CU Dent J. 2015;38(Suppl):83-96

Original Article

Microtensile Bond Strength of New Self-adhesive Flowable Resin Composite on Different Enamel Substrates

Mayurach Pipatphatsakorn D.D.S., Ph.D.

Department of Restorative Dentistry, Faculty of Dentistry, Naresuan University, Phitsanulok, Thailand

---

Abstract

Objective The purpose of this study was to evaluate the impact of etching time on the microtensile bond strength (µTBS) of Vertise® Flow™ on sound enamel, artificial initial caries-like enamel and remineralized artificial initial caries-like enamel.

Materials and Methods One hundred and twenty extracted human molars were ground to create a flat surface of enamel. Samples were randomly divided into 15 groups according to enamel substrates (S: sound enamel, D: artificial initial caries-like enamel, or R: remineralized artificial initial caries-like enamel), materials (C: Concise™ or V: Vertise® Flow™) and ethching time (0: Etching time 0 sec, 10: Etching time 10 sec, 15: Etching time 15 sec, 20: Etching time 20 sec). Enamel samples were bonded with either Vertise® Flow™ or Concise™ according manufacturer's instruction and trimmed into an hourglass shape. The µTBS test was performed and the failure modes were assessed by scanning electron microscope.

Results The highest µTBS was found in group VR15 (32.01±4.63 MPa) and the lowest µTBS was found in group VS0 (8.04±2.96 MPa). The µTBS values of Concise™ groups were significantly lower ($p<0.05$) compared to the Vertise® Flow™ groups and the bond strength were not significantly different regardless of the enamel substrates. Etching on enamel substrates in Vertise® Flow™ groups gave significantly higher µTBS than the groups without etching ($p<0.05$). The µTBS obtained from Vertise® Flow™ on sound enamel had a significantly lower bond strength compared to Vertise® Flow™ on artificial initial caries-like enamel and remineralized artificial initial caries-like enamel for all groups with 10-seconds, 15- seconds and 20-seconds etching time ($p<0.05$). Considering the effect of etching time on Vertise® Flow™ groups with 15-seconds and 20-seconds etching time gave significantly higher µTBS than the 10-seconds etching time groups for all the three different enamel substrates ($p<0.05$). The majority of samples presented an adhesive failure between the material and enamel.

Conclusion From this study, it can be concluded that the bonding effectiveness of self-adhesive flowable resin composite on different enamel substrates are better when conditioned by phosphoric acid. The μTBS was significantly influenced by different enamel substrates, where remineralized caries-like enamel and artificial initial caries-like enamel demonstrated the higher μTBS values comparing with sound enamel.

(CU Dent J. 2015;38(Suppl):83-96)

***Key words**: enamel; bond strength; flowable composite; microtensile; self-adhesive*

Correspondence to Mayurach Pipatphatsakorn, Mayurach_dt17@hotmail.com

Introduction

Pit and fissure caries have been shown to occupied over 80% of all caries in early erupted permanent teeth (Feigal, 2002). This may be due to the medium to deep pit and fissure morphology of the first permanent molar teeth which allowed greater plaque accumulation (Wang et al, 2012). Also because most of children are lack of knowledge and hand skills to perform correct tooth brushing technique, therefore deep pits and fissures may not be cleaned properly. These may lead to high prevalence of dental caries in permanent dentition (Wang et al, 2012; Al-Samadani et al, 2012).

At present, the concept of dental caries management has changed to prevention by minimal intervention to modify risk factors of dental caries using various strategies. Prevention includes preventing demineralization of the tooth and intercepting its progression (Gunda, 2013). Pit and fissure sealing has proven to be an effective mean for caries prevention (Simonsen, 2002). Sealants are flowable resin materials used for covering over pits and fissures of the tooth to prevent plaque accumulation, therefore improve cleanability and cease early carious process (Mertz-Fairhurst et al, 1986). Initial enamel carious lesions tend to occur in areas where plaque accumulates: gingival 1/3 of the crown, around occlusal pits and fissures and below the interproximal contact area. These lesions can progress to a cavitated lesion or just stay as a non-continuous demineralization lesion depending on host factors. Arrested enamel caries is seen as a smooth, opaque and shiny lesion of demineralized enamel which has already been remineralized and arrested. Dentists often hesitate to treat rough and non active white or brown lesions. Minimally invasive dentistry usually avoid aggressive treatment by filling of early carious enamel lesions and arrested carious enamel surface (Kidd, 2003). Leaving the active/inactive white spot lesion and/or shallow cavitated/non cavitated lesion in poor oral hygiene patient will convert the lesion into cavitated lesion in the future. Sealing these lesions give the opportunity to cease the caries progression (Simonsen, 2002).

Flowable resin composites have been developed since the 1990s as liners under hybrid resin composite or for the whole restoration in small cavities and also been applied as pit and fissure sealant (Francescut, 2006; Rada, 1998). Recently, the new flowable composites have been developed and these materials do not require cavity pretreatment, as theirs resin matrix contains adhesive monomers which can bond to enamel or dentin. Vertise® Flow™ (Kerr, Orange, CA, USA) is one of the self-adhesive flowable resin composite and therefore does not require a bonding application prior to placement. The bonding mechanism is primarily based on the chemical bond between the phosphate functional group of GPDM monomers and the calcium ions of enamel or dentin. A micromechanical bond results from interpenatration network between the Vertise® Flow™ polymerized monomers and dentin collagen fibers or microporosities of the conditioned enamel. Despite its simplicity and time saving, the effectiveness of this new material on various dental substrates remains questionable. Successful restoration should have a long-term retention to the tooth surface. Only a few studies of this innovative self-adhesive flowable resin composites have been published. Regarding the physical properties and microleakage of this material have been reported (Salerno et al, 2011; Wei et al, 2011a; Wei et al, 2011b; Ozel et al, 2013; Rengo et al, 2012; Yazici et al, 2013; Kamal et al, 2013). The shear bond strength and microtensile bond strength recently revealed in the literature have shown the effectiveness of restoration in vitro (Poitevin et al, 2013; Chantchaiongkol et al, 2015). However, there is no study of microtensile bond strength (µTBS) of Vertise® Flow™ adhering to initial caries-like enamel and remineralized artificial initial caries-like enamel. The complex anatomical characteristics of initial caries-like enamel and remineralized artificial initial caries-like enamel may affect the etching capacity and penetration of materials. Therefore, the purpose of this study was to evaluate the impact of etching time on the microtensile bond strength of Vertise® Flow™ to sound enamel, artificial initial caries-like enamel and remineralized artificial initial caries-like enamel.

Materials and methods

One hundred and five extracted non-carious and non-restored human molars were obtained from Naresuan university dental hospital under the protocol approved by the commission for ethics of Naresuan university. Teeth were stored in 0.1% Thymol at room temperature and used within 1 month after extraction. The teeth were randomly divided into three groups: sound enamel (1), artificial initial caries-like enamel (2) and remineralized artificial initial caries-like enamel (3). Buccal surfaces of molars were ground to obtain flat enamel surface (dimension of 5 x 5 mm) using a water-cooled mechanical grinding machine (Buehler Metadi II). Enamel surfaces were polished using 400-grit, 600-grit, and 1200-grit Al_2O_3 abrasive paper respectively. Polishing was performed carefully without exposing dentin. The roots of teeth were mounted in acrylic resin blocks. The proximal and occlusal surfaces were cut and flattened into 5 x 5 mm^2 cube shape using the above mentioned procedure. Sound enamel blocks were kept separately and stored in a moist atmosphere in each container throughout the whole preparation and test procedure.

Artificial initial caries-like enamel Formation

Seventy enamel blocks were double coated with acid-resistant nail varnish, except for the polished enamel area (buccal surface). Artificial initial caries-like lesions were produced by suspending enamel blocks in demineralizing solution containing 0.05 M acetate buffer 50% saturated with enamel, pH 5.0, for 16 h at 37°C. To prepare this demineralizing solution, enamel powder (particles of 74 to 105 µm) was agitated in 0.05 sodium acetate buffer, pH 5.0, for 96 h at 37°C (0.50 g/l). The solution was applied at a proportion of 2.0 ml per mm^2 of exposed enamel area (Paes et al, 2003; Kantovitz et al, 2011). Thirty five enamel blocks were thoroughly rinsed with distilled water and stored under moist environment until the experiment and the other Thirty five enamel blocks were used for remineralization of artificial caries-like lesions.

Remineralized artificial initial caries-like enamel

Following Artificial initial caries-like enamel formation, thirty five demineralized enamel blocks were then applied with topical fluoride. The enamel surfaces of these blocks were coated with Vanish™ 5% Sodium Fluoride White Varnish with TCP (3M ESPE Omni, St. Paul, MN, USA). The enamel blocks were individually immersed in artificial saliva (1.5 mM calcium, 0.9 mM phosphate, 150 mM KCl in 0.1 M Tris buffer, 0.05 µg F/mL, pH 7.0) at 37°C for 1 week. The solution was used at a proportion of 1.25 ml per mm^2 of exposed enamel area (Kantovitz et al, 2011; Featherstone et al, 1985). After one week, the enamel blocks were moved from artificial saliva and rinsed with distilled water (pH 6).

Sample Preparation

The enamel blocks were randomly divided into fifteen subgroups (n = 7) according to enamel substrates and materials: Concise + Sound enamel (CS); Concise + Artificial initial caries-like enamel (CD); Concise + Remineralized artificial initial caries-like enamel (CR); Vertise® Flow™ + Etching time 0 sec + Sound enamel (VS0); Vertise® Flow™ + Etching time 0 sec + Artificial initial caries-like enamel (VD0); Vertise® Flow™ + Etching time 0 sec + Remineralized artificial initial caries-like enamel (VR0); Vertise® Flow™ + Etching time 10 sec + Sound enamel (VS10); Vertise® Flow™ + Etching time 10 sec + Artificial initial caries-like enamel (VD10); Vertise® Flow™ + Etching time 10 sec + Remineralized artificial initial caries-like enamel (VR10); Vertise® Flow™ + Etching time 15 sec + Sound enamel (VS15); Vertise® Flow™ + Etching time 15 sec + Artificial initial caries-like enamel (VD15); Vertise® Flow™ + Etching time 15 sec + Remineralized artificial initial caries-like enamel (VR15); Vertise® Flow™ + Etching time 20 sec + Sound enamel (VS20); Vertise® Flow™ + Etching time 20 sec + Artificial initial caries-like enamel (VD20); Vertise® Flow™ + Etching time 20 sec + Remineralized artificial initial caries-like enamel (VR20).

The enamel samples were dried out and etched with 37% phosphoric acid (Kerr, Orange, CA, USA) for 10, 15 and 20 seconds according to the protocol, followed by water rinsing for 10 seconds, and then gently air-dried for 5 seconds until all visible water was removed. Dispense a thin layer (<0.5 mm) of Vertise® Flow™ (shade A3) using a provided applicator with a brushing motion for 15-20 seconds; light cure for 20 seconds usingt the Demi light-curing unit (Kerr, Danbury, CT, USA); syringe additional material in increments of less than 2 mm and light cure each increment for 20 seconds. Restorative procedures were performed strictly according to the manufacturer's instructions to create 5 mm thickness on the enamel surface of each sample and then all the samples were kept at 37°C under 100% relative humidity for 24 hours.

Concise™ sealant was applied to the enamel blocks in increments according to the manufacturer's instructions. The Concise groups were prepared and stored using the same procedure as Vertise® Flow™ groups.

After 24-hour storage, specimens were sectioned perpendicular to the material-tooth interface using a fully automated precision water-cooled diamond saw (Isomet 1000, Buehler, Lake Bluff, IL, USA) to obtain four rectangular samples of 5 mm x 5 mm x 1 mm-slice from each tooth. Seven teeth from each group yielded twenty eight slices for bond strength evaluation (n=28 per group). The slices were trimmed to an hourglass shape with the neck area 1 mm x 1 mm using a cylindrical diamond bur (FG 3097, KG Sorensen). The center of hour glass curve exists in between the bonding area of tooth enamel and restorative material. The width and thickness of each specimen were measured to the nearest 1 mm using a digital calliper (Mitutoyo, Tokyo, Japan).

The hourglass-shaped specimens were individually mounted to a metal plate with cyanoacrylate glue (Model Repair II Blue, Dentsply-Sankin, Tochigi, Japan) and stressed in tension at a crosshead speed of 0.5 mm/min using a Universal Testing machine (8872 Instron, Canton, MA, USA.). The µTBS was derived by dividing the force imposed at the time of fracture by the bond area (mm^2). Pretest failures were not included in the statistical analysis. The failure pattern and side interlocking quality were determined using a scanning electron microscope (SEM) in order to analyze the failure in terms of fractures and the interlocking quality of the material. The mode of failure was determined with a stereomicroscope at 50x magnification, and was recorded as either ‘cohesive failure in enamel’, ‘cohesive failure in resin’, ‘interfacial failure between adhesive and enamel’, or ‘mixed failure’.

All data were analyzed using SPSS statistical software for Windows, version 15.0 (SPSS Inc., Chicago, IL, USA). The means of µTBS were analyzed with one-way ANOVA and Bonferroni post hoc test with level of significance set at 5% ($p<0.05$).

Results

Means of microtensile bond strength, standard deviations, and numbers of pretest failures are shown in Table 1. The highest µTBS was found in group VR15 (32.01±4.63 MPa) and the lowest µTBS was found in group VS0 (8.04±2.96 MPa). The µTBS values of Concise™ groups were significantly lower ($p<0.05$) than Vertise® Flow™ groups and the bond strength remained practically the same regardless of the different enamel substrates. Pretreatment on enamel substrates in Vertise® Flow™ groups gave significantly higher µTBS than the groups without pretreatment

Table 1 Mean microtensile bond strength values and standard deviations of Concise™ and V: Vertise® Flow™ on sound enamel, artificial initial caries-like enamel and remineralized artificial initial caries-like enamel.

Group	PTF (n)	Minimum (MPa)	Maximum (MPa)	Mean ± SD (MPa)
CS	0	12.68	24.75	18.27 ± 3.64 a
CD	0	11.15	16.14	16.14 ± 2.96 a
CR	0	11.17	19.77	17.24 ± 3.79 a
VS0	16	2.35	12.34	8.04 ± 2.96
VD0	13	2.34	13.43	8.15 ± 3.39
VR0	11	2.12	14.34	9.31 ± 3.72
VS10	0	18.93	34.10	23.46 ± 3.73
VD10	0	16.20	39.82	28.05 ± 6.45
VR10	0	10.58	37.08	28.97 ± 4.34
VS15	0	16.20	39.82	28.03 ± 6.57 a#
VD15	0	20.98	44.68	30.46 ± 6.70 a*
VR15	0	19.12	43.97	32.04 ± 4.63 a*
VS20	0	13.79	29.98	26.58 ± 3.31
VD20	0	15.56	31.67	29.91 ± 2.27
VR20	0	16.58	32.23	29.23 ± 5.60

Groups having similar letters or symbols (# or *) (letters compare with letters; symbols compare with symbols) are not significantly different in their µTBS; PTF=pretest failures; n=number of specimens

($p<0.05$). In addition, a high number of pretest failures was found in the groups without pretreatment.

Comparison of the μTBS of Concise™ groups and Vertise® Flow™ groups on the different substrates was performed. The μTBS resulting from VS15, VD15 and VR15 were higher than CS, CD and CR ($p<0.05$). When comparing among groups, Concise™ groups showed no statistical difference.

The μTBS of VD15 and VR15 presented higher values than VS15 significantly ($p<0.05$). The μTBS obtained from Vertise® Flow™ on sound enamel had a significantly lower bond strength compared to Vertise® Flow™ on artificial initial caries-like enamel and remineralized artificial initial caries-like enamel in the 10-seconds, 15-seconds and 20-seconds etching time ($p<0.05$) (Table 3 and Table 4).

Considering the effect of etching time on Vertise® Flow™ groups, the groups with 15-seconds and 20-seconds etching time gave significantly higher μTBS than groups with 10-seconds etching time in all three different enamel substrates ($p<0.05$) (Table 5, 6 and 7)

Table 2 Mean microtensile bond strength values of Concise™ and Vertise® Flow™ on different substrates with 15-seconds etching time.

Group	Mean ± SD (MPa)
VS15	28.03 ± 6.57 a
VD15	30.46 ± 6.70 b
VR15	32.01 ± 4.63 b

Groups having similar letters are not significantly different in their μTBS

Table 3 Mean microtensile bond strength values of Vertise® Flow™ on different substrates with 10-seconds etching time.

Group	Mean ± SD (MPa)
VS10	23.46 ± 3.73 a
VD10	28.05 ± 6.45 b
VR10	28.97 ± 4.34 b

Groups having similar letters are not significantly different in their μTBS

Table 4 Mean microtensile bond strength values of Vertise® Flow™ on different substrates with 20-seconds etching time.

Group	Mean ± SD (MPa)
VS20	26.58 ± 3.31 a
VD20	29.91 ± 2.27 b
VR20	29.23 ± 5.60 b

Groups having similar letters are not significantly different in their μTBS

Table 5 Mean microtensile bond strength values of Vertise® Flow™ on sound enamel with different etching times.

Group	Mean ± SD (MPa)
VS10	23.46 ± 3.73 a
VD15	28.03 ± 6.57 b
VR20	26.58 ± 3.31 b

Groups having similar letters are not significantly different in their μTBS

Table 6 Mean microtensile bond strength values of Vertise® Flow™ on artificial demineralized enamel with different etching times.

Group	Mean ± SD (MPa)
VS10	28.05 ± 6.45 a
VD15	30.46 ± 6.70 b
VR20	29.91 ± 2.27 b

Groups having similar letters are not significantly different in their μTBS

Table 7 Mean microtensile bond strength values of Vertise® Flow™ on remineralized artificial initial caries-like enamel with different etching times.

Group	Mean ± SD (MPa)
VR10	28.97 ± 4.34 a
VR15	32.01 ± 4.63 b
VR20	29.23 ± 5.60 b

Groups having similar letters are not significantly different in their μTBS

Table 8 Percentage of failure pattern after microtensile bond strength test

Group	N	Adhesive	Cohesive in material	Cohesive in enamel	Mixed
CS	28	82.1	14.3	0	3.6
CD	28	85.7	3.6	0	10.7
CR	28	78.6	10.7	0	10.7
VS0	12	91.7	9.1	0	0
VD0	15	100.0	0	0	0
VR0	17	94.1	6.3	0	0
VS10	28	71.4	3.6	0	25.0
VD10	28	75.0	10.7	0	14.3
VR10	28	75.0	7.1	0	14.3
VS15	28	82.1	7.1	0	10.7
VD15	28	85.7	3.6	0	10.7
VR15	28	75.0	3.6	0	21.4
VS20	28	85.7	10.7	0	3.6
VD20	28	78.6	10.7	0	10.7
VR20	28	82.1	3.6	0	14.3

The majority of failures were adhesive failure between the material and enamel. Every group showed a few cohesive failures within material and mixed failures were found, and cohesive failures within enamel were not found. (Table 8)

The SEM results are shown in Fig. 1. The photomicrography of Vertise® Flow™ group shows the opening dentinal tubules with resin tags. The phosphoric acid produces a deep etched pattern in enamel with well-defined tag-like formations. Vertise® Flow™ on three different enamel substrates produced a hybridized enamel layer with typical resin penetration into the demineralized zone (indicated by white arrows) which did not show the different of a hybridized enamel layer pattern among the different enamel substrates.

Discussion

The clinical success of the resin composite restorative material is related to the ability of material to adhere and seal to the tooth surface. The materials have to tightly and durably seal the tooth surfaces treated; this is critically important to reliable, long-term caries prevention. Recently, an innovative self-adhesive flowable resin composite has been introduced using for a small restoration or sealant. Vertise® Flow™ need acid etchant applying on enamel but not on dentin prior to restoration. With this systems, enamel demineralization with both acid etchant and self adhesive flowable resin composite and resin penetration occur simultaneously (Garcia et al, 2013; Juloski et al, 2012). One major advantage of self adhesive flowable resin

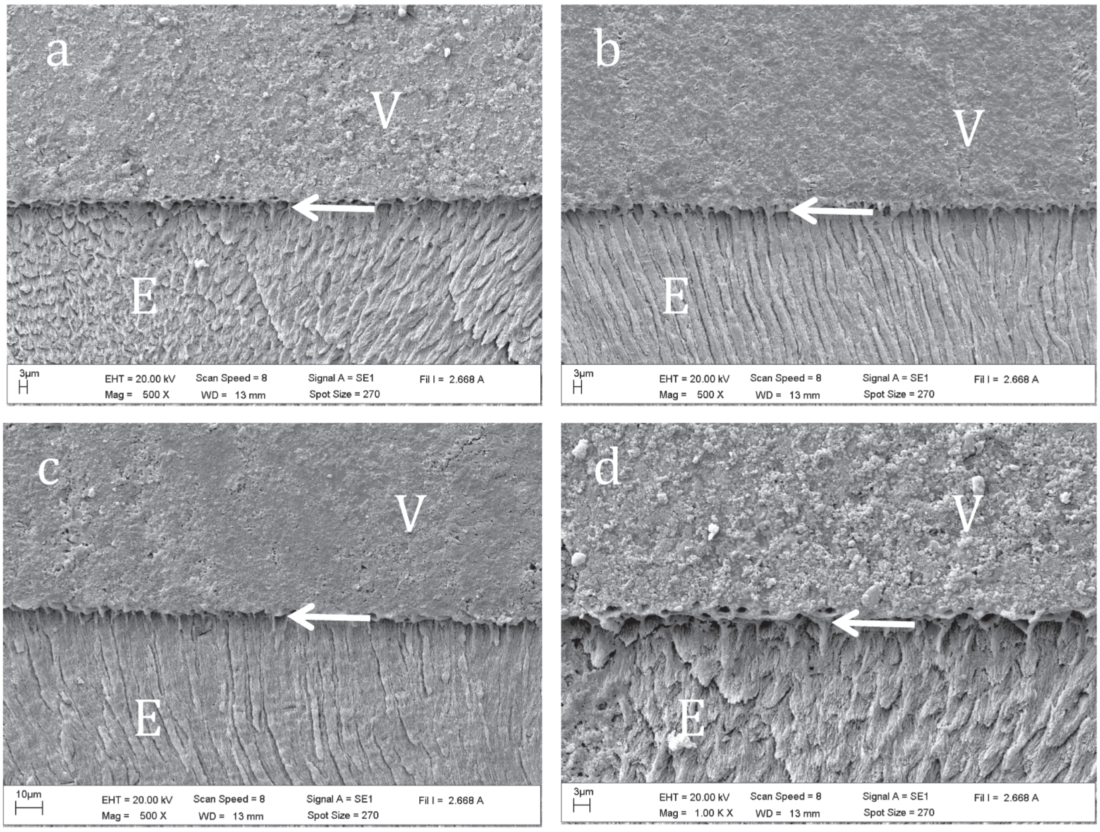

Fig. 1 SEM photomicrograph illustrating enamel (E) interfaces bonded with Vertise® Flow™ (V). (a) Group VS15 (500X), (b) Group VD15 (500X), (c) Group VR15 (500X), (d) VS15 (1000X) The white arrow depicts the hybrid layer and resin tag.

composite is a reduction in treatment time required for the bonding procedure. In addition, there is no ambiguity about the remaining moisture in dentin, as these systems contain water and are not dependent on surface moisture in dentin. Moreover, it offers favourable mechanical and physical properties. (Salerno et al, 2011; Wei et al, 2011a; Wei et al, 2011b; Ozel et al, 2013; Rengo et al, 2012; Yazici et al, 2013; Kamal et al, 2013; Sabbagh, 2004).

It has been documented that microtensile bond strength of self adhesive to enamel was about 16-40 MPa (Juloski et al, 2012). The results of the our present study demonstrated an acceptable µTBS values of Vertise® Flow™ to sound enamel, artificial initial caries-like enamel and remineralized artificial initial caries-like enamel. Bonding effectiveness of self adhesive flowable resin composite can be ascribed to many factors, the actual composition and the kind of functional monomer contained in material are probably the most important factors in bonding effective. The functional monomer used in Vertise® Flow™ is glycerol phosphate dimethacrylate (GPDM). To our knowledge, no chemical analytic data on the bonding mechanism of GPDM are available. However, GPDM contained in the 3-step etch-and-rinse adhesive OptiBond FL (Kerr) has proven good adhesive performance in both laboratory and clinical research (Van Meerbeek et al, 2003; Poitevin et al, 2008). The OptiBond XTR (Kerr) also contains GPDM revealed a 2 mm deep hybrid layer free of hydroxyapatite this observation indicates that GPDM 'etches' rather than 'bonds' to hydroxyapatite (Poitevin et al, 2013). To achieve self-adhesiveness, a relatively viscous self-adhesive flowable resin composite should contain a functional monomer that rather has an effective chemical bonding potential, as it can not penetrate deeply.

The penetration ability of Vertise® Flow™ is slightly low which is probably because the high loading of filler (70 wt%) (Wei et al, 2011). The high filler content of flowable composites can increase the wear resistance. Unfortunately, it shows more stickiness and more difficulty handling for the flowable composites. The high filler content results in less contraction, which in turn influences the marginal integrity of the restoration (Munksgaard et al, 1987). Although Vertise® Flow™ offers high bond strengths to enamel but its high viscosity should to be noted that using the Vertise® Flow™ as pit and fissure sealant may probably leads to adhesive failure.

The results show that pre-etching enamel significantly improved the bonding effectiveness of the Vertise® Flow™ (Rengo et al, 2012). Moreover, the bond of this material to non-ethched enamel was significantly low and debonding occured during sample preparation in all the three types of enamel substrates. This result may support discussion that a combination of phosphoric acid etching with acidic self-etching monomers resulted in high bond strength on unground enamel surfaces, which could not be achieved by self-etching primers alone (Erhardt et al, 2004). Since phosphoric acid significantly increase the surface free energy of enamel and thus provides more retention (Van Meerbeek et al, 2003). The phosphoric acid is effectively dissolve and, upon rinsing, remove the smear layer, thus the smear layer can not play a role in bonding effectiveness. In this study, SEM revealed that phosphoric acid clearly exposed prism of enamel rod and absence of smear layer up to a few micrometers depth. The selective etching of prism cores (Type 1 pattern) and prism peripheries (Type 2 pattern) along with areas without selective demineralization could be observed in the same specimen (Retief, 1973; Silverstone et al, 1975; Shinohara et al, 2006). The relative viscous Vertise® Flow™ could adequately penatrated to form hybridized complex of resin in enamel. This is the reason of retrieving the good quality bond strength and maginal sealing. Vertise® Flow™, in combination with the use of 37% phosphoric acid etching gave a significant higher μTBS than using Vertise® Flow™ alone.

The surface topographies of both sound and artificial initial caries-like enamel appear quite similar, with relatively smooth and intact surfaces. The sound and artificial initial caries-like enamel exhibit a very similar morphology after etching. Tandon S and Mathew TA, 1997 showed that acid etching of caries-like lesions treated with fluoride showed etching patterns similar to sound enamel (Tandon et al, 1997). The conditioned artificial caries exhibits more micro-porosity which permits the unpolymerized resin to spread rapidly and deeply due to an increase of wettability, surface roughness and larger pore volume. This study found that remineralized enamel show accepatable μTBS values. Similar to other studies shown that over all bond strength is not significantly different in groups with and without fluoride pretreatment (Thornton et al, 1986; Kimura et al, 2004). However, some studies reported that topical fluoride application fills the interprismatic spaces occupied by $Ca_5(PO)_3$ and CaF_2 and reduced the bonding effectiveness (Koh et al, 1998).

Our study showed that μTBS values of Vertise® Flow™ to artificial initial caries-like enamel and remineralized caries-like enamel demonstrated the higher μTBS values com paring with sound enamel.

Differences in the structure and physiology of the enamel present on prepared surfaces play a role in the bond strength (Lee et al, 1975; Low et al, 1975). Koh et al. studied about sealant on remineralized enamel and data showed clinically acceptable tensile bond strength values (Koh et al, 1998). On the other hands, it has been showed in many studies that self-etched and self-adhesive monomers did not effectively dissolving the superficial acid-resistant enamel layer due to their lower acidity than phosphoric acid (Tay et al, 2005; Heintze et al, 2008). Kantowitz et al. showed results in μTBS of sealant on different substrates with the highest values for remineralized caries-like enamel lesions (Eliadesa et al, 2013). In caries-like lesion and arrested caries on enamel, the surface topographies appears relative smooth and intact with a larger pore volume. Regarding the porosity of these substrates, the penetration of the high filler and high viscosity flowable resin material were able to flow and form hybrid layer. The SEM analysis confirmed that enamel specimens have complete form hybrid layer by interacting chemically between hydroxyapatite and functional monomer of the material and also resin infiltration appear uniformly. The similar hybrid layer pattern was found in all three enamel substrates.

In this study, pretesting failures were excluded from statistic analysis. However, pretesting failures are typically associated with relatively low bond strength data measured for those specimens that did not fail prior to testing. The micro tensile bond strength of no surface treatment group must be carefully interpreted (Eckert et al, 2007; Loguercio et al, 2005; ISO. Dental materials, 2003).

Vertise® Flow™ can be used as a sealant providing good flowability and good adaptation. However, because of the high viscosity, care must be used during application to allow better adaptation of the material. It can be applied directly after etching in a sealant application. The penetration of the highly viscous Vertise® Flow™ showed no statistically significant differences with the others self-adhesive restorative materials groups applied on acid-etched enamel. Moreover, using this material in preventive resin restoration (PRR) greatly simplify the restorative procedure by eliminating bonding application step. The PRR is a procedure using only Vertise® Flow™ as restorative material to fill up the cavity and spread this same material to seal the pit and fissure.

Conclusion

From this study, it can be concluded that the bonding effectiveness of self adhesive flowable resin composite on difference enamel substrates are acceptable when conditioned by phosphoric acid. The μTBS was significantly influenced by different enamel substrates, where remineralized caries-like enamel and artificial initial caries-like enamel demonstrated higher μTBS values comparing with sound enamel.

References

Al-Samadani KHM, Ahmad MS. Prevalence of first permanent molar caries in and its relationship to the dental knowledge of 9-12-Year Olds from Jeddah, Kingdom of Saudi Arabia. ISRN Dentistry. 2012:1-6.

Chantchaimongkol S, Srisawasdi S. Microtensile bond strength of self-adhesive resin composite to dentin. CU Dent J. 2015;38:21-34.

De Munck J MA, Poitevin A, Van Ende A, Vivan Cardoso M, Van Landuyt K, et al. Meta-analytical review of parameters involved in dentin bonding. J Dent Res. 2012;91:351-7.

Eckert GJ, Platt JA. A statistical evaluation of microtensile bond strength methodology for dental adhesives. Dent Mater. 2007;23:385-391.

Eliadesa A, Birpou E, Eliadesb T, Eliades G. Self-adhesive restoratives as pit and fissure sealants: A comparative laboratory study. Dent Mater. 2013;29:752-62.

Erhardt MC CL, Pimenta LA. Influence of phosphoric acid pretreatment on self-etching bond strengths. J Esthet Restor Dent. 2004;16:33-40.

Featherstone JDB ORM, Shariati M, Brugler S. Enhancement of remineralization in vitro and in vivo. Factors relating to demineralization and remineralization of the teeth. Proceedings of a Work-shop 1985. (ed). ILSA, editor. Washington DC: Oxford, 1986.

Feigal RJ. The use of pit and fissure sealants. Pediatr Dent. 2002;24:415-22.

Francescut P LA. Performance of a conventional sealant and a flowable composite on minimally invasive prepared fissures. Oper Dent. 2006;31:543-50.

Garcia RN, Morelli AE, Giongo BM, et al. Bonding performance of a self-adhering flowable composite to substrates used in direct technique. RSBO. 2013;10:343-9.

Gunda S VN. Minimal intervention in pediatric dentistry. J Orofacial Res. 2013;3:28-33.

Heintze S FM, Cavalleri A. Microleakage of class II restorations with different tracers-comparison with SEM quantitative analysis. J Adhes Dent. 2008; 10:259-67.

ISO. Dental materials-Testing of adhesion to tooth structure. Technical Specification 2003: No. 11405.

Juloski J1, Goracci C, Rengo C, Giovannetti A, et al. Enamel and dentin bond strength of new simplified adhesive materials with and without preliminary phosphoric acid-etching. Am J Dent. 2012;25:239-43.

Kamal El-Din M. El Motayam; Walid Ali Fouad and Randa Youssef. Assessment and Comparison of Nanoleakage and Resin Tag Length of Three Different Pit and Fissure Sealants: An In-vitro Scanning Electron Microscope Study. Journal of American Science 2013;9:329-37.

Kantovitz KR, Alves MC, Nociti FH, Tabchoury CP, Puppin-Rontani RM. Influence of Different Enamel Substrates on Microtensile Bond Strength of Sealants After Cariogenic Challenge. J Adhes Dent. 2011;13:131-7.

Kidd EAM VAJ. Dental Caries: The Disease and Its Clinical Management. Ole Fejerskov (Editor) EKE, editor. Ames, Iowa, USA: Blackwell Munkgaard; 2003.

Kimura T DW, Taloumis LJ. Effect of fluoride varnish on the in vitro bond strength of orthodontic brackets using a self-etching primer system. Am J Orthod Dentofacial Orthop 2004;125:351-6.

Koh SH CJ, You C. Effects of topical fluoride treatment on tensile bond strength of pit and fissure sealants. Gen Dent. 1998;46:278-80.

Lee H SD, Orlowski J, Swartz ML, Ocumpaugh D, Neville K. Sealing of developmental pits and fissures. Effects of fluoride on adhesion of rigid and flexible sealers. J Dent Res. 1972;51:151-152.

Loguercio AD, Barroso LP, Grande RH, Reis A. Comparison of intra-and inter-tooth resin-dentin bond strength variability. J Adhes Dent. 2005;7:151-158.

Low T vFJ, Winter GB. The bonding of a polymeric fissure sealant to topical fluoride-treated teeth. J Oral Rehabil. 1975;2:303-7.

Mertz-Fairhurst EJ SG, Fairhurst CW. Arresting caries by sealants: results of a clinical study. J Am Dent Assoc. 1986;112:194-7.

Munksgaard EC HE, Kato H. Wall-to-wall polymerisation contraction of composite resin versus filler content. Scan J Dent Res. 1987;95:526-31.

Ozel Bektas O ED, Akin EG, Akin H. Evaluation of a new self-adhering flowable composite in terms of micro-shear bond strength and microleakage. Acta Odontol Scand. 2013;71:541-6.

Paes Leme AF TC, Zero DT, Cury JA. . 18. Paes Leme AF, Tabchoury CPM, Zero DT, Cury JA. Effect of fluoridated dentifrice and acidulated phosphate fluoride application on early artificial carious lesions. Am J Dent. 2003;16:91-5.

Poitevin A DMJ, Van Landuyt K, Coutinho E, Peumans M, Lambrechts P, et al. Critical analysis of the influence of different parameters on the micro-tensile bond strength of adhesives to dentin. J Adhes Dent. 2008;10:141-6.

Poitevin A, Suyama Y, Mine A, Peumans M, Van Meerbeek B. Bonding effectiveness of self-adhesive composites to dentin and enamel. Dent Mater. 2013;29:221-30.

Rada RE. The versatility of flowable composites. Dent Today. 1998;17:78-83.

Rengo C GC, Juloski J, Chieffi N, Giovannetti A, Vichi A, et al. Influence of phosphoric acid etching on microleakage of a self-etch adhesive and a self-adhering composite. Aust Dent J. 2012; 57:220-6.

Retief DH. Effect of conditioning the enamel surface with phosphoric acid. J Dent Res. 1973;52: 333-41.

Salerno M DG, Thorat S, Ceseracciu L, Ruffilli R, Barone AC. Surface morphology and mechanical properties of new generation flowable resin composites for dental restoration. Dent Mater. 2011;27:1221-8.

Sabbagh J, Physical and mechanical characterization of resin-based materials. PhD Thesis, Catholic University of Louvain, Belgium 2004.

Shinohara MS, de Oliveira MT, Di Hipolto V, Giannini M, de Goes MF. SEM analysis of the acid-etched enamel patterns promoted by acidic monomers and phosphoric acids. J Appl Oral Sci. J Appl Oral Sci. 2006 Dec;14:427-35.

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;9:373-87.

Simonsen RJ. Pit and fissure sealant: review of the literature. Pediatr Dent. 2002;24:393-414.

Tandon S1, Mathew TA. Effect of acid-etching on fluoride-treated caries-like lesions of enamel: a SEM study. ASDC J Dent Child. 1997;64:344-8.

Tay FR FR, Carvalho RM, Pashley DH. Pit and fissure sealing, bonding of bulk-cured, low-filled, light-curing resins to bacteria-contaminated uncut enamel in high c-factor cavities. Am J Dent. 2005;18:28-36.

Thornton JB RD, Bradley EL Jr, Denys FR. The effect of fluoride in phosphoric acid on enamel fluoride uptake and the tensile bond strength of an orthodontic bonding resin. Am J Orthod Dentofacial Orthop. 1986;90:91-101.

Van Meerbeek B DMJ, Yoshida Y, Inoue S, Vargas M, Vijay P, et al. Buonoccore memorial lecture: adhesion to enamel and dentin: current status and future challenges. Oper Dent. 2003;28:215-35.

Wang J-D, Chen X, Frencken J, Du M-Q, Chen Z. Dental caries and first permanent molar pit and fissure morphology in 7-to 8-year-old children in Wuhan, China. Int J Oral Sci. 2012;4:157-60.

Wei YJ, Silikas N, Zhang ZT, Watts D.C. Diffusion and concurrent solubility of self-adhering and new resin-matrix composites during water sorption/ desorption cycles. Dent Mater. 2011;27:197-205.

Wei Y SN, Zhang Z, Watts D. Diffusion and concurrent solubility of self-adhering and new resin-matrix composites during water sorption/ desorption cycles. Dent Mater. 2011;27:197-205.

Wei Y SN, Zhang Z, Watts D. Hygroscopic dimensional changes of self-adhering and new resin-matrix composites during water sorption/ desorption cycles. Dent Mater. 2011;27:259-66.

Yazici AR AI, Campillo-Funollet M, Munoz-Viveros C, Antonson SA, Antonson DE, et al. Effect of laser preparation on bond strength of a self-adhesive flowable resin. Lasers Med Sci. 2013; 28:343-7.