The shear bond measurement of two self-adhesive composite resins to both enamel and dentin (An in vitro study)

Abdulkareem Ramadhan Ibrahim[(1)]

Background and objectives: The aim of this study is to measure the shear bond strength of two self-adhesive composite resins (Vertise Flow, Kerr and Constic, DMG) to both enamel and dentin and compared it to that of conventional flowable composite (used with self-etching bonding system).
Methods: Sixty freshly extracted human third molar teeth were chosen for this study (thirty for enamel samples and thirty for dentin samples). The teeth were mounted horizontally, in blocks of self-cured acrylic resin to leave only buccal surfaces exposed. Then 0.5 and 2mm were cut from the buccal surface to obtain flat enamel and dentin surfaces successively. Thirty enamel samples were divided into three groups; group E1: Vertise Flow, group E2: Constic and group E3: conventional composite with self-etching bonding. Also the thirty dentin groups were divided into three groups, group D1, D2 and D3 with the same corresponding composites as in enamel groups. For all the specimens composite cylinders (4mm height and 4 mm in diameter) were built of the flat surface of the sample then subjected to shear bond testing in a universal testing machine.
Results: Group E3 (conventional flowable composite bonded to enamel) had the highest bond strength while group D1 (Vertise Flow bonded to dentin) had the lowest bond.
Conclusion: Both self-adhesive composites provided insufficient shear bond strength less than that required for using in most clinical conditions.

Keywords: Shear bond strength, self-adhesive, Vertise Flow, Constic.

[(1)] College of Dentistry, University of Duhok, Duhok, Kurdistan Region, Iraq.

Introduction

The use of composite resins has considerably increased in recent years, concurrently with the improvement of their performances [1].The etch-and-rinse adhesive approach pioneered by Buonocore in 1955 is still used by the dentists [2]. Efforts are being made to simplify and reduce the number of steps and the time during bonding procedure, and are less technique-sensitive while keeping the efficiency of adhesives [3,4].With self-etching adhesives the demineralization and resin infiltration procedures are ideally performed almost simultaneously due to the presence of the acidic functional monomers that demineralize and infiltrate the tooth surface at the same time [5]. Flowable composites were first introduced in 1995 to restore Class V lesions. They have excellent handling properties, low viscosity, and superior injectability. Easy handling is a highly desired characteristic because it reduces the working time of clinicians and chairside time of patients [2]. Self-adhering flowable composites are new composite resin systems which reportedly bond to dentin and enamel without the application of an adhesive bonding agent. They combine adhesive and composite technology [6]. These adhesive-free composites are claimed to rely on chemical and micromechanical interaction between material and tooth structures or other substrates, achieved with incorporation of an acidic adhesive monomer into the flowable composites [2]. The bonding mechanism of self-adhering composite relies on a monomer glycerol phosphate dimethacrylate (GPDM) adhesive [7].With the simplified application procedure of this new flowable composite, it has been claimed to be indicated for the restoration of Class V cavities, small Class I cavities, lining material, pit and fissure sealing, restoration non-carious cervical lesions, and ceramic repair [8].

Methods

Sample preparation. Sixty freshly extracted human third molar teeth with no carries or other surface defects were used in this study. Any remaining soft tissues were removed from the teeth surfaces using rotary brushes and dental scaler. The teeth were stored in normal saline solution and room temperature, up to the beginning of the experiment. The teeth were mounted horizontally, in blocks of self-cured acrylic resin to leave only buccal surfaces exposed [9].

Enamel specimen preparation. To obtain enamel samples, 0.5 mm layer was removed from the buccal surface of thirty teeth with a water-cooled low-speed minitome (Struers, Denmark) to obtain a flat enamel surface which were subsequently polished for 1minute with wet 320 grit silicon carbide abrasive paper [10].The enamel specimens then divided into three groups (n=10) according to the materials used:
Group E1: Self-adhesive flowable composite Vertise Flow. Group E2: Self-adhesive flowable composite Constic. Group E3: Conventional flowable composite (Filtek Z350 XT Flowable, 3M ESPE), with one-step self-adhesive bonding agent (Single Bond Universal, 3M ESPE).

Dentin specimen preparation. To obtain dentin specimens, 2 mm layer was removed from the buccal surface of thirty teeth with a water-cooled low-speed minitome (Struers, Denmark) to obtain a flat dentin surface [11]. The dentin specimens then were divided into three groups (n=10) according to the materials used: ***Group D1:*** Same material as group E1. ***Group D2***: Same material as group E2. ***Group D3***: Same material as group E3.

Surface preparation with the bur. The surface of the all enamel and dentin samples was prepared with a flat end diamond cylin-der bur No. (10557M) using a high-speed turbine handpiece (NSK, Japan) at 200,000 rpm with air/water coolant. The turbine handpiece was secured to a modified surveyor to ensure that teeth surfaces were prepared in a standard manner, flat and parallel to the floor. The handpiece was held by a special holder made of cold-cure acrylic resin which attached the handpiece to the surveyor arm that left freely moved to permit handpiece to move freely forward, backward, and laterally. The adjustable table of the surveyor was adjusted in zero angled horizontal plane using balancing instrument.

Application of composite resin. For all the enamel and dentin samples a rubber mold 3mm thick and with a circular hole 4 mm in diameter was positioned exactly over the hole of the double-sided adhesive tape that was placed over the bonding surface of each sample and dentin surface.For the groups (E1 and D1) the Self-adhesive flowable composite Vertise Flow was applied to the mold in 3 layers. The first layer of about 0.5 mm was dispensed to bonding surface with dispensing tip and a moderate pressure was applied with a brush for 20 seconds according to manufacturer instructions, then light cured for 20 seconds. The next two layers were applied successively and each light cured for 20 seconds.
For the groups (E2 and D2), the Self-adhesive flowable composite Constic was applied to the mold in the procedure as in the groups (E1 and D1).
In the groups (E3 and D3), a layer of self-adhesive bonding agent (Single bond Universal adhesive, (3M ESPE) was applied for 20 seconds then thinned for 5 seconds and light cured for 10 seconds. The conventional flowable composite (Filtek Z350 XT Flowable 3M ESPE) was applied to the mold two successive layers (each of 2 mm thickness) and each light cured for 20 seconds.

Shear bond testing. The shear bond strength was measured with a Universal Testing Machine. A knife-edge shearing rod with a crosshead speed of 0.5 mm/minute will be applied at the composite-tooth structure interface until debonding. The data were analyzed statistically using one-way analysis of variance (ANOVA) ($P<0.05$) and post hoc Tukey's test for studying the differences among the different composite groups. The paired sample t-test was then used to study the differences between the enamel and dentin groups.

Results

The descriptive statistics (Table 1) for the shear bond strength for all groups; showed that the D1 had the lowest value for bonding (3.58 ± 0.8), while the E3 had the highest value for bonding (9.47 ± 1.32).

Difference between Enamel Groups. The analysis of variance (ANOVA) test showed that there was highly significant difference between the three enamel groups at $p<0.05$ (table 2).

Further analysis using Tukey HSD test revealed that shear bond strength between E1 and E2 was statistically non-significant while the difference between E1 and E3 was highly statistically significant and also the difference between E2 and E3 showed highly statistically significant at $p < 0.05$ as shown in (Table 3).

Difference between Dentin Groups. The analysis of variance (ANOVA) test showed that there was highly significant difference between the three Dentin groups at $p<0.05$ (table 4).

Further analysis using Tukey HSD test revealed that shear bond strength between D1 and D2 was statistically non-significant while the difference between D1 and D3 was highly statistically significant and also the difference between D2 and D3 showed highly statistically significant at $p < 0.05$ as shown in (Table 5).

Table 1: the descriptive statistic for mean value and standard deviation for shear bond strength.

Group	N	Min.	Max.	Mean %	Std. Deviation	Std. Error	Variance
E1	10	3.18	5.57	4.617	.90472	.28610	.819
E2	10	3.18	6.37	4.378	1.07993	.34150	1.166
E3	10	7.17	11.15	9.477	1.32445	.41883	1.754
D1	10	2.39	4.78	3.582	.86102	.27228	.741
D2	10	3.18	4.78	3.740	.53996	.17075	.292
D3	10	5.57	9.56	7.485	1.20001	.37948	1.440

Table 2: One way ANOVA for the difference in shear bond strength between the three-Enamel groups.

Enamel groups	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	**165.588**	**2**	**82.794**	**66.431**	**.000**
Within Groups	**33.650**	**27**	**1.246**		**HS**
Total	**199.239**	**29**			

Table 3: Tukey HSD test for the shear bond strength between all enamel groups.

Enamel groups						
(I) EN	(J) EN	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
E1	E2	.23900	.49926	.882 NS	-.9989	1.4769
	E3	-4.86000*	.49926	.000 HS	-6.0979	-3.6221
E2	E1	-.23900	.49926	.882 NS	-1.4769	.9989
	E3	-5.09900*	.49926	.000 HS	-6.3369	-3.8611
E3	E1	4.86000*	.49926	.000 HS	3.6221	6.0979
	E2	5.09900*	.49926	.000 HS	3.8611	6.3369

Table 4: One Way ANOVA for the difference in .shear bond strength between the three-Dentine groups

Dentin groups	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	97.611	2	48.806	59.208	.000
Within Groups	22.256	27	.824		HS
Total	119.868	29			

Table 5: Tukey HSD test for the shear bond strength between all dentin groups.

Dentin groups						
(I) D	(J) D	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
D1	D2	-.15800	.40603	.920 NS	-1.1647	.8487
	D3	-3.90300*	.40603	.000 HS	-4.9097	-2.8963
D2	D1	.15800	.40603	.920 NS	-.8487	1.1647
	D3	-3.74500*	.40603	.000 HS	-4.7517	-2.7383
D3	D1	3.90300*	.40603	.000 HS	2.8963	4.9097
	D2	3.74500*	.40603	.000 HS	2.7383	4.7517

Discussion

Successful adhesive restoration is based on the development of materials, which establish an effective bond with the hard tooth tissues. Successful bonding depends on the chemistry of adhesive and morphological changes caused on the dental tissue by different bonding techniques [12]. The rationale behind the bond strength testing is that higher the actual bonding capacity of an adhesive, the better it will withstand such stresses and longer the restorations will survive *in vivo*. Shear bond strength testing is relatively easy and fast and remains most popular methodology for measuring the bonding effectiveness of adhesive systems [13,14].The bonding mechanism is different for enamel and dentin. The dentin is more humid and more organic than enamel, while enamel is predominantly mineral, dentin contains a significant amount of water and organic material [15,16]. Therefore, in the present study, we aimed to test the bond strength of a self-adhesive flowable composite to enamel and dentin.

In the present study the shear bond strength values of both types of self-adhesive composite are significantly less than the values obtained by the conventional composite used with self-adhesive bonding system in both the enamel and dentin groups.

These results agreed with the results of Tuloglu et al 2014, who showed that shear bond strength values of Vertise flow composite were less than the bond strength values for conventional flowable composite resins used with self-etch adhesive bonding [17]. And also agreed with the results of Abdelrahman et al., 2016, who concluded that the bond strength of Vertise flow was less than that of bulk-fill flowable composite [18].

Similarly, the Shear bond values of two self-adhesive flowable composites (Constic, Dyad™-flow) in a study by Rangappa, et al., 2018 were also reported to be lower than that of conventional composite Tetric N Flow on the dentine surfaces prepared with both diamond and carbide burs [19].

The present study findings also agreed with the findings of Rubens et al., 2013 [20], İşman et al.,2012 [21], Yuan et al.,2015 [22] and Tuloglu et al., 2014 [17].However, the present study results disagreed with the result of Aurwade et al., 2018 who found that the bonding of Constic self-adhering flowable composite is comparable with conventional other flowable composites utilizing one-step self-etch adhesives [23].

In the present study, no significant differences were found between Vertise Abdelrahman et al., 2016 [18], but disagreed with Veli et al., 2014 who found that the bond strength of Constic is greater than that of the other self-adhesive composite [24].In the present study both Vertise flow and Constic composites provided significantly lower shear bond strength than conventional flowable composite used with single bond universal adhesive. This may be due to the non-homogenous adhesive layer in these composites which might explain its low bond strength. Also the low dentin wettability of self-adhesive composites did not allow intimate contact between the material and dentin structure and consequently chemical interaction was limited. As a matter of fact, the viscosity of Vertise Flow and Constic is considerably higher than that of single bond universal with Filtek flowable bulk-fill composite. Single bond universal which is the main cause of adhesion of Filtek flowable bulk-fill makes deeper penetration and more wetting to the dentine substrate than Vertise flow which works superficially [17,25].

Both Vertise Flow and Constic are self-adhering, flowable composite resin, with a bonding technology that uses the adhesive monomer glycerol phosphate dimethacrylate GPDM. GPDM monomers ensure a tenacious bond to both enamel and dentin. GPDM adhesive monomer acts like a coupling agent. It is indicated that GPDM monomer etches rather than bonds to hydroxyapatite. To achieve self-adhesiveness, it is speculated that a relatively viscous (flowable) composite should contain a functional monomer that rather possesses an effective chemical bonding potential, as it cannot penetrate deeply [26].

The higher bond strength values of single bond Universal may be due to the presence of 10-methacryloyloxydecyl dihydrogen phosphate (10-MDP) monomer as a functional monomers in the constitution of this bond. The more effective bonding promoted by 10-MDPcontaining adhesives has recently been demonstrated [16].

This monomer is contributed to chemical calcium. It is a hydrophilic phosphate monomer that increases resin diffusion and adhesion by causing acidic decalcification and binding to calcium ions or amino groups of tooth structure [27]. the ionic interaction of 10-MDP with hydroxyapatite has been revealed by X-ray diffraction (XRD) complemented by Transmission Electron Microscopy (TEM), presenting it as a "nanoFlow and Constic in term of shear bond strength value. This agreed with result of layered" structure at the tooth-adhe bonding to hydroxyapatite of enamel and dentin due to its stability against hydrolysis and forming strong ionic bonds with sive interface,. Each layer of this self-assembled nano-layered structure constitutes of two 10 -MDP molecules with their methacrylate groups directed towards each other and their functional hydrogen phosphate groups directed away from each other via bond strength tests [28].

Conclusion

Within the limitations of the present study, both self-adhesive composites, Vertise Flow and Constic when applied to both enamel and dentin provided insufficient bonding strength needed for successful restoration lasting for long time.

Conflict of interest

The authors reported no conflict of interests.

References

1.Christensen GJ. Amalgam vs. composite resin. J Am Dent Assoc 1998; 129:1757-9

2. Garcia RN, Morelli AE, da Silva BS. Bonding performance of a self-adhering flowable composite to substrates used in direct technique. Rev Bras Odontol 2013; 10:343-9.

3.Van Meerbeek B, Yoshihara K, Yoshida Y. State of the art of self-etch adhesives. Dent Mater 2012; 27:17-28.

4. AlHumaid J, Al Harbi FA, ElEmbab AE. Performance of Self-adhering Flowable Composite in Class V Restorations. J Contemp Dent Pract 2018; 19 (7):785-791

5. Milia E, Cumbo E, Cardoso RJ and Gallina G. Current Dental Adhesives Systems. A Narrative Review. Curr Pharm Design J 2012; 18: 5542-52.

6. Özcan S, Yıkılgan I, Bala O, Üçtaşlı MB, Ömürlü U. The Effect of Different Liners on the Microleakege of Class II Restorations after Thermocycling and Occlusal Loading. Marmara Dent J 2013; 2: 71-5.

7. Yesilyurt C, Ceyhanli KT, Alp CK, Yildirim T, Tasdemir T. In vitro bonding effectiveness of new self-adhering flowable composite to calcium silicate-based material. Dent Mater J 2014; 33: 1-6

8. Erdemir U, Sancakli HS, Sancakli E. Shear bond strength of a new self-adhering flowable composite resin for lithium disilicate reinforced CAD/CAM ceramic material. J Adv Prosthodont 2014; 6:434-43.

9. Parhami P, Pourhashemi SJ, Ghandehari M. Comparative Study of the Shear Bond Strength of Flowable Composite in Permanent Teeth Treated with Conventional Bur and Contact or Non-Contact Er:YAG Laser. *Laser Med Sci* 2014; 5:140-5

10. Lopes GC, Marson FC, Vieira LCC. Composite Bond Strength to Enamel with Self-etching Primers. Oper Dent 2004; 29: 424-9.

11. Juloski J, Goracci C, Rengo C. Enamel and dentin bond strength of new simplified adhesive materials with and without preliminary phosphoric acid-etching. Am J Dent 2012;25: 239-43

12. De Munck J, Vargas M, Van Landuyt K, Hikita K, Lambrechts P, Van Meerbeek B. Bonding of an auto-adhesive luting material to enamel and dentin. Dent Mater 2004; 20: 963-71

13. 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.

14. Kumari RV, Sinddaraju K, Nagarai H, Polur RK. Evaluation of Shear Bond Strength of Newer Bonding Systems on Superficial and Deep Dentin. J Int Oral Health 2015; 7: 31-35.

15. Perdigão J. Dentin bonding-variables related to the clinical situation and the substrate treatment. Dent Mater 2010; 26: e24-37.

16. Matos AB, Trevelin LT, Silva BTF, Francisconi-dos -Rios LF, Siriani LK, Cardoso MV. Bonding efficiency and durability: current possibilities. Braz. Oral Res 2017; 31: 3-22.

17. Tuloglu N, Tunc ES, Ozer S, Bayrak S. Shear bond strength of self-adhering flowable composite on

dentin with and without application of an adhesive system. J Appl Biomater Funct Mater 2014; 12: 97-101.
18. Abdelrahman MH, Mahmoud EM, Ghoneim MM, Kammar AA. Comparative study of microleakage and shear bond strength between bulk fill and self adhesive flowable composite resins. Alexandria Dent J 2016; 41:322-327.
19. Rangappa A, Srinivasulu J, Rangaswamy V,Eregowda S, Lakshminarasimhaiah V, Lingareddy U.. Comparative evaluation of bond strength of self-adhering flowable composites to the dentin prepared with different burs: An in vitro study. J Conserv Dent 2018; 21:618-21.
20. Rubens NG, Andrey EM, Beatriz SS, Bruna MG, Camila PP, Gabriela SL. Bonding performance of a self‑adhering flowable composite to substrates used in direct technique. Rev Sul Bras Odonto 2013l; 10:343‑9.
21. İşman E, Karaarslan ES, Okşayan R, Tunçdemır AR, Üşümez S, Adanir N. Inadequate shear bond strengths of self‑etch, self‑adhesive systems for secure orthodontic bonding. Dent Mater J 2012; 31:947‑53.
22. Yuan H, Li M, Guo B, Gao Y, Liu H, Li J. Evaluation of microtensile bond strength and microleakage of a self‑adhering flowable composite. J Adhes Dent 2015; 17:535‑43
23. Aurwade V , Gundappa M, Rani A, Agarwal A. Comparative evaluation of shear bond strength of a self adhering Flowable composite to dentin of permanent teeth With different flowable composites used with self-etch Bonding agents: an ex-vivo pilot study. TMU J Dent 2018; 5: 5-7
24. Veli I, Akin M, Kucukyilmaz E, Uysal T. Shear bond strength of a self-adhering flowable composite when used for lingual retainer bonding. J Orofac Orthop 2014; 75: 374-83.
25. Fu J, Kakuda S, Pan F, Hoshika S, Ting S, Fukuoka A. Bonding performance of a newly developed step -less all-in-one system on dentin. Dent Mater J 2013; 32: 203-11
26. Poitevin A, De Munck J, Van Ende A, Suyama Y, Mine A, Peumans M. Bonding effectiveness of self-adhesive composites to dentin and enamel. Dent Mater 2013;29: 221-30.
27. Wang T, Nikaido T, Nakabayashi N. Photocure bonding agent containing phosphoric methacrylate. Dent Mater 1991; 7: 59-62.
28. Van Landuyt KL, De Munck J, Mine A, Cardoso MV, Peumans M, Van Meerbeek B. Filler debonding & subhybrid-layer failures in self-etch adhesives. J Dent Res; 2010; 89:1045-50.