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Evaluation of marginal leakage of self-adhesive flowable composite on anterior primary teeth: In vitro study

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Objectives: This study aims to evaluate the bonding of self-adhesive flowable composite in comparison with traditional flowable composite with a fifth-generation total-etch bonding system in primary anterior teeth, by studying microleakage after application of these materials in-vitro.

Materials and Methods: The study sample consisted of 32 extracted primary canine teeth. The sample was divided into two equal groups (n=16) according to the type of restoration applied: (Group 1): Traditional flowable composite resin was applied with a fifth-generation total-etch bonding system, (Group 2): Self-adhesive flowable composite resin was applied alone. A class v cavity was prepared on the facial/lingual surface at the cemento-enamel junction, with 1.5 mm depth, 2 mm height, and 3 mm width. In this way, the incisal wall of the cavity is above the cemento-enamel junction within the enamel, while the gingival wall is below the cemento-enamel junction within the dentin or cementum.

The restorations were applied according to the group the tooth belongs to, after that all teeth were subjected to 500 thermocycling. then, a methylene blue dye microleakage test was performed, and longitudinal sections of the teeth were made and studied under the microscope.

Results: In the incisal wall, the scores of microleakage in the traditional flowable composite group was lower than the self-adhesive flowable composite group. While in the gingival wall, the scores of microleakage was similar in both groups of traditional flowable composite and self-adhesive flowable

composite, with no statistically significant differences.

Conclusions: within the limitations of this study, the bonding of the self-adhesive flowable composite resin is similar to the bonding of conventional flowable composite resin using the fifth generation bonding system.

Keywords: self-adhesive composite resin, total_etch, self-etch, microleakage

تقييم التسرب الحفافي للكومبوزيت السيال ذاتي الإلصاق على الأسنان الأمامية المؤقتة: دراسة مخبرية

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الملخص:

هدف البحث: تهدف هذه الدراسة لتقييم ارتباط الكومبوزيت السيال ذاتي الإلصاق بالمقارنة مع الكومبوزيت السيال التقليدي مع نظام رابط كامل التخريش من الجيل الخامس بالأسنان الأمامية المؤقتة مخبرياً وذلك من خلال دراسة التسرب الحفافي بعد تطبيق هذه المواد.

المواد والطرائق: تألفت عينة البحث من 32 ناباً مؤقتاً مقلوعاً، قسمت العينة إلى مجموعتين متساويتين **(n=16)** وفقاً لنوع الترميم الراتنج المركب ذاتي الإلصاق لوحده دون تطبيق أي نظام رابط. حضرت حفر صنف خامس على السطح الدهليزي/اللساني عند الملتقى الميناوي الملاطي بعمق 1.5 مم وارتفاع 2 مم وعرض 3 مم، وبهذا الشكل يكون الجدار القاطعي للحفرة فوق الملتقى الميناوي الملاطي ضمن الميناء بينما يكون الجدار اللثوي يكون تحت الملتقى الميناوي الملاطي ضمن العاج أو الملاط، لم يتم إجراء أي شطب لجدران التحضير. طبقت الترميمات حسب امجموعة التي ينتمي إليها، ومن ثم خضعت الأسنان ل 500 دورة حرارية. بعد ذلك أجري اختبار التسرب الحفافي لصباغ أزرق الميثلين وتم عمل مقاطع طولية للأسنان ودراستها تحت مكبرة ضوئية.

النتائج: في الجدار القاطعي كانت درجة التسرب الحفافي في مجموعة الكومبوزيت السيال التقليدي أقل من مجموعة الكومبوزيت السيال ذاتي الإلصاق. في الجدار اللثوي تشابهت نسبة التسرب الحفافي في كل من مجموعتي الكومبوزيت السيال التقليدي والكومبوزيت السيال ذاتي الإلصاق لوحده مع عدم وجود فروق دالة إحصائياً.

الاستنتاج: إن ارتباط الراتنج المركب ذاتي الإلصاق مشابه لارتباط الراتنج المركب السيال التقليدي باستعمال المادة الرابطة من الجيل الخامس.

الكلمات المفتاحية: الراتنج المركب ذاتي الإلصاق، التخريش الكامل، التخريش الذاتي، التسرب الحفافي.

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Introduction

Enhancing the bond between dental structures and restorative materials is crucial to preventing micro leakage and the durability of the restoration. Extensive research efforts have been made over the past two decades that have focused on the structure of dentin and the precise physical and mechanical aspects of the bonding mechanism [1].

The durability of restorations on primary teeth is very low, and breakage or complete loss of the restoration is the main reason for replacing restorations on primary teeth. Therefore, there is ongoing research to this day to develop restorative materials to manage caries in primary teeth [2].

The current focus is on developing bonding materials whose main goal is to reduce the sensitivity of this technology and make it less complicated. Within a very short period of time, one-Pack bonding agent and self-etch bonding systems have become very popular (All-in-One-Step Bonding Systems) [3].

Surface treatment with self-etch bonding systems maintains the smear layer compared to a total-etch bonding system. Recently a new bonding system has been invented that combines the composite resin and the bonding system into one product called Self-adhering flowable composite This eliminates the need to separate the bonding materials application step from the composite resin application step [3].

There are limited studies that have evaluated the effectiveness of the adhesion of self-adhesive resin materials to primary teeth.

The idea of this study came about because restoring anterior primary teeth constitutes an important challenge for the dentist due to the limited cooperation of children and the ability to keep the mouth open during the treatment period. The application of the restoration material in one-step reduces treatment time, significantly reduces the sensitivity of the technique and reduces the need for patient cooperation.

The aim of study

To evaluate the marginal leakage of self- adhesive flowable composite resin without applying a bonding system in comparison with the use of traditional flowable composite resin with the application of a fifth generation bonding system in class V restorations on primary anterior teeth.

Materials and Methods

Study Design

A laboratory study to evaluate marginal leakage in restorations using self- adhesive flowable composite resin, and to compare self-adhesive resin materials with conventional fifth generation bonding systems.

Description of the sample

The sample size was calculated using the G Power 3-0-10 program, adopting a significance level of α = 5% and a confidence level of CI = 95%. The research sample included 32 primary canine teeth extracted for orthodontic reasons or due to the close date of their instinctive loss (upper or lower). They were randomly divided into two groups:

The first group: traditional flowable composite resin with the fifth generation bonding system (total-etch bonding system).

The second group: the self-adhesive flowable composite resin alone without the use of any Dentin bonding agent or surface conditioner.

Randomization

Extracted teeth were given a number from 1 to 32 and were randomly distributed to the studied groups using the website (https://www.randomizer.org).

Inclusion criteria

1. Extracted upper or lower primary canines.
2. Tooth crowns to be intact and free of caries or mild caries of class v.
3. Tooth crowns to be free of developmental defects at the site of the restoration.
4. Teeth to be free of any fractures or visible cracks.
5. At least one-third of the root must be present.

Exclusion criteria

1. Deteriorated teeth.
2. Teeth with developmental defects.
3. Teeth with visible fractures or cracks.

Methods of the study

Collect the sample and place it in preservation media After ensuring that the samples conform to the inclusion criteria, several steps were followed to sterilize and preserve the teeth, where the soft tissues were removed and the tooth was washed directly with running water after extraction, then the teeth were stored in tightly sealed containers containing liquid chloramine T (0.5). %) for one week in order to sterilize it, then it was transferred to plastic containers containing distilled water, which was replaced weekly, and stored at a temperature of 4-5 degrees Celsius until it was time to use it.

Preparation of dental cavity

Class V cavity were prepared on the facial/lingual surface at the cemento- enamel junction using a hard diamond bur under water and air cooling on a high- speed handpiece with a depth of 1.5 mm, a height of 2 mm and a width of 3 mm. In this way, the incisal wall of the cavity is above the cemento-enamel junction with in enamel While the gingival wall below the cemento-enamel junction within the dentin or cementum [4].

Tooth restoration

First group

The cavity walls were etched using 37% phosphoric acid, where the phosphoric acid was applied to the enamel edges first, then the rest of the cavity, so that the time for etching the enamel was 30 seconds and the time for etching the dentin was 15 seconds, then the acid etch was washed for 15 seconds with a heavy stream of water. Then the bonding material was applied to the surfaces of the cavity using a plastic holder with a sponge tip, and it cured for 10 seconds. The tooth was later restored using traditional flowable composite resin in two layers to avoid Polymerization shrinkage, followed by cured for 20 seconds.

Second group

The self-adhesive flowable composite resin was applied directly into the prepared cavity without applying the conditioner or Dentin bonding agent according to the manufacturer's instructions. A small amount of the self- adhesive flowable composite resin was placed in the cavity using the tip attached to the package, and this thin layer (which does not exceed 0.5 mm) brush on the walls of the prepared cavity for 15-20 seconds and then cured for 20 seconds. Then the entire cavity was filled with a second layer of self-adhesive flowable composite resin and cured [5].

The restorations were finished using diamond finishing burs, then polished using rubber tips and cones of varying roughness. After completing the restorations, the samples were stored in distilled water at room temperature for 24 hours, followed by thermal cycling.

Marginal leakage test

The teeth after their restoration were subjected to 500 thermal cycles at a temperature between (5±1ºC) and (55±1ºC). Each thermal cycle lasts 80 seconds, and includes 30 seconds at 5ºC, 30 seconds at 55ºC, and 20 seconds at Room temperature 24ºC, then the teeth were returned to distilled water until the marginal leakage test was performed. The apices of the teeth were sealed using sticky wax, then each tooth was painted using two layers of nail polish, excluding the composite resin restoration and a distance of 1 mm of tooth material surrounding the restoration, as in Figure 1. After the polish dried, the teeth of each group were placed in a container containing a Methylene blue solution 1% for 4 hours. The teeth were washed with running water after the required time had passed to remove the remnants of the colored solution, then dried in preparation for studying the microleakage test. Then, lingual facial sections of the teeth were conducted parallel to the longitudinal axis of the tooth and passing through the middle of the restoration. The sections were examined using an microscope under 40X magnification, and then a picture of each restoration was taken individually as in Figure 2 and Figure 3. Then the images of the sections were numbered without indicating the restoration group to which each section belonged, in order to blind the evaluator to the type of restorative material used and to prevent bias in evaluating the degrees of leakage in favor of any group. The degrees of marginal leakage on both the incisal and gingival wall were evaluated on each Severity. The evaluation of the results was based on a categorical scale consisting of 5 grades, ranging from (0-4) in evaluating the marginal leakage for each tooth, as in Table 1.

Fig 1. Sealing the tooth apices with sticky wax and painting the tooth with nail polish.

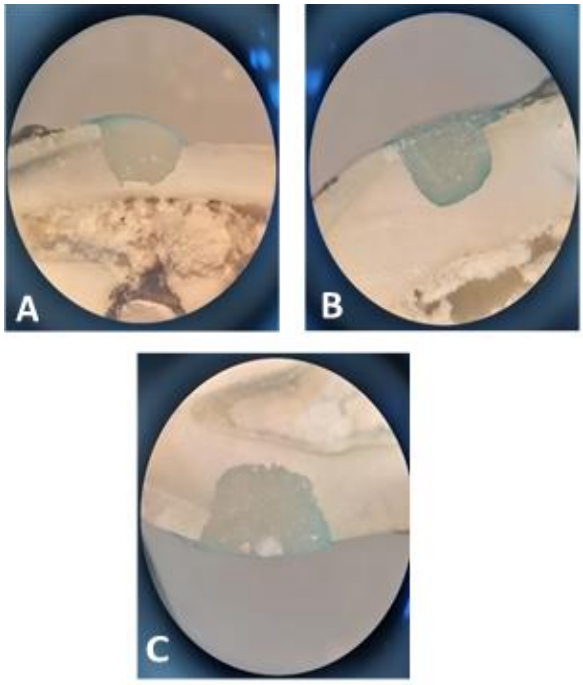

Fig. 2 (A, B, C) Magnified images of the restorations after performing longitudinal sections. These images belong to the first group: traditional flowable composite**.**

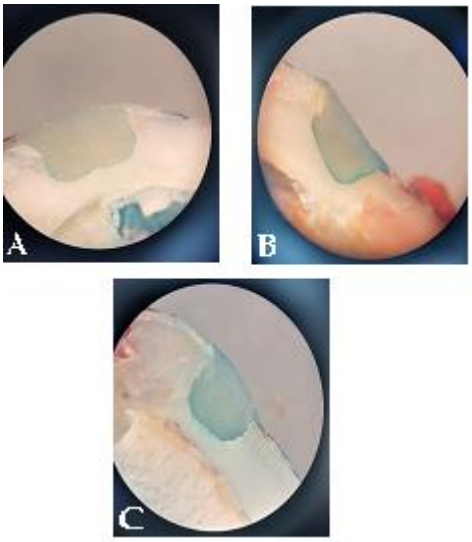

Fig 3. (A, B, C) Magnified images of the restorations after performing longitudinal sections. These images belong to the second group: self-adhesive flowable composite alone.

Table 1. Indicates the scale used in assessing marginal leakage.

Marginal leakage degree	0	1	2	3	4
Incisal wall	No marginal leakage	Marginal leakage reaches the cemen to enamel junction.	Marginal leakage that extends beyond the cemen to enamel junction without reaching the axial wall.	Marginal leakage reaching the axial wall	Marginal leakage penetrates the dentin and reaches the tooth pulp.
the gingival wall	No marginal leakage	Marginal leakage less than half the distance of the axial wall	Marginal leakage extending more than halfway to the axial wall without reaching the axial wall.	Marginal leakage reaching the axial wall	Marginal leakage penetrates the dentin and reaches the tooth pulp.

Results

The study sample consisted of 32 primary canines extracted for orthodontic reasons, divided into two equal samples of 16 canines each (traditional flowable composite resin, self-adhesive flowable composite resin). The research sample was distributed according to the groups studied and according to the rate of marginal leakage in the tooth in general and in each tooth. From the incisal and gingival wall as shown in Table 2, Table 3, and Table 4.

The Mann Whitney U test was conducted to study the significance of differences between groups, as it shows the following:

As for the degree of leakage in the incisal wall, we note that the value of the (Sig = 0.151) is greater than the value of ($\alpha = 0.05$), that is, at the level of confidence 95% there are no statistically significant differences in the degree of leakage in the incisal wall in the sample. As for the degree of leakage in the gingival wall, we note that the value of the (Sig = 0.827) is greater than the value of ($\alpha = 0.05$), that is, at the level of confidence 95% there are no statistically significant differences in the degree of leakage in the gingival wall in the sample. As for the degree of leakage in general, we notice that the value of the (Sig = 1) is greater than the value of ($\alpha = 0.05$), that is, at the level of confidence 95% there are no bilateral differences with statistically significant in the degree of leakage in general in the sample.

The type of composite resin applied was studied in terms of the frequency of the degree of marginal leakage and the presence of marginal leakage, and the effect of the measurement site on the frequency of marginal leakage in the research sample. The results of the analysis were as follows:

The percentage of marginal leakage on the incisal wall in the groups was (0%) in the first group and (12). %) in the second group. The percentage of marginal leakage on the gingival wall was (69%) in both the first and second group. The percentage of marginal leakage in the tooth in general was (69%) in both the first and second groups. With no significant bilateral differences Statistics.

Table 2. Indicates the distribution of the sample according to the variable of the presence of marginal leakage according to the study groups.

Group	General presence of leakage	Repetitions	Percentages
Control group, traditional flowable composite resin with 5th generation bonding system (total-etch bonding system).	Yes	11	69%
	No	5	31%
Self-adhesive composite resin without the use of any adhesive or surface conditioner.	Yes	11	69%
	No	5	31%

Table 3. Indicates the distribution of the sample according to the variable of marginal leakage degree on the incisal wall.

Group	No marginal leakage	Marginal leakage reaches the cemento- enamel junction.	Marginal leakage that extends beyond the cemento- enamel junction without reaching the axial wall.	Marginal leakage reaching the axial wall	Marginal leakage penetrates the dentin and reaches the tooth pulp.	Total
Control group, traditional flowable composite resin with 5th generation bonding system (total-etch bonding system).	16	0	0	0	0	16
	100%	0%	0%	0%	0%	100%
Self-adhesive composite resin without the use of any adhesive or surface conditioner.	14	1	1	0	0	16
	88%	6%	6%	0	0	100%

Table 4. Indicates the distribution of the sample according to the variable of the degree of marginal leakage on the gingival wall.

Group	No marginal leakage	Marginal leakage less than half the distance of the axial wall	Marginal leakage extending more than halfway to the axial wall without reaching the axial wall.	Marginal leakage reaching the axial wall	Marginal leakage penetrates the dentin and reaches the tooth pulp.	Total
Control group, traditional flowable composite resin with 5th generation bonding system (total-etch bonding system).	5	2	2	6	1	16
	31%	12.5%	12.5%	37.5%	6%	100%
Self-adhesive composite resin without the use of any adhesive or surface conditioner.	5	3	1	7	0	16
	31%	19%	6%	44%	0	100%

Discussion

The marginal seal is an important factor in increasing the Permanence of composite restorations, despite the many studies that measure the arrest leakage of the traditional composite resin restorations, but a few studies that dealt with the bonding of self -adhesive composite in primary teeth. Pedodontist often face clinical difficulties related to behavioral problems for young patients, which requires choosing a restoration material that is applied in the least possible time and shortening the procedure if possible [7].

In the current study, a newly developed material was tested, which is the Nova Compo SF, which is a flowable composite resin with bonding properties that do not require any application of the bonding system, and thus restoration is made with one step, which shortens the time of processing [5].

In this study, previous studies were relied on similar to primary teeth, and the preparation dimensions applied in them, as the class v cavity was prepared similar to the shape and dimensions and the location as much as possible in order to unify the criteria, so the cavity attended at the cemento-enamel junction at a depth of 1.5 mm and a height of 2 mm and a width of 3 mm. In this way, the incisal wall of the cavity is above the cemento-enamel junction within the enamel, while the gingival wall below the cemento-enamel junction within the dentin or cementum to test the difference in the marginal leakage, if any, between the enamel and dentin [4]. The manufacturer of the Self Adhesive flowable composite recommends with some steps that the doctor must take in the clinical application, unlike the traditional system, the Self Adhesive flowable composite does not need to apply a adhesive material. For this reason, in order to properly deal with the material, a suitable contact between the restored material and the tooth must be achieved by starting a thin layer not exceeding 0.5 mm and doing brushes using a precise brush for 15-20 seconds [5]. In the current study, the composite resin in both the two types of resin was applied on layers to reduce the Polimerization shrinkage, as the second layer compensates for the shrinkage and the deficiency of the previous layer, and thus the Polimerization shrinkage is limited to the surface layer of restoration [5]. Evaluation of the microleakage can be performed through clinical and laboratory studies. However, it is preferable to conduct laboratory studies due to the easy of practical application. Marginal leakage can be evaluated in the laboratory using many methods, including: dye, chemical detectors, radioactive isotopes, air pressure, bacteria, neutron activation analysis, scanner electronic microscope, artificial decay, electrical connection. The dye penetration technique is one of the oldest and most common technologies. This technique is used because the gaps that allow the passage of bacteria are relatively large (0.05 Micrometer), but toxins and bacterial products sometimes pass from smaller gaps, so the ability of the dye to penetrate exceeds the ability of bacteria. However, the smaller size of some dye molecules compared to the pathogenic factors is a defect in this method. Several dye is used to study the marginal leakage, including: 0.2% Rhodamine, methylene blue 1%, silver nitrate 50%, fushene red 0.5%. It is preferable to use methylene blue because of: its high ability to penetrate, the small size of its molecules, low cost, and easy of use [4]. Therefore, the Methylin Blue Dye penetration Methods were used at a concentration of 1% to investigate the amount of marginal leakage. The results of the marginal leakage were read on both the incisal and gingival walls, after photographing the sample teeth under 40x enlargement. Because of the differences in the thermal expansion factor of the dental structures and the Restorative materials, the thermal changes in the oral cavity cause varying degrees of expansion and contraction for both dental structures and restoration, which leads to the formation of a gap between the tooth and the restoration that causes the marginal leakage at a later time, the thermal cycles are made to simulate the clinical reality within Oral cavity [4]. In the current study, 500 thermal cycle were conducted as in similar studies. By studying the values of the marginal leakage, we note the superiority of the traditional flowable composite in terms of the bonding on the incisal wall, while the rates of marginal leakage in general and the marginal leakage on the gingival wall in both groups are similar with the lack of statistically significant differences. These results can be explained by the following: The similar marginal leakage rates between the traditional flowable composite group, the self -adhesive flowable composite, on the gingival wall: These results can be explained because the self - adhesive flowable composite resin is subject to an expansion when exposed to moisture and this contributes to improving its ability to marginal sealing as a result of compensation for the Polymerization shrinkage

during the application Restoration [8, 9]. The bonding of the traditional flowable composite resin with the fifth generation bonding system over the in the incisal wall with the marginal leakage rates of the gingival wall compared to the self -adhesive composite resin: this result may be due to the use of the etching step with phosphoric acid separately from the applying of the bonding system, This step can improve the penetration of bonding materials and resin in the enamel, on the contrary, the use of etching with phosphoric acid is excessive to remove minerals with dentin and the subsequent collapse of the collagen network fibers [10]. The results of this study agreed with a study by Yuan et al in 2015, which showed the absence of a statistically significant difference between the traditional bonding system with two steps and the bonding system with one step and the self-adhesive composite resin in the values of the marginal leakage in both the incisal and gingival walls, and also showed that the marginal leakage on The gingival wall was significantly higher than the incisal wall in the total-etch bonding system with two steps [10]. It also agreed with a study conducted by Bektas et al in 2012, where the results of this study showed that there is no statistically significant difference between the traditional flowable composite resin with a single -step bonding system and self -adhesive on the marginal leakage values on incisal and gingival walls [11]. The results of the Derelioglu et al study in 2013 also showed the lowest valuable marginal leakage on the enamel in the traditional flowable composite resin comparing, the self -adhesive composite resin, with the lack of statistically indicative difference between the groups. (12) Our study also agreed with the study of Wajdowicz et al in 2012, which valued the bonding strength of two types of self - adhesive composite Fusio and Vertise Flow with the enamel compared to the traditional composite group using a traditional fifth generation bonding system. This study showed a weakness in the bonding of the self -adhesive composite with the enamel. (13) The results of this study differed with a study conducted by Poitevin et al in 2013, the results of the study showed that the bonding strength in the self -adhesive resin groups are lower than in the traditional composite resin groups with a self -etch bonding system and a traditional bonding system. (14) The results of this study were also different with the study conducted by Makishi et al in 2015 in order to assess the bonding strength of self -adhesive composite, it was found that the bonding strength of the traditional composite resin with the use of two different bonding system was higher than the bonding strength of two different types of self - adhesive composite resin (Fusio and Vertise Flow) With statistically significant differences between traditional composite and self -adhesive composite. (15) Based on the results of our study and comparing it with previous studies, we find that the use of self -adhesive composite is effective similar to the traditional composite without the presence of statistically significant differences, which makes its application in children preferred as it is an effective restoration technique in terms of providing effort and time and earning the patient's cooperation.

Conclusions

Within the limits of this study, we can conclude that: The bonding of traditional composite resin with the enamel is better than the self -adhesive composite resin applied alone without using a bonding system. The bonding of traditional composite resin with dentin is similar to the self - adhesive composite.

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