EGYPTIAN
DENTAL JOURNAL

Vol. 60, 983:989, January, 2014

I.S.S.N 0070-9484

WWW.EDA-EGYPT.ORG

EFFECT OF STORAGE ON MICRO TENSILE BOND STRENGTH OF VARIOUS TYPES OF FLOWABLE COMPOSITE

Sara Hassan El- Toukhy*; Faten M. Kamel**;
Iman El-Sayyed*** *and* Mohamed Foad Haridy ****

ABSTRACT

Objective :The aim of the study is to investigate the effect of storage on micro-tensile bond strength of two self- adhesive flowable resin composites (Vertise Flow & Fusio Liquid Dentin) compared to conventional flowable resin composite (Filtek flow Z350 XT).

Materials & Methods : Fourty-five extracted sound human molars were selected for this study. They were divided into three groups of fifteen each according to the type of resin composite used. The three main groups were further sub-divided into three subgroups of five each according to the storage time either twenty-four hours, three months and six months storage in distilled water. Each tooth was mounted on the cutting machine and sectioned into a series of 1 mm thick slabs under water cooling, then, by rotating the tooth 90° and again sectioning it lengthwise, sticks of 1.0 mm^2 cross-section area were obtained. The central sticks from each specimen were selected and attached to the specially designed attachment jig, which was mounted on a universal testing machine. Data were recorded using computer software. A tensile load was applied via testing machine at a crosshead speed of 0.5 mm/min. The applied tensile force resulted in de bonding along the substrate-adhesive interface. The load (Newton) required for de bonding of each stick was divided by the area to express bond in MPa.

Results : Filtek Z350 XT showed the highest mean micro-tensile bond strength, Vertise flow came next with the lowest mean microtensile bond strength values for the Fusio Liquid Dentin.

Conclusion : The conventional etch and rinse flowable resin composite (Filtek Z350 XT) remains the gold standard of all other types of the flowable resin composites. The bond stability of the self-adhesive flowable resin composites was questionable after aging for three months and was adversely affected after six months.

* Instructor of operative Dentistry, Faculty of Dentistry, October University for modern Science and Arts
** Professor of Conservative Dentistry , Faculty of Oral and Dental Medicine , Cairo University
*** Assistant Professor of Conservative Dentistry , Faculty of Oral and Dental Medicine , Cairo University
**** Lecturer Operative Dentistry , Faculty of Oral and Dental Medicine , Cairo University

INTRODUCTION

Dentistry has seen ongoing changes and the launch of innovative products which dramatically affect the dental profession. The development of adhesive materials and techniques represents an improvement for the reduction of the number of steps or materials required for bonding (1)**.** Flowable composites, introduced nearly two decades ago, have become handy for many applications. They offer the advantage of favorable handling properties. Their viscosity made material placement easier and improved adaptation to cavity walls. Flowable composite resins have also found applications in pit and fissure sealing (2), orthodontic brackets bonding, and restoration of small-sized class I cavity (3 , 4).

Among dental adhesive systems, all- in-one adhesive systems are gaining popularity mainly due to their simplified handling, the exclusion of rinsing and drying steps which is indeed an attractive clinical advantage. Recently, an innovative resin-based material, combining the properties of self-adhesion and flowability was developed, introducing a new category of restorative materials defined as "self-adhering composite resins" eliminating the need for a separate bonding application step, thus simplifying the direct restorative procedure. Thus starting the 8th generation of dental adhesive systems or to represent a cross-link between all-in-one adhesive systems and flowable composite resins (5)**.**

MATERIALS AND METHOD

Three different resin –based materials were used in this study, Conventional etch and rinse flowable resin composite; Filtek Z350 XT (3M ESPE, St.Paul, USA), one self adhesive flowable resin composite; Vertise Flow (Kerr Corporation) and another self adhesive flowable resin composite; Fusio Liquid Dentine (Pentron Clinical, Orange, CA, USA).

Forty-five freshly extracted sound human molars were selected for this study. Teeth were divided into three groups of fifteen each according to the type of resin composite used, then the three main groups were further sub-divided into three subgroups of five each according to the storage time either twenty-four, three months and six months. All samples were stored in distilled water.

The occlusal enamel was reduced perpendicular to the long axis of each tooth using a low speed saw and a diamond wafering blade under water cooling until a flat dentin surface parallel to the occlusal surface was obtained for the three groups.

Cylindrical resin composite discs were placed on the prepared dentin surface with the aid of an especially fabricated cylindrical mold of 6mm diameter and 4mm height.

Group 1: the dentinal surface was etched with 37% phosphoric acid for 15 seconds, washed with direct water spray for 10 seconds and dried under jet of air for 5 seconds according to the manufacturer's instruction, then the composite was applied in increments of 1 mm each up to a height of 4 mm, each layer was light cured for 30 seconds with a light-curing unit (Denjoy LED light curing unit 2000 Mw/cm2). Group 2: the resin composite was applied in incremental 1 mm. layers up to a height of 4 mm. each layer was cured for 40 seconds with a light-curing unit. Group 3: the resin composite was applied in incremental 2 mm. layers up to a height of 4 mm. each layer was cured for 20 seconds with a light-curing unit.

Each tooth was mounted on the cutting machine (Bronwill E. McGrath Inc, 35 Osborne Street Salem MA), and sectioned into a series of 1 mm thick slabs under water cooling. The sectioning was performed using a diamond disc of 4"diameter x 0.3 mm thickness x 0.5" arbor impregnated diamond cutting blades with Wear-resistant TiC coating for low speed saw (MTI Corporation 860 South 19th Street, Richmond, CA, USA) . Then, by rotating the tooth 90° and again sectioning it lengthwise, sticks of 1.0 mm^2 cross-section area were obtained. The central sticks from each specimen were selected and their thickness was checked using a digital caliper (Tresna Series: EC05 USA). The specimens were then subjected to the microtensile bond strength testing.

The failure mode of the specimens was classified according the imaging preformed under a stereo microscope at 30X magnification. The specimen were classified as: Adhesive (failure of adhesion at resin/ dentine interface); Cohesive in dentin (failure exclusive in dentine tooth substrate); Cohesive in resin (failure exclusive in the resin composite); Mixed (failure at resin/ dentine interface, which included cohesive failure of the neighboring substrates).

RESULTS

The results showed that the resin composite type, storage period and the interaction between the two variables had a statistically significant effect on mean micro-tensile bond strength.

Regarding resin composite type; flowable resin composite showed the statistically significantly highest mean micro-tensile bond strength (28.9 Mpa). Vertise showed statistically significantly lower mean micro-tensile bond strength (19.8 Mpa). Fusio showed the statistically significantly lowest mean micro-tensile bond strength in the storage period of 24 hours, 3 months and six months (9.1 Mpa).

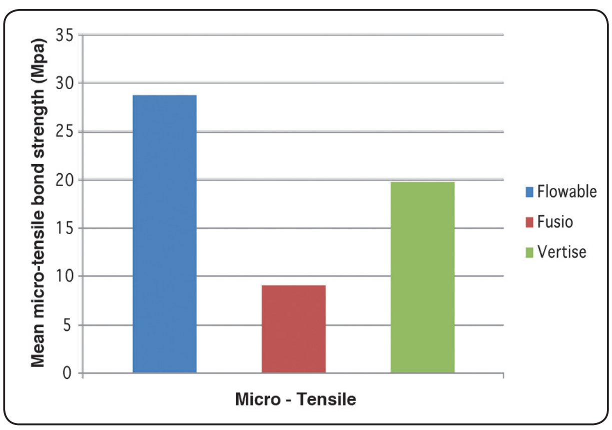

Fig. (1) Bar chart representing mean values for comparison between micro-tensile bond strength of the three resin composite types regardless of the storage period.

Regarding the different storage intervals on the types of the resin composite used; twenty-four hours time showed the highest mean micro tensile bond strength among all the other intervals. With the flowable resin composite at 38.57 Mpa , Vertise at 24.41 Mpa and the Fusio at 10.69 Mpa. The three months storage period showed lower mean micro tensile bond strength with the conventional flowable resin composite at 29.19 Mpa, Vertise at 19.79 Mpa and the Fusio at 10.24 Mpa. Finally, the six months storage interval showed the lowest mean micro tensile bond strength with the conventional flowable resin composite at 19.09 Mpa, Vertise at 15.07 Mpa and the Fusio at 6.52 Mpa.

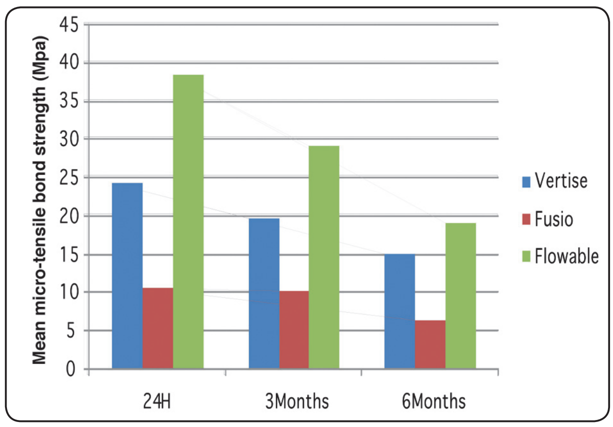

Fig. (2) Bar chart representing Mean values of effect of Storage time on mean micro-tensile bond for each type of resin composite used.

Regarding the effect of the Storage period, Table (1) shows the mean and standard deviation of the effect of time on mean micro-tensile bond strength for each resin composite material used.

Collectively, flowable resin composite stored for 24 hours showed statistically significant highest mean micro-tensile bond strength. Then came the vertise in the middle ranking values. While Fusio stored for 6 months showed statistically significant lowest mean micro-tensile bond strength values. These results where shown in Table (2).

TABLE (1)

	Time						P-value
	24 H		3 Months		6 Months		
	Mean	SD	Mean	SD	Mean	SD	
Vertise	24.41[a]	3.56	19.79[b]	3.53	15.07[c]	3.89	<0.001*
Fusio	10.69[a]	1.51	10.24[a]	4.12	6.52[b]	2.25	<0.001*
Flowable	38.57[a]	2.78	29.19[b]	2.81	19.09[c]	3.82	<0.001*

: Significant at $P \leq 0.05$, Different letters are statistically significantly different according to Tukey's test within each row.

TABLE (2) Collective differences between the micro-tensile bond strength values with different resin composites types at different storage intervals

Composite type	Storage period	Mean	SD	Rank	*P*-value
Flowable	24 hours	38.6	2.8	A	<0.001*
	3 months	29.2	2.8	B	
	6 months	19.1	3.8	D	
Fusio	24 hours	10.7	1.5	F	
	3 months	10.2	4.1	F	
	6 months	6.5	2.2	G	
Vertise	24 hours	24.4	3.6	C	
	3 months	19.8	3.5	D	
	6 months	15.1	3.9	E	

: Significant at $P \leq 0.05$, Different letters are statistically significantly different according to Tukey's test

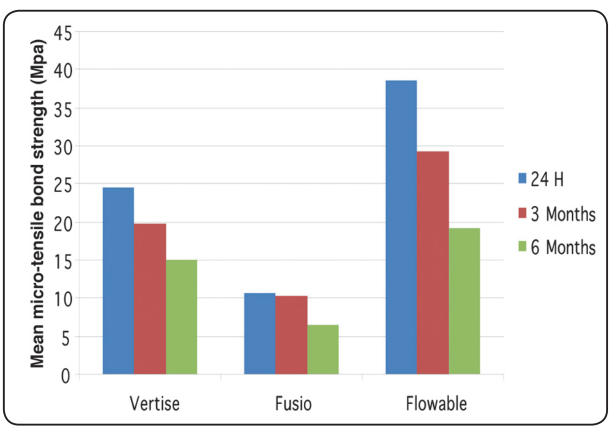

Fig. (3) Bar chart representing Mean values of the effect of time on mean micro-tensile bond for each of the three resin composite materials used.

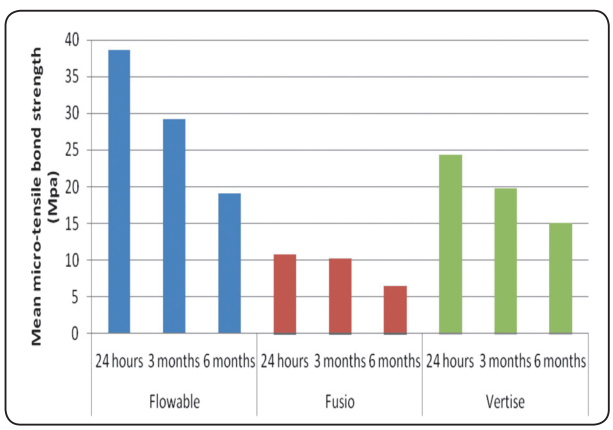

Fig. (4) Bar chart representing mean values for comparison between micro-tensile bond strength of the different resin composites types at the three storage periods.

Mode of failure by Stereomicroscope

Stereomicroscopic pictures of the Filtek Z350 XT, Fusio and Vertise after de bonding showed a combination of failures of the bond between all the samples. With the Filtek Z350 XT predominantly showing cohesive failure at the 24 hours and the three months and the 6 months storage period showed less cohesive failure and more adhesive failure. While the Vertise and the Fusio showed less cohesive and more adhesive failures predominating especially after the 6 months storage period of the Fusio.

DISCUSSION

Current trends in adhesive technology are shifting towards the "all in one" adhesive systems. The advancement of both the dentin bonding agents and the nano-hybrid flowable composites have now evolved by uniting these two materials together to produce a new era of dental restoratives 'the compobonds'.[6] The compobonds exhibit the benefits of self etch dentin bonding agents and nano filled resins eliminating the precursory bonding stage and thus are termed self adhering resin composites.

Clinical conditions were standardized by subjecting the specimens to equal time intervals and storage in distilled water, being the key factor in the degradation process of resin based materials, as the plasticization effect is recognized to affect the mechanical properties after few months of storage[7-9]. According to the present study, the storage period affected the micro- tensile bond strength for the three types of resin based materials used, where the 24 hours period showed the highest mean micro-tensile bond strength (24.6 MPa) and the six month period showed the lowest mean micro-tensile bond strength (13.6 MPa) for the three materials. This may be due to the effect of water sorption which, explained by[10] stating that these hydrophilic adhesives tend to rapidly absorb water, owing to their chemical composition of lower filler content, which results in polymer swelling, plasticizing and weakening of the polymer network, adversely effecting the resin–dentin interface created by hydrophilic one-step self-etch adhesives which make them more unstable over time. Upon comparison between self etch and total etch flowable resin composites along the three intervals of time (24 hours, 3months, 6 months) the total etch (Filtek Z350 XT) showed the highest micro-tensile bond strength (38.6 MPa) than the two self adhesive resin based materials. This may be related to the one bottle self etching adhesives might absorb the water from dentinal tubules during bonding by osmosis, leading to nano-leakage formation with a subsequent decline in the bond strength by the formation of water trees, water bubbles and phase separation at the adhesive interface [11 , 8].

Other study [12] speculated that bond durability may be attributed to both compositional differences among adhesive systems and their ability to completely infiltrate de-mineralized dentin matrix. The interfacial degradation of polymers and collagen hydrolysis as a result of water diffusion has been demonstrated in several studies [13 , 12 and 14] confirming our results.

The presence of high amounts of residual solvents has also been reported to cause significant decrease in the tensile bond strength of adhesives resins [15]. Clinically, incomplete solvent evaporation is regarded as an application error that cause poor sealing ability of the adhesive systems that lead to poor bond strength resulting in a weak tooth restoration interface [11]. The residual monomer entrapped with in the polymerized material create additional channels for rapid water permeation and consequently enhance water sorption leading to premature interfacial deterioration [12] this might also be a reason for our results of micro-tensile bond strength deterioration over the 3 months and 6 month storage periods.

Regarding the type of the self adhesive flowable resin composite used, the Vertise showed a higher mean micro-tensile bond strength value (19.8 MPa) when compared with self adhesive Fusio (9.1 MPa) along the three periods of storage evaluated. This could be as a result of the composition of the Fusio which contains HEMA (Hydroxylethyl methacrylate) as bond degradation by hydrolysis is generally increased with HEMA containing bonding systems [16, 11, 7]**.** According to ***Youshida*** [17] HEMA containing one step self etch adhesives, have shown enhanced water sorption from the host dentin showing clear evidences of water uptake and droplet accumulation at the adhesive/composite interface, through were most of the fractures occurred. Secondly, increased amounts of HEMA may have led to reduced polymerization due to its hydrophilicity and water attraction, leading to dilution of the monomers and a thinner adhesive layer [18,19]**.** Therefore, correlating with the low mean micro-tensile bond strength readings the of Fusio resin composite along with all the storage intervals**.** Fracture modes pictures of the stereomicroscope confirmed our results revealing the adhesive failure that occurred at the interface of the Fusio resin composite at the 6 months storage period. [20]

Thus the conventional etch and rinse flowable resin composite remains the gold standard of all other types of the flowable resin composites. The total etch resin based composite filtek Z350 XT, still took the lead with its high micro-tensile bond value between the different storage period owing to the better depth of penetration of the 37% phosphoric acid used, removing the smear layer, exposing the collagen matrix and forming the typical resin tags at the dentinal/ composite interface that was reflected in the results of the present study.

REFRENCES

1. Heintze SD. Clinical relevance of tests on bond strenghth, microleakage and marginal adaptation. Dent Mater, 2013;29:59-84.
2. Francescut P, Lussi A. Performance of a conventional sealant and a flowable composite on minimally invasive prepared fissures. Oper Dent, 2006;31(5):543-550.
3. Unterbrink GL, Liebenberg WH. Flowable resin composites as filled adhesives: Literature review and clinical recommendations. Quintessence Int. 1999;30:249.
4. Park SB, Son WS, Ko CC, Garcia-Godoy F, Park MG, KimHI, Kwon YH. Influence of flowable resins on the shear bond strength of orthodontic brackets. Dent Mater, 2009;28(6):730–734.
5. Pashley DH, Tay FR. Aggressiveness of contemporary selfetching adhesives. Part II: etching effects on unground enamel. Dent Mater, 2001;17(5):430-44.
6. Ahmad I. Protocols for predictable aesthetic dental restorations. 2006, Blackwell Munksgaard, Oxford, UK. ISBN 1405173211, 9781405173216.
7. Paul SJ, Leach M, Rueggeberg FA, Pashley DH. Effect of water content on the physical properties of model dentine primer and bonding resins. J Dent, 1999;27:209–14.
8. Yiu CK, King NM, Pashley DH, Suh BI, Carvalho RM, Carrilho MR, et al. Effect of resin hydrophilicity and water storage on resin strength. J Biomat, 2004;25:5789–96.
9. De Munk J, Mine A, Poitevin A, Van Ende A, Cardoso MV, Van Lunduyt KL. Meta- analytical review of parameters involved in dentine bonding. J Dent Res, 2012;91:351-357.
10. Bayne SC, Thompson JY, Swift EJJ, Stamatiades P, Wilkerson M. A characterization of first-generation flowable composites. J Am Dent Ass, 1998;129:567–577
11. Hashimoto M, Tay FR, Svizero NR, de Gee AJ, Feilzer AJ, Sano H, et al. The effects of common errors on sealing ability oftotal-etch adhesives. Dent Mater, 2006;22:560–8.
12. Hashimoto M, Ohno H, Sano H, Kaga M, Oguchi H. In vitro degradation of resin–dentin bonds analyzed by microtensile bond test, scanning and transmission electron microscopy. J Biomat, 2003;24:3795–803.
13. Shono Y, Terashita M, Shimada J, Kozono Y, Carvalho RM, Russel CM, et al. Durability of resin–dentin bonds. J Adhes Dent, 1999;1:211–8.
14. Koshiro K, Inoue S, Tanaka T, Koase K, Fujita M, Hashimoto M, et al . In vivo degradation of resin–dentin bonds produced by a self-etch vs. a total-etch adhesive system. Eur J Oral Sci, 2004;112:368–75.
15. Ikeda T, De Munck J, Shirai K, Hikita K, Inoue S, Sano H. Effect of evaporation of primer components on ultimate tensile strengths of primer-adhesive mixture. Dent Mater, 2005;21:1051–8

16. Armstrong S, Geraldeli S, Maiab R, Luís Henrique Araújo Raposoc, Soaresc CJ, Yamagawa J. Adhesion to tooth structure: A critical review of “micro”bond strength test methods. Dent Mater, 2010;26:50–62.

17. Yoshida Y, Nagakane K, Fukuda R, Nakayama Y, Okazaki M, Shintani et al. Comparative study of adhesive performance of functional monomers. J Dent Res, 2004;83:454-8.

18. Zheng L, Pereira PN, Nakajima M, Sano H, Tagami J.Relationship between adhesive thickness and microtensile bond strength. Oper Dent, 2001;26:97–104.

19. Munoz MA, Lugue I, Hass V, Reis A, Loguercio AD, Bombarda NHC. Immediate bonding properties of universal adhesives to dentine. J Dent, 2013.

20. Wang Y, Spencer P. Continuing etching of an all-in-one adhesive in wet dentin tubules. J Dent Res, 2005;84:350–4.