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Comparative evaluation of self-adhering flowable and conventional flowable composites using different adhesive systems

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Abstract

Introduction: The ability to seal margins is considered as one of the best predictors for the long-term success of bonded restorations. The aim of this study was to compare microleakage in occlusal and gingival margins between cavities filled with self-adhesive flowable and conventional flowable composites using dye penetration. Composite restorations were bonded with self-etch, total etch and universal adhesives.

Materials & Methods: In this in vitro study, 32 extracted human premolars for orthodontic purpose were included. Class V cavities ($3 \times 3 \times 1.5\ mm$) were prepared on the facial and lingual surfaces of each tooth. The teeth were randomly divided into four equal groups based on the type of material: Single Bond 2 (3M ESPE), Clearfil SE Bond (Kuraray, Tokyo, Japan), Universal Scotch Bond (3M ESPE), and Vertise Flow (Kerr Corp). Bonding agents were applied according to the manufacturer instructions. Then, the cavities of the first three groups were restored with Filtek Flow (3M ESPE, USA). In addition, the teeth were thermocycled for 30 seconds and 1000 cycles at 5°-55°C. Microleakage was evaluated using a stereomicroscope ($\times 40$). Specimens were subjected to a dye leakage test. Data were analyzed using Kruskal-Wallis and Mann-Whitney U tests.

Results: Significant difference was observed in microleakage among four groups in both occlusal and gingival levels ($p \leq 0.05$). No significant difference was found regarding microleakage between Vertise Flow, and Etch - and - rinse and Universal groups.

Conclusion: Vertise Flow is a useful material with adequate marginal seal.

Keywords: Composite resins, Dental leakage, Dentin-bonding agents

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بررسی میزان ریزنشت کامپوزیت های فلو سلف ادهزیو و کامپوزیت های فلوکانونشنال باند شده با سیستم های ادهزیومختلف

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چکیده

مقدمه: یکی از بهترین فاکتورهای پیش بینی کننده موفقیت دراز مدت ترمیم‌های باند شونده، توانایی سیل لبه‌ای است. بنابراین هدف از این مطالعه ارزیابی مقایسه‌ای میکرولیکیج لبه‌ای اکلوزال و لثه‌ای بین کامپوزیت‌های فلو سلف ادهزیو با کامپوزیت‌های فلو کانونشنال باند شده با ادهزیوهای توتال اچ، سلف اچ و یونیورسال می‌باشد.

مواد و روش ها: این مطالعه تجربی آزمایشگاهی بر روی ۳۲ دندان پره مولر انسانی که به منظور ارتودنسی کشیده شده بودند انجام شد. حفرات کلاس 5 ($3\times 3\times 1.5mm$) در هر دو سطح فاسیال و لینگوال هر دندان آماده شد. دندان‌ها بر اساس نوع ماده و به صورت تصادفی به چهار گروه برابر تقسیم شدند:Single Bond 2، Clearfil SE Bond، Scotch Bond Universal وVertise Flow باندینگ‌ها براساس دستورالعمل شرکت سازنده به کار برده شده و سه گروه اول با Filtck Flow ترمیم شدند. نمونه‌ها در دمای ۵ تا ۵۵ درجه سانتی گراد به مدت ۳۰ ثانیه تا ۱۰۰۰ سیکل قرار گرفتند. سپس میزان ریزنشت به وسیله استریومیکروسکوپ($\times 40$)ارزیابی شد. نمونه‌ها براساس تست نفوذ رنگ درجه بندی شدند. داده‌ها با استفاده از آزمون‌های آماری Kruskal Wallisو Mann_whitney U آنالیز گردید.

یافته ها: اختلاف معنادار در میزان میکرولیکیج در هر دو مارجین اکلوزال و جینجیوال در هر چهار گروه مشاهده شد .($p\leq 0.05$) ریزنشت کامپوزیت فلو سلف ادهزیو با گروه های Etch- and -rinse و یونیورسال اختلاف معناداری نداشت.

نتیجه گیری: Vertise Flow یک ماده مفید با سیل لبه ای مناسب می باشد.

واژگان کلیدی: رزین کامپوزیت، ریزنشت دندانی،عامل چسبنده عاجی

Introduction

Succession of composite restoration and prevention of microleakage requires good adhesion. It is known that constant microleakage may lead to staining, defective restorations, recurrent caries, and possible pulpal pathosis. [1, 2] Dental adhesives are generally classified into "etch-and-rinse" and "self-etch" approaches. In addition, priming and bonding components can be separated or combined, resulting in three or two steps for etch and rinse systems, and two or one step for self-etch adhesives.[3] Recent advances in adhesive systems result in producing multi-purpose multi-mode or universal adhesive systems, which can be used both methods (etch-and-rinse and self-etch) using the same bottle. Manufacturers claim that bonding effectiveness is not compromised when either strategy is employed. [4-6] The manufacturers of dental material are trying to simplify the application process. Recently, flowable self-adhering composites have been offered to promise a combination of easy handling and time-saving procedures, the absence of additional etching and bonding steps and significantly reduction of technique sensitivity. Flowable self-adhering composite consists of glycerophosphate dimethacrylate (GPDM), a functional monomer that acts like a coupling agent. GPDM has an acidic phosphate group for etching the enamel and dentine as well as two methacrylate functional groups for copolymerization with other methacrylate monomers to supply increased crosslinking density and elevated mechanical strength for the polymerized adhesive. Thus, this new version of composite eliminates the need for a separate bonding application step. Yuan et al.[7] showed that using the self-adhering flowable composite alone yielded the lowest bond strength and similar marginal sealing ability compared to self-etching and etch-and-rinse adhesives combined with flowable composite. According to Bektas et al and Vichi et al., [8,9] the Vertise Flow certainly is a useful material with acceptable bond strength and marginal seal, whereas Poitevin et al. [10] warned against routine clinical use of this composite. Therefore, the aim of this study was to evaluate the sealing ability of self-adhesive compared to conventional flowable composite bonded with self-etch, total etch, and universal adhesive in class V restorations.

Materials & Methods

Ethics Committee of Babol University of Medical Sciences (IR.MUBABOL.REC.1397.025) approved this in vitro study. Totally, 32 caries-free human premolar teeth [11] extracted within six months for orthodontic purpose were collected. The specimens were immersed in 0.5% chloramines T solution for 24 h at room temperature for disinfection. Using a high-speed handpiece and a diamond fissure bur with 0.10 mm diameter (Jota AG, Rüthi, Switzerland) along with the water flow, Class V cavities were prepared on the buccal and lingual surfaces of each tooth. These cavities were prepared by a 3-mm mesiodistal and 3-mm occlusogingival dimensions in addition to 1.5mm depth. The gingival half of the preparation was extended 1 mm below the CEJ. No line angle was beveled in the preparation. A periodontal probe was used to measure the cavity sizes. A new bur was used to prepare every five cavities. After washing and revising the cavities, the teeth were divided into four equal groups based on the type of used bonding agent. Table 1 illustrates all used materials in this study. The adhesive agents were applied as follows: group 1: for using Single Bond 2, Etchant was applied with a syringe on enamel and dentine. Waiting for 15 seconds, it was rinsed with water. Next, the cavity was gently dried using an air syringe while leaving a slightly moist surface. Single coat of Adper Single Bond (fifth generation) bonding agent was applied with an applicator tip. Air was blown gently followed by second coat of bonding agent. Light curing (VALO, Ultradent Products Inc, South Jordan, UT, USA) was done for 10 seconds. Then, the composite resin Filtek Flow was used for filling the cavities in two layers and light cured for 20 seconds.

Group 2: For using Clearfil SE Bond, only enamel etchant was applied with a syringe. After waiting for 15 seconds, the enamel was rinsed with water for 20 seconds. After that, the cavity was gently dried using an air syringe. Self-Etch Primer was applied with a microbrush for 20 seconds followed by gentle air dispersion. Adhesive Clearfil SE Bond (sixth generation) was used with a microbrush followed by gentle air dispersion. Then, light curing was done for 10 seconds. Finally, the cavity was restored with Fitek Flow.

Group 3: For using Scotch Bond Universal, only enamel etchant was applied with a syringe. After waiting for 15 seconds, the etchant was rinsed with water for 20 seconds. Afterwards, the cavity was gently dried using an air syringe. Adhesive was used with a microbrush followed by gentle air dispersion. Then, light curing was done for 10 seconds. Finally, the cavity was restored with Filtek Flow.

Group 4: For using Vertise Flow (according to manufacturer's instructions), an initial layer was dispensed on a forcefully dried surface; the surface was brushed 15-20s with moderate pressure and light cure for 20 s; additional material was syringed in increments <2mm and each increment was lighted cure for 20s. A light curing unit with an intensity of 1000 mW/cm2[12] determined by the radiometer was used to polymerize the resin for 20 seconds followed by polishing. The specimens were stored for 24 hours in distilled water. Thermocycling of 1000 cycles was carried out at 5°C to 55°C for 30-second dwell time and 5-second transfer time at low and high temperature chamber, respectively. After thermocycling, the apical 2 mm of teeth was sealed with a layer of sticky wax and every tooth surface was covered with two coats of nail varnish with the exception of 1 mm around the tooth/restoration interface. The teeth were then immersed in 0.5% basic fuchsin solution of dye for 24 hours.

A diamond disc was used to section each tooth longitudinally. Each restoration was observed under a binocular stereomicroscope (Dewinter, Itlay) with magnifying loop of ×40. For each restoration, the sectioned half with greater leakage was recorded for occlusal and gingival edges of each section on anon-parametric scale from 0 to 3 based on the ordinal ranking system.[13]

0: No dye penetration

1: Dye penetration from cavosurface margin of the tooth to less than half the length of the prepared wall

2: Dye penetration from cavosurface margin of the tooth to more than half the length of the prepared wall, but not involving the axial wall

3: Dye penetration from cavosurface margin of the tooth along the whole length of the prepared wall and also involving the axial wall (Figure 1).

Degree of penetration was scored to convert the ranking data into quantitative data. The data were analyzed using SPSS 23. Statistical analysis of data relating to occlusal and gingival surfaces was done by Mann-Whitney U test. Comparing the mean value of microleakage based on experimental groups was conducted using Kruskal-Wallis test. If Kruskal-Wallis was significant, multiple comparisons Mann-Whiney would be done. $P<0.05$ was considered significant.

Table1. Materials used in this study

Materials	Manufacturer	Lot number	General composition
Adper Single Bond2(two-step etch&rinse)	3M,ESPE,St Paul, MN, USA	N884586	Ethanol. Water. Bis-GMA. 5nm silane treated colloidal silica .2-hydroxyethylmethacrylate. glycerol 1, 3dimethacrylate.methacrylate functional copolymer of polyacrylic and poly itaconic acids and diurethane dimethacrylate
Clearfil SE Bond(two-step self-etch)	Kuraray, Tokyo, Japan	3N0388	Primer:N,N-diethanol-p-toluidine,10MDP,HEMA,hydrophilic dimethacrylate, DL-camphorquinone, water Bond: N,N-diethanol-p-toluidine,10-MDP,bis-GMA, HEMA, hydrophobic dimethacrylate, DL camphorquinone, silanated, colloid
Scotch Bond Universal	3M,ESPE,St Paul, MN, USA	661544	10-MDP phosphate monomer, dimethacrylate resins, HEMA, Vitrebond Copolymer, filler, ethanol, water, initiators, silane
Filtek Flow	3M,ESPE,St Paul, MN, USA	N900873	BIS-GMA,TEG-DMA, bis-EMA, Functionalized dimethacrylate polymer, silica and zirconia nanofiller
Vertise Flow	Kerr Corporation, Orange, CA, USA	G74G257	GPDM, HEMA, prepolymerized filler, 1-lm barium glass filler, nanosized colloidal silica, nanosized ytterbium fluoride
Phosphoric acid etchant	Pulpdent corporation, Watertown, MA, USA	170809	38% Phosphoric acid gel

Results

Table (2) indicates that more than 40% of the samples in each group have no microleakage in neither occlusal nor gingival surface. Microleakage of the samples based on Kruskal Wall test showed that there were significant differences between these four groups in both occlusal and gingival levels regarding microleakage ($p\leq0.05$). The image of different microleakage scores is represented in figure (1). Intragroup comparison showed the SE group had a significant difference with other groups, both in occlusal and gingival margins (Figure 2). Same small subscript letters represent no significant differences between every two groups in each surface ($p=0.05$)

Table 2. The mean score of microleakage based on the type of adhesive agent

Margins Groups	Occlusal Mean±SD	Median	No microleakage n(%)	Gingival Mean±SD	Median	No microleakage n (%)	P-value
Single Bond 2	1.40±548[a]	1.00	11(68.8%)	1.78±.833[a]	2.00	7(43.8%)	.16
Clearfil SE Bond	2.43±787[b]	3.00	9(56.3%)	2.83±.408[b]	3.00	10(62.5%)	.96
Scotch Bond Universal	1.20±447[a]	1.00	11(68.8%)	1.00±.000[a]	1.00	13(81.3%)	.51
Vertise Flow	1.29±488[a]	1.00	9(56.3%)	1.57±.535[a]	2.00	9(56.3%)	.81
P-Value	.022		.785	.007		.178	

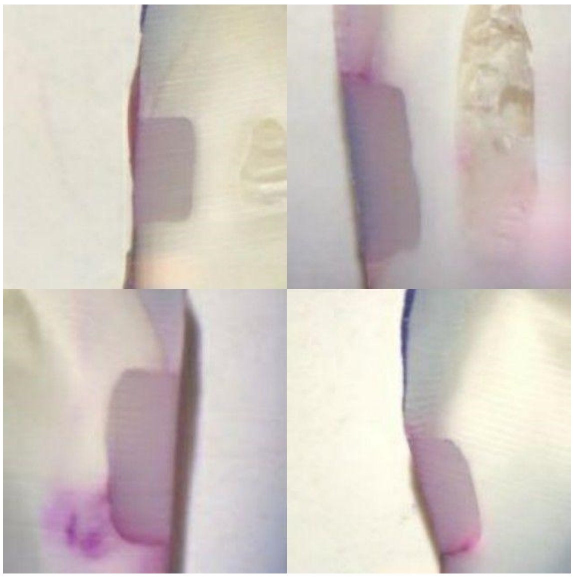

Figure1. Specimen with different leakage (Scores 0,1,2,3)

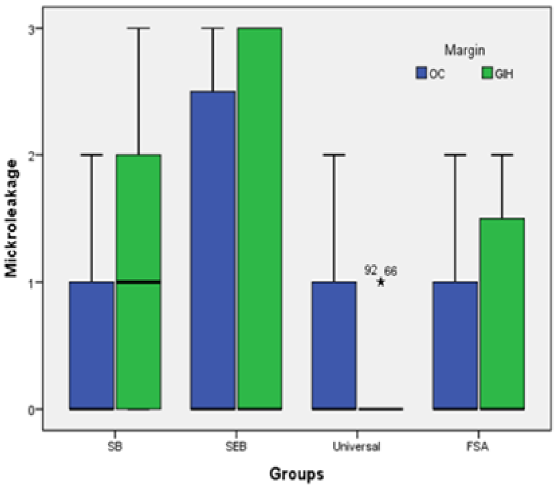

Figure2. Box plot of the four groups in two margins

Discussion

Based on the results, the lowest and highest rates of gingival microleakage belonged to Clearfil SE Bond and Scotch Bond Universal groups, respectively, while the occlusal microleakage was the same in three groups (Single Bond 2، Vertise Flow ،Scotch Bond Universal) (Table 2). The aim of the current study was to measure the microleakage of self-adhesive composite and compare it with a conventional flowable composite bonded with the above-mentioned bonding systems. The findings indicated that the microleakage of this material had no significant difference from Single Bond 2 and Universal Scotch Bond, which are in accordance with those of other studies. [7-9] However, Hosseinipour et al. [14] suggested that microleakage of conventional fissure sealant was less than that of self-adhesive fissure sealant and self-adhesive composite, regardless of saliva contamination. A possible reason explaining lower microleakage of self-adhesive composites is higher hygroscopic expansion of these materials and their relatively low polymerization shrinkage. Acidic resins exited in self-etch adhesives absorb more water than conventional resins, which results in greater hygroscopic expansion. [15, 16] Greater hygroscopic expansion compensates for the polymerization shrinkage and provides a better seal. [17] However, another explanation for this finding can be the unique polymerization/bonding process. During the restoration process through conventional flowable composites followed by bonding process, filling material was placed in cavity and light curing. As a result, polymerization stress of flowable composite may affect the bonding of adhesive material to tooth structure and cause debonding. Nevertheless, when using self-adhesive composite, bonding and filling processes occur simultaneously. Therefore, the interaction between bonding and polymerization stress is less. [18]

Scotch Bond Universal can be used in self-etch and etch-and-rinse modes. Based on manufacturer's claim, a high percentage of tested specimens illustrates the consistent margins in both self-etch and etch-and-rinse modes. However, selective enamel etching is offered by the manufacturer to enhance the bond to the enamel. The acidity of this adhesive is mild (PH=2.7) compared to phosphoric acid. Hence, phosphoric acid may be preferred for application on prepared or intact enamel .[19-21] Thus, in our study enamel was optionally etched with phosphoric acid before applying Universal adhesive. Motevaselian et al. in 2016 conducted a study to evaluate microleakage in three adhesive systems (Single Bond 2, Scotch Bond Universal, Clearfil SE Bond). Based on their results, the microleakage of dentin margin was the same in above mentioned. In addition, microleakage of Universal adhesive group was the same in self-etch and etch-and-rinse modes. [12] Further, a separate etching step is not clinically required to decrease microleakage. These results may be due to the specific compounds in this adhesive including 10-methacryloxydecyl dihydrogen phosphate (10-MDP), which can create a stable chemical bond and VitreBond copolymer, providing a bond to dry and wet dentin. The functional monomer 10-MDP forms a more stable bond with hydroxyapatite hydrolytically, which raises durability of the resin/tooth interface. [19,21, 22]

In the present study, the microleakage of Clearfil SE Bond group was highest, which disagreed with the results of other studies. [6, 12] In the Single Bond adhesive group, the gingival microleakage is more than that of occlusal. Nevertheless, the difference is not significant (Table2). The presence of higher organic content, tubular configuration, fluid pressure in dentine and its lower surface energy cause bonding to dentine relatively more difficult than enamel.[23,24] Another factor is great magnitude of polymerization shrinkage which cannot be compensated by water sorption and stress relaxation. [25] Organic component and amount of dentin moisture (overdry or overwet) may affect the bonding ability of etch-and-rinse bonding systems. Overdrying etched dentin prevents full coverage of collagen fibers by resin monomers hydrolytic destruction and reduces the bonding performance. [26] In addition, in overwet state, phase separation between the hydrophobic and hydrophilic ingredients of the bonding due to excess water forms a gap at the resin/dentin interface. [27] However, in clinical condition, it is difficult to determine the amount of moisture left in the dentine.

Conclusion

Based on the results of this in vitro study, Scotch Bond Universal had the lowest microleakage and Vertise Flow did not have a significant difference with it. Furthermore, in vivo studies are expected to clarify whether the sealing ability of Vertise Flow self-adhering flowable composite is clinically adequate.

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Conflict of interest: There was no conflict of interest.

Authors 'Contributions

The study was designed by Fariba Ezoji and Effat Khodadadi. The study data were collected by Maede Rahmanifard. Results were evaluated by Soraya Khafri.

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