effect is extensive decalcification or ''etching'' effect, as it is clearly known when phosphoric acid is used, which is used as an ''etchant'' in the ''etch-and-rinse'' approach. Because the calcium-phosphate/carboxylate bond originally formed at the enamel/dentin surface is not stable, the bond will dissociate, leading to a typical etch pattern at enamel and a relatively deep (3–5 mm) hybrid layer at dentin that no longer contains any apatite crystals.[9]

Enamel Etching

Advantages: enhance resin-enamel bond, strengthening adhesive properties of restoration aids in creating a seal to prevent marginal leakage. Thixotropic nature of gels gives better control while applying.

Disadvantages: Need a dry working environment viscosity of gels thought to affect etching quality as less uniformity of 'wetting' enamel surface self-etching adhesives sometimes clear the smear layer well so retention strength can be compromised Aprismatic, one-directional primary enamel may prevent effective etching and reduce formation of sufficient resin tags lower strength require much longer etching times which is not convenient in dental setting typical honeycomb appearance due to the preferential loss of material from the prisma core, Type 1 and Type 2 etching patterns may be due to variations in crystallite orientation in the enamel prisms.[3]

Type 3 etching pattern is produced on prismless enamel that is enamel surfaces in which the enamel prisms do not reach the surface.[4] Type 1 and Type 2 etching patterns provide the maximum retention.[7] This typical etching pattern in 3 different types was proposed by Silverstone et al.[17] Only a random distribution of depressions with no preferential destruction of either cores or peripheries could be seen. These pitted areas sometimes could be seen in little patches on enamel surface.

Type 4 etching was often observed in the cervical areas and has a lesser frequency in the occlusal areas. Type 5 etching shows no evidence of prism outlines. In fact, the part of enamel classified as Type 5 are very flat and smooth, and they lack micro-roughness for penetration and retention of resins.

Type 5 etching patterns can be seen on teeth, which have previously got fluoride treatment or possibly from patients who stayed water having high fluoride areas.[18]

Dentin Etching

We achieve two goals by dentin etching. First, we eliminate the smear layer and debris formed due to tooth preparation. The dentinal tubules get blocked with cut tooth structure, saliva, red blood cells and other contaminates like oil from dental hand piece.

The etching process adequately eliminates all of this to expose open dentinal tubules, which can be filled with resin. Secondly, the etchant demineralizes a layer of the dentin, exposing the collagen fibers, permitting the resin to penetrate into the dentin structure. We correctly manage the chemicals and time while etching (total etch or self-etch) to facilitate effective removal of the smear layer, open the tubules and create an adequately demineralized zone that resin can penetrate. Both under-etching and over-etching adversely affect the success of the final restoration.

Amount of tooth structure lost during etching: Acid etching removes approximately 10 μm of enamel surface and creates a morphologically porous layer (5 μm to 50 μm deep).[1] The surface free energy is doubled.[2] Studies have demonstrated that acetone-based all-in-one adhesives result in a hybrid layer 0.2 to 0.5 μm thick, interfacial gaps, and limited resin penetration into the dentinal tubules.[5] While micromechanical retention of resin tags on roughened surfaces is still the best bonding mechanism on enamel.[6,7]

Time for remineralization: It begins after 24 hours exposure to saliva by deposition of calcium phosphate salts.

Higher concentration of acid: Honeycombed structures were not achieved in enamel prisms after etching with 85% phosphoric acid, and rewarding results as regards retention were not achieved.[6,7,8]

Lower concentration of acid: In concentrations phosphoric acid lower than 27%, there was production of "dicalcium phosphate dihydrate," which showed difficulties in cleaning by washing and negatively affected the bond strength Etching time: Earlier it was reported that etching times of less than 10 seconds and more than 60 seconds do not result in enough shear bond strength.[6,7]

Various Etchants

Etching with 10% or 37% phosphoric acid produces the highest bond strengths (28 MPa) to enamel. The use of 10% maleic acid for etching results in a lower bond strength (18 MPa), and no etching yields a very low bond strength. No differences in bond strengths are observed when enamel is etched with phosphoric acid ranging in concentration from 2% to 37%. One study reported that 2% phosphoric acid etchant was adequate for bonding, whereas another recommended 10–30% phosphoric acid. Other effects include loss of enamel while debonding, increased plaque retention, loss of fluoride rich enamel with aging.

Effects of etching: While etching the enamel surface, lot enamel tissue is eliminated, a macro-porosity layer forms, and deeper inside another layer of micro-porosity is created. While many clinicians believe acid etching of enamel as a practice followed regularly, there are also some iatrogenic effects.

Acid etching of enamel eliminates around 10–20 μm of enamel. Etched enamel is porous, making it favourable to retain stains, although the porosities are filled by from salivary precipitate with time. In fact the most careful debonding technique causes fracture of small enamel fragments and cracks. An additional 6–50 μm of enamel is considered to be lost on debonding.

Another issue is that the resin tags that remain in the enamel post debonding may change color with time. Etching enamel has rarely produced postoperative tooth sensitivity. Etching dentin has shown to cause commonly postoperative tooth sensitivity.

Etching sclerotic dentin: It is hard to achieve optimum bond strength with sclerotic dentin because: [10–12].

(a) Sclerotic casts present inside dentinal tubules that prevent required resin infiltration into the dentinal tubules, and/or

(b) Surface hypermineralized layer that is more resistant to acid-etching is present. Also, partially mineralized surface bacterial layer and intratubular mineral casts that are relatively more acid-resistant.[13–15]

Contemporary self-etching adhesives have been developed by avoiding the separate acid-conditioning step with increased concentrations of acidic resin monomers in a primer. With these high pH self-etching primers good bonding can be achieved. Etching without roughening: Untreated enamel does not allow any durable bond with the composite material because it has very minimal porosities and its surface energy is not optimum for wetting with monomers. Owing to the acid treatment, for example with 30% to 40% ortho-phosphoric acid, enamel prisms and interprismatic enamel are dissolved to a variable extent and a microretentive relief is formed. On etched enamel, a low-viscosity composite or an enamel adhesive (bonding agent) spreads easily, penetrates the microporosities of the treated enamel surface and thus improves microretentive bonding of the composite.

Phosphate esters in self-etching adhesives: Self-etching adhesive monomers are bifunctional molecules that has at least these components: first, a polymerizable Group P, which can react both with the other monomers present in the adhesive and the monomers in restorative material by copolymerization, second, an acid adhesive group AD that can both etch the dental hard tissues and interact with the tooth substance, and, finally, a spacer Group R designed to influence, e.g.

The solubility, flexibility and wetting properties of the adhesive monomer. The acidic monomers strength to etch dental hard tissues like enamel mainly depends on the acidity of the monomers that increases in the following order: carboxylic acids < phosphonic acids < acid phosphates < sulfonic acid.[19]

Chemical interaction is attained by specific functional monomers, such as 10-methacryloyloxydecyl dihydrogen phosphate (10-MDP), 4-methacryloxyethyl trimellitic acid (4-MET) and 2-methacryloxyethyl phenyl hydrogen phosphate (Phenyl-P), GPDM (glycero-phosphate dimethacrylate). XPS revealed that the chemical bonding enhanced by 10-MDP is not only more effective, but also more resistant in water than that provided by 4-MET and Phenyl-P, in this order.[8,9] In the case of the functional monomer Phenyl-P, its functional groups (hydrogen phosphates) ionically bond to Ca at the HAp surface.

This first phase is mainly determined by the number of ionized acidic monomers. In the second phase, the formed Phenyl-P_Ca bindings easily dissociate in the solution. Since at the same time enough phosphate (PO_4) and hydroxide (OH) ions are extracted from the apatite surface by hydronium ions (H_3O^+), saturation of these ions in the acidic solution is readily achieved, and leads to the very fast deposition of dicalcium phosphate dihydrate (DCPD: $CaHPO_4 2H_2O$) in the third phase.

As a result, Phenyl-P greatly decalcifies apatite around collagen fibrils. The TEM of adhesive—dentin interfaces produced by the Phenyl-P-based adhesive indeed disclosed that essentially all apatite was dissolved and collagen exposed up to a depth of about 1 μm. Total etch vs self etch: complete permeation of the acrylic monomers to the depth of the demineralized zone is guaranteed.[5] With conventional total-etch systems, it is clinically possible to etch deeper than the subsequent primer/adhesive can penetrate, leaving a zone of unsupported, demineralized dentin that can weaken the adhesive layer and leave it vulnerable to hydrolysis and premature degradation.

Conclusion

Etching is a double-edged sword. When it is properly done it can result in good bond strength provided other steps are also followed meticulously but when etching is done aggressively; it will result in excessive loss of mineralized tissue resulting in weakening of the tooth. The tissues involved the type of bonding agent being used and their composition should be understood to get the best results.

Conflict of interest: None

Source of funding: Self

Acknowledgments: None Ethical clearance: Not applicable

References

1. Gwinnett AJ. Histologic changes in human enamel following treatment with acidic adhesive conditioning agents. Arch Oral Biol 1971 Jul;16(7):731–38.
2. Jordan RE, Suzuki M, Davidson DF. Clinical evaluation of a universal dentin bonding resin: preserving dentition through new materials. J Am Dent Assoc 993 Nov;124(11):71–76.
3. Simmelink JW, Nygaard VK, and Scott DB. Theory for the sequence of human and rat enamel dissolution by acid and by EDTA: A correlated scanning and transmission electron microscopic study. Arch Oral Biol 1974;9:183.
4. Gwinnett AJ. The ultrastructure of the "prismless" enamel of permanent human teeth. Arch Oral Biol 1967;12:381.
5. De Munck J, Van Meerbeek B, Yoshida Y, et al. Four-year water degradation of total: Etch adhesives bonded to dentin. J Dent Res 2003;82:136–40.
6. Retief DH., Retief CJ., Dreyer. & Gavron G. The direct bonding of orthodontic attachments to teeth by means of an epoxy resin adhesive. American Journal of Orthodontics 1970;l(58):21–40.
7. Zachrisson BU & Büyükyılmaz T. Bonding in Orthodontics. In: Orthodontics: current principles and techniques, Graber TM, Vanarsdall RL, Vig KW of editors 2005;579–659. Elsevier Healt Sciences, St Louis
8. Üşümez S. & Erverdi N. Adhesive and bonding in orthodontics 2008;45–67, Elsevier.
9. Yoshida Y, Nagakane K, Fukuda R, et al. Comparative study on adhesive performance of functional monomers. J Dent Res 2004 Jun;83(6):454–8.
10. Yoshida Y, Inoue S. Chemical analyses in dental adhesive technology, Japanese Dental Science Review 2012;48:141–52.
11. Tay FR, Pashley DH. Resin bonding to cervical sclerotic dentin: A review F, Journal of Dentistry 2004 Mar;32(3):173–96.
12. Yoshiyama M, Sano H, Ebisu S, et al. Regional strengths of bonding agents to cervical sclerotic root dentin. J Dent Res 1996 Jun;75(6):1404–13.
13. Kwong SM, Cheung GS, Kei LH, et al. Micro-tensile bond strengths to sclerotic dentin using a self-etching and a total-etching technique. Dent Mater 2002;18(5):359–69.
14. Gwinnett AJ, Jendresen M. Micromorphological features of cervical erosion after acid conditioning and its relation with composite resin. Journal of Dental Research 1978 Apr;57(4):543–49.
15. Van Meerbeek B, Braem M, Lambrechts P, et al. Morphological characterization of the interface between resin and sclerotic dentine. Journal of Dentistry 1994 Jun;22(3):141–46.
16. Buonocore MG. A Simple Method of Increasing the Adhesion of Acrylic Filling Material to Enamel Surface. J Dent Res 1955 Dec;34(6):849–53.
17. Silverstone LM, Saxton CA, Dogon IL, Fejerskov O. Variation in the pattern of acid etching of human dental enamel examined by scanning electron microscopy. Caries Res 1975;9(5):373–87.
18. Galil KA, Wright GZ. Acid Etching Patterns on Buccal Surfaces of Permanent Teeth, Pediatr Dent 1979 Dec;1(4):230–4.
19. Moszner N, Salz U, Zimmermann J. Chemical aspects of self-etching enamel-dentin adhesives: A systematic review. Dent Mater 2005 Oct;21(10):895–10.