Biomaterials Journal
http://www.biomatj.com
Online ISSN: 2812-5045

Type of the Paper (Mini-Review Article)

Dental Composite/ Adhesives –Tooth Interface

Rasha M. Abdelraouf [1*]

[1] ***Biomaterials Department, Faculty of Dentistry, Cairo University, Cairo 11553, Egypt***

* Corresponding author e-mail: rasha.abdelraouf@dentistry.cu.edu.eg

Abstract: The fast progress in dental adhesive technology has extensively influenced modern restorative dentistry. Although decayed and fractured teeth can be reconstructed minimal invasively and nearly invisibly using adhesive technology, the clinical longevity of composite restorations is today still too short. Notwithstanding the enormous advances made in adhesive technology during the last 50 years, the bonded interface remains the main challenge of an adhesive filling.

Keywords: Dental; composites; adhesives**;** Interface; surface.

Citation: *Rasha M. Abdelraouf* . ***Dental Composite/ Adhesives – Tooth Interface*** *. Biomat. J., 1 (6),44 – 47 (2022).*

*https://doi.org/10.5281/*znodo.5829408

Received: 30 May 2022

Accepted: 15 June 2022

Published: 30 June 2022

Introduction

The fast progress in dental adhesive technology has extensively influenced modern restorative dentistry. Although decayed/fractured teeth can be reconstructed minimal invasively and nearly invisibly using adhesive technology, the clinical longevity of composite restorations is today still too short [1, 2]. Despite the enormous advances made in adhesive technology during the last 50 years, the bonded interface remains the main challenge of an adhesive filling [3, 4]. Modern adhesive approaches include (1) etch & rinse, (2) self-etch.

a- Etch & rinse

The multi-step etch&rinse approach involves a phosphoric acid-etch step that at enamel produces deep etch-pits in the hydroxyapatite (HAp)-rich substrate, and at dentin demineralizes up to a depth of a few micrometers to expose a HAp-deprived collagen mesh. The next step involves either the application/curing of a combined primer/adhesive resin, or a separate primer and adhesive resin step. The final objective is to micro-mechanically interlock upon diffusion and *in situ* polymerization of monomers into the enamel etch-pits, the opened dentin tubules and the exposed collagen network, the latter forming the well-documented hybrid layer.

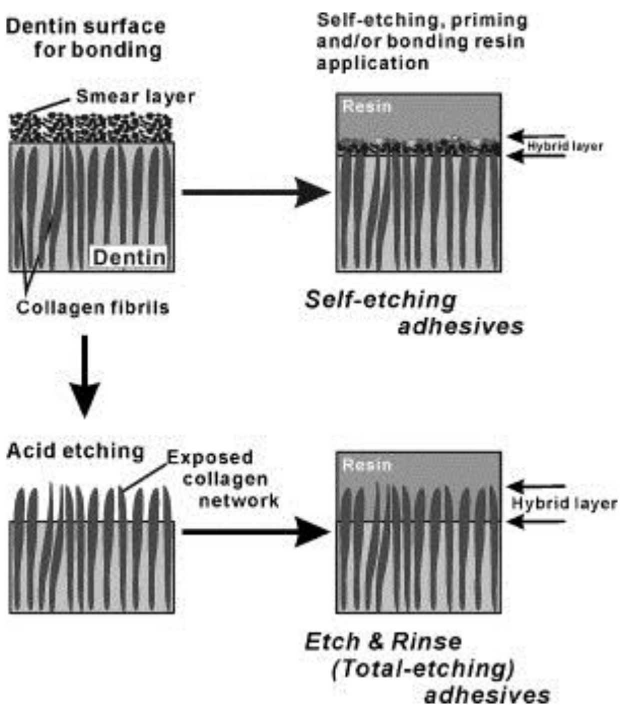
Without doubt, the micro-mechanical interlocking of tiny resin tags within the acid-etched ***enamel*** surface is still today the best achievable bond to enamel [5]. It not only effectively seals the restoration margins on the long term, but also protects the more vulnerable bond to dentin against degradation [6].

On the contrary, etching ***dentin*** is a rather aggressive procedure as it dissolves and removes (through rinsing) the natural protection of collagen, thereby producing a resin–collagen complex that is vulnerable to degradation upon water sorption, possibly enhanced by the documented enzymatic degradation process [7-9]. As the most intimate and stable intermolecular interaction possible, primary chemical interaction between resin and the mainly organic substance remaining at acid-etched dentin would definitely contribute to the bond durability but is however lacking [10,11]. This deficient chemical interaction should most likely be regarded as the major shortcoming of today's etch & rinse approach. Nevertheless, traditional 3-step etch & rinse adhesives are still today regarded as 'gold-standard' [12].

b- Self-etch

The self-etch approach can be further subdivided into a 'strong' (pH < 1), an 'intermediately strong' (pH≈1.5), a 'mild' (pH≈2), and an 'ultra-mild' (pH≥2.5) self-etch approach depending on the self-etching or demineralization intensity [13].

Self-etching only dissolves the smear layer, but does not remove the dissolved calcium phosphates, as there is no rinse phase. In particular **'mild'** (pH≈2) self-etch adhesives appear to deal reasonably well with bur-smear, producing a submicron hybrid layer with substantial HAp-crystals still protecting the collagen fibrils.



Schematic illustration of bond structure of a self-etching system and etch-and-rinse system (total-etching system).

Figure Reference: Hashimoto M et al: A review: Biodegradation of resin–dentin bonds. Japanese Dental Science Review Volume 47, Issue 1, February 2011, Pages 5-12

Important:

Functional monomers, in particular like 10-***MDP*** (10-methacryloyloxydecyl dihydrogen phosphate), have been proven to interact with this residual HAp through primary ionic binding (14, 15). The resultant two-fold micro-mechanical and chemical bonding mechanism closely resembles that of glass-ionomers (16-20). However, chemical bonding potential on its own is insufficient; the formed ionic bonds should also be stable in an aqueous environment. Chemical bonding promoted by 10-MDP appeared not only more effective, but also more stable in water than that provided by other functional monomers like 4-MET (4-methacryloyloxyethyl trimellitic acid) and phenyl-P (2-methacryloyloxyethyl phenyl phosphoric acid), in this order (15).

Examination of Restorative Material-Tooth Interface

As the longevity of an adhesive composite restoration is mainly affected by leakage of oral fluids along the interface between restorative material and tooth substrate (21, 22). Examination of this interface included micro-leakage, marginal adaptation/gap formation, bacterial leakage permeability, nano-leakage and 3D-leakage. Acoustic emission and Micro-CT have been used for non-destructive examination of interfacial debonding (23).

Bond durability can be measured using bond strength test (macro or micro test, basically depending upon the size of the bond area), measured in 'shear', 'tensile', or using a 'push-out' protocol. Despite the importance of laboratory studies attempting to predict clinical performance of biomaterials, clinical trials remain the ultimate way to collect scientific evidence on the clinical effectiveness of a restorative treatment (24, 25). Clinical effectiveness of adhesives should best be determined using Class-V clinical trials.

References

1. **Manhart J, Chen H, Hamm G, Hickel R. Buonocore memorial lecture.** Review of the clinical survival of direct and indirect restorations in posterior teeth of the permanent dentition. Oper Dent 2004; 29:481–508.
2. **Peumans M, Kanumilli P, De Munck J, Van Landuyt K, Lambrechts P, Van Meerbeek B.** Clinical effectiveness of contemporary adhesives: a systematic review of current clinical trials. Dent Mater 2005; 21:864–81.
3. **De Munck J, Van Landuyt K, Peumans M, Poitevin A, Lambrechts P, Braem M.** A critical review of the durability of adhesion to tooth tissue: methods and results. J Dent Res 2005; 84:118–32.
4. **Breschi L, Mazzoni A, Ruggeri A, Cadenaro M, Di Lenarda R, Dorigo ES.** Dental adhesion review: aging and stability of the bonded interface. Dent Mater 2008; 24:90–101.
5. **Van Meerbeek B, De Munck J, Yoshida Y, Inoue S, Vargas M, Vijay P.** Buonocore memorial lecture: adhesion to enamel and dentin: current status and future challenges. Oper Dent 2003; 28:215–35.
6. **De Munck J, Van Meerbeek B, Yoshida Y, Inoue S, Vargas M, Suzuki K.** Four-year water degradation of total-etch adhesives bonded to dentin. J Dent Res 2003; 82:136–40.
7. **Pashley DH, Tay FR, Yiu C, Hashimoto M, Breschi L, Carvalho RM**. Collagen degradation by host-derived enzymes during aging. J Dent Res 2004; 83:216–21.
8. **Hebling J, Pashley DH, Toderhane L, Tay FR.** Chlorhexidine arrests subclinical degradation of dentin hybrid layers in vivo. J Dent Res 2005; 84:741–6.
9. **De Munck J, Van den Steen PE, Mine A, Van Landuyt KL, Poitevin A, Opdenakker G.** Inhibition of enzymatic degradation of adhesive–dentin interfaces. J Dent Res 2009; 88:1101–6.
10. **Xu J, Stangel I, Butler IS, Gilson DF.** An FT-Raman spectroscopic investigation of dentin and collagen surfaces modified by 2-hydroxyethylmethacrylate. J Dent Res 1997; 76:596–601.

11. **Nishiyama N, Suzuki K, Komatsu K, Yasuda S, Nemoto K.** A study on the adsorption characteristics of HEMA to dentinal collagen. J Dent Res 2002; 81:469–71.
12. **Van Meerbeek B, Peumans M, Poitevin A, Mine A, Van Ende A, Neves A, De Munck J.** Relationship between bond-strength tests and clinical outcomesdental materials 2010;26: e100–e121.
13. **De Munck J.** An in vitro and in vivo study on the durability of biomaterial–tooth bonds. PhD dissertation, KULeuven; 2004.
14. **Van Meerbeek B, Yoshida Y, Van Landuyt K, Perdigão J, De Munck J, Lambrechts P.** In: Summitt JB, Robbins JW, Hilton TJ, Schwartz RS, editors. Fundamentals of operative dentistry. A contemporary approach. 3rd ed. Chicago: Quintessence Publishing; 2006. p. 183–260.
15. **Yoshida Y, Nagakane K, Fukuda R, Nakayama Y, Okazaki M,Shintani H.** Comparative study on adhesive performance of functional monomers. J Dent Res 2004; 83:454–8.
16. **Yoshida Y, Van Meerbeek B, Nakayama Y, Snauwaert J, Hellemans L, Lambrechts P.** Evidence of chemical bonding at biomaterial–hard tissue interfaces. J Dent Res 2000;79:709–14.
17. **Fukuda R, Yoshida Y, Nakayama Y, Okazaki M, Inoue S, Sano H.** Bonding efficacy of polyalkenoic acids to hydroxyapatite, enamel and dentin. Biomaterials 2003; 24:1861–7.
18. **Yiu CK, Tay FR, King NM, Pashley DH, Sidhu SK, Neo JC.** Interaction of glass-ionomer cements with moist dentin. J Dent Res 2004; 83:283–9.
19. **Tay FR, Sidhu SK, Watson TF, Pashley DH.** Water-dependent interfacial transition zone in resin-modified glass-ionomer cement/dentin interfaces. J Dent Res 2004; 83:644–9.
20. **Coutinho E, Van Landuyt K, De Munck J, Poitevin A, Yoshida Y, Inoue S.** Development of a self-etch adhesive for resin-modified glass ionomers. J Dent Res 2006; 85:349–53.
21. **Raskin A, D'Hoore W, Gonthier S, Degrange M, Déjou J.** Reliability of in vitro microleakage tests: a literature review. J Adhes Dent 2001; 3:295–308.
22. **Almeida JB, Platt JA, Oshida Y, Moore BK, Cochran MA, Eckert GJ.** Three different methods to evaluate microleakage of packable composites in Class II restorations. Oper Dent 2003; 28:453–60.
23. **Li H, Li J, Yun X, Liu X, Fok AS-L**. Non-destructive examination of interfacial debonding using acoustic emission. Dental Materials 2011; 27: 964–971.
24. **Van Meerbeek B, Peumans M, Verschueren M, Gladys S,Braem M, Lambrechts P.** Clinical status of ten dentin adhesive systems. J Dent Res 1994; 73:1690–702.
25. **Van Meerbeek B, Perdigo J, Lambrechts P, Vanherle G.** The clinical performance of adhesives. J Dent 1998; 26:1–20.