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ORIGINAL RESEARCH ARTICLE

In-vitro bond strength of a flowable compomer to primary teeth dentin with different applying techniques

Bahar Zincir [1,*], Elif Şenay [1], Ece Öztoprak [1] and Levent Özer [1]

[1]Department of Pedodontics, Faculty of Dentistry, Ankara University, Ankara, Turkey

[*]Corresponding Author; bahar_zincir@hotmail.com

Abstract

Purpose: The study aimed to investigate the effect of applying flowable compomer using different techniques and long-term water storage on microtensile bond strength (µTBS) to primary teeth dentin and present a comparison with packable compomer.
Materials and methods: 90 primary molars were used to evaluate the µTBS of the materials. Specimens were randomly divided into 3 main groups for restoration: Group 1 and 4, compomer (Glasiosite, VOCO GmbH, Cuxhaven, Germany) filling alone; Group 2 and 5, flowable compomer (Twinky Star Flow, VOCO GmbH, Cuxhaven, Germany) lining/pre-cured and overlaying compomer; and Group 3 and 6, flowable compomer lining/co-cured with overlaying compomer. All specimens were thermocycled (500X), after which half of them (n=45) were stored in distilled water for 24 h (Group A: Groups 1-3), and the remaining half (n=45) for 24 months (Group B: Groups 4-6). Samples were tested for µTBS (1 mm/min) with a microtensile testing machine (T 61010 Ki, Bisco, Schaumburg, USA). Failure modes were determined with the aid of a stereomicroscope. Results were analyzed using the Kruskal-Wallis H test.
Results: There was no statistically significant difference between the groups regarding bond strength (p>0.05). Mixed cohesive failure of both adhesive and dentin was the most common type of failure in all groups (p<0.05). 2-year water storage significantly decreased the bond strength for all groups (p<0.05).
Conclusion: Flowable compomers applied using different techniques produced similar bond strength to dentin compared to compomer. However, long-term water storage decreased bond strength significantly.

Key words: Flowable compomer; Micro-tensile bond strength; Primary teeth

Introduction

Researchers are striving to find varied restorative materials which can be applied quickly, maintain healthy tooth structure and more adhesion to tooth structure in pediatric dentistry as well as in restorative dentistry. The use of tooth-colored restorative materials, together with adhesive systems, is often preferred as it allows for minimal cavity preparation in the restoration of the primary teeth. [1–3] A good prognosis requires a strong adhesion between resin materials and dental hard tissues. [4,5] Flowable composites and compomers have become popular for the restoration of primary teeth with their low viscosity, good aesthetic properties, good marginal sealing and bond strength to dentine. [6–10] However, long-term success results are missing for routine clinical use. In order to improve marginal sealing and maintain stronger bond strength between dental tissues and restorative materials, different incremental techniques, curing techniques, and liner materials have been designed besides the introduction of new materials. [11–13] There are two different curing techniques termed as 'pre-cured' and 'co-cured' with using flowable resin materials. The application of the packable composite on top of the cured flowable composite is defined as 'pre-cured'. Pre-cured technique both reduces the amount of uncured composites and polymerization shrinkage and related stress above the cavity. [14] The "modified incremental layering technique" is the application of a thin layer of flowable composite to the cavity followed by the application of a packable composite. In this technique, called 'co-cured', two different materials are light cured simultaneously. While the excess flowable composite overflows, their volume can be minimized by placing the packable composite. It benefits from the advantages of using two different composites, such as the adaptation of the filling and improved handling properties. [15,16] The aim of this study was to examine the impact of varied applying techniques including modified incremental layering technique and long-term water storage on the microtensile bond strength (µTBS) of a flowable compomer in juxtaposition to a compomer used in primary teeth.

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Material and Methods

This study used caries-free extracted primary second molar teeth. Ethical approval was received from the Institutional Review Board of Ankara University, Faculty of Dentistry (No: B.30.2.ANK.0.21.63.00/824-02/9-8/150). Participants and their parents gave their informed consents. To determine the differences between the study groups, power calculation indicated that a minimum of 15 teeth in each group were required based on an effect size of 0.5, an alpha significance level of 5% (0.05), and a beta significance level of 20% (0.20) to achieve an 80% power. Therefore, 90 caries-free, freshly extracted human primary molars were used in this study. After teeth were completely cleansed, they were kept in distilled water for up to 1 month at room temperature before they were used. To expose a flat dentin surface, a slow speed diamond saw with water spray was used to cut occlusal surfaces of all teeth. A smear layer was created by abrading surfaces for 1 min using wet 600 grit silicon carbide paper. For restoration, specimens were cleansed and dried before being randomly allocated into six equal groups: Group 1 and 4: Compomer (Glasiosite, VOCO GmbH, Cuxhaven, Germany) filling alone, Group 2 and 5: Flowable compomer (Twinky Star Flow, VOCO GmbH, Cuxhaven, Germany) lining/pre-cured and overlaying compomer, Group 3 and 6: Flowable compomer lining/co-cured with overlaying compomer, The restorations were placed by a single operator. For each group the cavities were etched with 35% phosphoric acid, water rinsed for 20 seconds and air blasted to remove excess water. Bonding agent were applied to the whole cavity surface, and light-cured for 20 seconds using a light source at a power of 1,500 mW/cm2 LED (Light Emitting Diode, Radii plus, SDI, Australia). according to the manufacturer's instructions. For group 1 and 4 the cavities were restored with Compomer (Glasiosite, VOCO GmbH, Cuxhaven, Germany) using the horizontal incremental technique, with each increment about 2.0-mm thick. Each increment of compomer was light cured for 20 seconds. For group 2 and 5 first the flowable compomer (Twinky Star Flow, VOCO GmbH, Cuxhaven, Germany) was injected onto the floor of the cavity to a thickness of 0.5 to 1.0 mm. The thickness of the flowable composite was controlled, referring to the original cavity depth, then light-cured for 20 seconds according to the manufacturer's instructions. After curing flowable compomer rest of the cavity were restored with Compomer (Glasiosite, VOCO GmbH, Cuxhaven, Germany) using the horizontal incremental technique, with each increment about 2.0-mm thick. Each increment of compomer was light cured for 20 seconds.[12] For group 3 and 6 the flowable compomer (Twinky Star Flow, VOCO GmbH, Cuxhaven, Germany) was injected onto the floor of the cavity to a thickness of 0.5 to 1.0 mm. The thickness of the flowable composite was controlled, referring to the original cavity depth. Immediately following the flowable compomer lining, the first Compomer (Glasiosite, VOCO GmbH, Cuxhaven, Germany) increment, 2-mm thickness, was inserted and packed to expel flowable composite material. The expelled flowable compomer was carefully cleaned with a microbrush. This two-component layer was co-cured (light cured simultaneously) for 20 seconds. The remaining cavity was incrementally filled with compomer and each increment light-cured for 20 seconds.[12]

All specimens were thermocycled (500X), after which half of them (n=45) were stored in distilled water for 24 h (Group A consisting of Groups 1-3), and the remaining half (n=45) for 24 months (Group B consisting of Groups 4-6). After the aging protocols, specimens were planted upright in autopolymerising acrylic resin blocks and then a precision tooth cutting tool was used to create microbars of approximately 1x1 mm. For surface defect examination, microbars were placed under a stereomicroscope, and from each group, 15 sound specimens were randomly selected to test bond strength. However, in Group B, sound specimens of 15 in each group could not be achieved. Bonded surface area of specimens were calculated using a micrometer. The specimens were tested for μTBS (1 mm/min) using a microtensile testing machine (T-61010Ki, Bisco, Schaumburg, USA).[17] Cyanoacrylate adhesive (Zapit; Dental Ventures of America, Corona, CA, USA) was used to affix the bars to the flat grips of the microtensile testing machine and at a crosshead speed of 1 mm/min, they underwent tensile force until they fail. Failure tensile force was recorded in newtons (N) followed by conversion to tensile stress in megapascals (MPa). A stereomicroscope was used to examine fracture surfaces at X2 and X10 magnification, and failure modes were registered as follows[17]: (i) Type 1: cohesive failure within the adhesive (ii) Type 2: adhesive failure at the dentin interface (iii) Type 3: mixed cohesive failure of both adhesive and dentin (iv) Type 4: cohesive failure within the dentin. The Kruskal-Wallis H test was used to analyze the results. The significance value was determined as $p<0.05$.

Results

Fracture types of all groups were given in Table 1 and fracture forces were given in Table 2. In Group A; compomer (Group 1) showed a bond strength of 15.3±8.5 MPa; the pre-cured flowable compomer (Group 2) showed 10.6±9.3 MPa and the co-cured flowable compomer (Group 3) showed a bond strength of 14.5±10.8 MPa. There was no significant difference between the groups ($p>0.05$). The most common type of fracture in the subgroups of Group A was a mixed type fracture involving both the dentin and the adhesive surface (73.3% in Groups 1 and 3; 53.3% in Group 2).

In Group B; μTBS values were measured as 7.3±2.6 MPa for Group 4 (compomer), 6.6±2.9 MPa for Group 5 (pre-cured flowable compomer) and 6.0±3.3 MPa for Group 6 (co-cured flowable compomer). No statistically significant difference was found between the groups ($p>0.05$). It was determined that the bond strength of the samples, which were stored in distilled water for 2 years, decreased significantly in all groups ($p<0.05$). Mixed fracture was the most common fracture type in this group (55.6% in Group 4; 53.8% in Group 6). In the pre-cured flowable compomer group (Group 5), which was aged for 2 years, adhesive type fractures were mostly observed (57.1%). No statistically significant difference was found between the groups in terms of fracture type ($p>0.05$).

Discussion

In recent years, different materials and curing techniques have been used in primary tooth restorations in order to reduce polymerization shrinkage and provide better coverage of the restorative material. Evaluation of the bond strength between restorative material and dental tissues has also become an important determinant in primary tooth restorations because optimal bonding is required not only mechanically but also biologically and aesthetically. Durable bonding is expected to reduce microleakage of restorative material and indirectly prevent marginal discoloration, pulp inflammation and secondary caries formation.[18–20] In a previous study, different methods have been tried to reduce marginal microleakage and related problems in class II cavities. One of these methods is the use of flowable composites with packable composites using the pre-cured technique, compared to composite resins applied with the incremental technique. As a result, pre-cured technique was found to be more successful.[21] Authors revealed that flowable composite used by injecting through the syringe flows into the cavity, thus reducing the possibility of remaining gaps in the cavity.[19] Also the flowable composite has lower Young's modulus and therefore during polymerization shrinkage the flowable composite acts as a more flexible intermediate layer and reduces stress.[22,23] Another reason for good success of flowable composite can be attributed to similar thermal properties it shows to tooth tissue due to less filler content. That is, the flowable composite and the tooth tissue show similar contraction and expansion in temperature changes. This indicates that the marginal adaptation of the flowable composite is better than other packable composites.[17,24] In another study, where light-curing glass ionomer cements and composite

Table 1. Fracture types of all groups

Fracture Type	Groups													
	Group 1		Group 2		Group 3		Group 4		Group 5		Group 6		Total	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Type 1	1	6,7	0	0,0	0	0,0	0	0,0	0	0,0	0	0,0	1	1,4
Type 2	3	20,0	7	46,7	3	20,0	4	44,4	4	57,1	6	46,2	27	36,5
Type 3	11	73,3	8	53,3	11	73,3	5	55,6	3	42,9	7	53,8	45	60,8
Type 4	0	0,0	0	0,0	1	6,7	0	0,0	0	0,0	0	0,0	1	1,4
Total	15	100,0	15	100,0	15	100,0	9	100,0	7	100,0	13	100,0	74	100,0

Table 2. Groups according to the fracture force

	Fracture Force						Kruskall-Wallis H Test			
	n	Mean	Median	Minimum	Maximum	ss	Average Rank	H	p	Dual Comparison
Group 1	15	15,3	13,6	4,8	37,2	8,5	51,8			1-4
Group 2	15	10,6	7,3	0,7	34,8	9,3	35,2			1-5
Group 3	15	14,5	12,3	2,3	33,8	10,8	44,4			1-6
Group 4	9	7,3	7,6	4,2	12,6	2,6	32,8			2-4
Group 5	7	6,6	7,3	3,0	10,2	2,9	28,1			2-5 2-6
Group 6	13	6,0	5,2	2,3	14,1	3,3	23,9			3-4 3-5
Total	74	10,8	7,7	0,7	37,2	8,4		15,3	0,009	3-6

resin were applied with co-cured technique, it was observed that polymerization shrinkage and thus microleakage were reduced.[17] Yazıcı et al. compared flowable composite and hybrid composite by applying with the pre-cured and co-cured technique, and more microleakage was observed in the co-cured technique.[23] As a result of that study, although the most leakage was on the dentin surface, it was thought that this situation was due to the weakening of the connection on the enamel surface. According to the researchers, the reason for this evidence is that the shrinkage in the resin composite produces shrinkage forces from the cavity walls that can disrupt the bond of the uncured flowable composite. They also noted that due to the adhesive nature of many composites, the uncured flowable composite may have a tendency to retract from the cavity wall when removing the tools used for placement.[17] Although there have been studies in the literature in which composite and flowable composites with different curing techniques were used in permanent teeth; there is no study investigating the effects of different curing techniques (pre-cured and co-cured) when used with compomer and flowable compomer in primary teeth. Results of this study showed that microtensile bond strength of different applying techniques of flowable compomers did not show any statistically significant difference, although the co-cured technique revealed the least fracture force. The reason may be attributed to the gap between dentin tissue and restorative materials as a result of syringe delivery system of the flowable compomer and the condensation of the packable compomer with co-cured technique, as stated in previous studies. One of the most commonly used ways to measure the bond strength of a restorative material in in-vitro conditions is the microtensile bond strength test. The present study used the microtensile test to compare flowable and packable compomers applied by using pre-cured and co-cured techniques. As microtensile test uses specimens with cross-sectional areas of reduced size, more uniform interfacial stress distribution is provided.[17,25–27] When the microtensile bond strength test and shear bond strength test were compared, the researchers have specified that in the shear test there was significantly more failures in dentin and in the restoration.[26] Therefore, the results obtained from the microtensile test method are quite acceptable as it is thought to better reflect the dentin interfacial bond strengths.[26] It was observed that the bonding has weakened in all groups in the samples kept in water for 24 months. Materials plasticize when stored in water and a degrading effect on tooth-resin bonds.[26,28,29] Thus, the effects the aging has on the durability and quality of the tooth-restoration interface can be accurately detected. One possible way to investigate the nature of this process is the measurement of bond strength, and similar to this study, several studies – most of which were carried out on dentin surfaces – have investigated bond strength changes over extended water storage. These studies, similar to the results of the study at hand, have shown a dramatic reduction in the dentin bond strength after long-term water storage.[30,31] The fact that mixed type fractures were seen mostly in the samples with both 24 hours and 24 months water storage shows that the flowable and packable compomer provide a well bonding with the primary teeth and that the flowable compomer can be applied through different curing techniques in primary teeth. The easy application of flowable compomer is advantageous compared to the packable compomer in cases where there are problems with edge alignment, such as class 2 cavity restorations.

Conclusion

In vitro studies have some limitations. However, the following inferences can be made within the content of our study:

- It was observed that the bond strength of the co-cured technique was higher than the pre-cured technique in samples stored in distilled water for 24 hours. However, the bond strength of the pre-cured technique was found to be better than the co-cured technique in samples stored in distilled water for 24 months, although the results were not statistically different.
- It was observed that the bond strength in the compomer applied groups was higher than the other groups for the samples stored in distilled water for both 24 hours and 24 months.
- Tensile bond strengths decreased significantly in samples that were stored in distilled water for 24 months.
- The flowable and packable compomer offer a well bonding with the primary teeth and that the flowable compomer can be applied with different curing techniques in primary teeth.

Author Contributions

B.Z. and L.Ö conceived the ideas; B.Z., E.Ş and E.Ö collected and analyzed the data; B.Z., E.Ş., E.Ö and L.Ö. led the writing.

Conflict of Interest

Authors declare that they have no conflict of interest.

Authors' ORCID(s)

B.Z. 0000-0002-5284-696X
E.S. 0000-0002-9150-4997
E.Ö. 0000-0001-9951-5140
L.Ö. 0000-0001-6820-9052

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