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Research Article

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Marginal Microleakage of Self-Adhesive Flowable Composite as a Pit-Fissure Sealants Upon Different Application Techniques: A Comparative In-Vitro Study

Laila Shakfeh[1]*, Khaled Kabbesh[1] and Reem Alfares[1]

[1]*Department of Pediatric Dentistry, Faculty of Dentistry, University of Hama, Syrian Arab Republic*

***Corresponding Author**
Laila Shakfeh, Department of Pediatric Dentistry, Faculty of Dentistry, University of Hama, Syrian Arab Republic.

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Abstract

Background
The aim of the present study was to compare the microleakage of a self-adhesive composite (SAS) and a conventional resin-based fissure sealant using different application techniques.

Materials and Methods
100 intact human premolars with well-delineated pits and fissures were used and divided into 5 groups (n = 20). Group 1 specimens were etched (37% phosphoric acid) and sealed with conventional resin-based sealant (Helioseal F, Ivoclar Vivadent). In Group 2 Helioseal F was applied with bonding agent. For Group 3, pits and fissures were sealed with (Constic, DMG, Hamburg, Germany) according to the manufacturer's instructions. In Groups 4 and 5, specimens were sealed with Constic after enamel etching, but Group 5 bonding agent was also applied. Subsequently, specimens were thermocycled (1800 cycles, dwelling time of 10 s), immersed in 2% Methylene blue solution (24 h). Marginal leakage (dye penetration depth) was evaluated under a stereomicroscope and the worst score of each specimen was recorded (I–IV).

Results
Helioseal F showed the lowest microleakage (Helioseal F: 77.5% scored 0), regardless of bonding agent application (p = 0.200). Microleakage in groups sealed with Constic (with and without bonding agent) were not different (p = 0.449). The quality of marginal sealing after etching was improved when Constic was used (p = 0.000).

Conclusion
The present findings suggest that the conventional resin-based sealant provides better marginal sealing than SAS. Additional enamel pretreatment with 37% phosphoric acid reduces marginal microleakage of SAS. Bonding agent application do not enhance the marginal sealing of resin-based sealant.

Keywords: Fissure Sealants, Marginal Microleakage, Self-Adhesive Composite

1. Introduction

Dental caries is one of the most consequential infectious diseases known to humankind. Because of improved preventive methods in developing countries, dental caries in children and teenagers has declined in later decades. Whereas smooth surfaces have benefited from caries-prevention protocols, the high prevalence of occlusal caries is still a problem [1]. The most reason for this issue is the complex morphology of the pit and fissure on the occlusal surface of teeth, which are the foremost vulnerable zones to developing caries. Pits and fissures are generally considered incomplete forms of enamel during the odontogenesis of a cusp. As a result, pits and fissure are contract, profound, and sporadic in morphology [2]. The complex, sporadic shape of these parts of the tooth favors the arrangement of caries and makes determination troublesome, complicated, and some of the time incomprehensible through classical strategies of evaluation and determination. Dental plaque effortlessly gather in these areas and cannot be expelled viably by the patient [3]. Moreover, lack of saliva flow to the fissures and insufficient intake of remineralization agents do not compensate for a high incidence of occlusal caries [4]. Modern dentistry has focused on preventive treatments such as systemic and topical fluoride administration. However, these methods preferentially protect smooth surfaces rather than occlusal surfaces [5]. The structural defects of the occlusal surfaces are areas that favor plaque retention where fluoride is less effective. To prevent caries from developing in these zones, pit and fissure sealants have been developed successfully, and are used as an effective, minimally invasive preventive procedure [6]. Fissure sealants isolate pits and fissures from the bacteria and their by-products, provide a mechanical barrier, and avoid an accumulation of dental plaque. The effectiveness of the sealant application is significant caries risk reduction compared to non-sealed controls and lower cost compared to restorative treatment [7].

Resin-based materials have been traditionally used as a pit-fissure sealants. Several types of resin, both filled and unfilled have been employed. Resin-based sealants are generally used after etching with 37% phosphoric acid, with appropriate moisture control can obtain good sealant efficacy [8]. The resin-based material is lightly or not filled to keep the viscosity low, thus allowing for a deep penetration of the material into pits and fissures, where a resin-impregnated layer of enamel is formed, producing effective sealing [9]. The performance of pit and fissure sealant materials has been intensively investigated, yet no single product is reported as an ideal sealant. Some studies reported the use of bonding agents to enhance the bond strength of sealant to the tooth surface, especially in the case of saliva-contaminated surfaces, however, the technique is not widely used probably due to extended application time and increased cost [10].

Recently, a hydrophilic resin-based pit and fissure sealant was introduced as a moisture-tolerant, self-adhesive sealant where the addition of adhesive bonding can be avoided [11]. In self-adhesive resin-based pit and fissure sealant (SAS), the adhesion is based on the self-etching approach, and the three traditional steps of adhesion (etching, priming, and bonding), are accomplished by a single application of a solution [12]. Reducing clinical steps in application of adhesive eliminates the possibility of cavity contamination and over-drying/wetting issues.

There are a few studies investigate the adhesive properties of these simplified self-adhesive fissure sealant composite materials [13]. Some studies reported that SAS achieved lower bond strength compared to the traditional flowable composites that were used with bonding agents [13]. According to the manufacturer, Constic, a self-etching and self-adhesive flowable composite, combines an etching gel, bonding agent and flowable composite.

The efficacy of sealants strongly depends on their penetration capability into occlusal areas and maintaining an intimate adaptation of the sealant to the tooth surface [14]. The marginal sealing ability of sealing material is extremely important for the success of sealants, which can be assessed by evaluating microleakage [15]. Any breach in marginal integrity or weak sealing can lead to marginal leakage, resulting in a bacterial invasion, caries initiation, and progression underneath the restoration [7]. An important step to increase sealing abilities is an acid etching of the enamel before resin-based fissure sealant application. Physicochemical interactions between sealants and acid-etched enamel are the principal forces providing sealant retention [16]. Microleakage has been defined as the clinically undetectable passage of bacteria, fluids, molecules, or ions between the cavity wall and the applied restorative material [14]. Microleakage studies are a standard method to access the sealant efficacy either in-vivo or in-vitro and can predict the marginal integrity of restoration and how successful they might last [17]. Microleakage assessment may be qualitative or quantitative with different systems, including simple and computer-based methods. Dye penetration has been used in several studies to assess the presence of marginal leakage at the sealant-enamel interface [18]. With the advantages of reliability, simplicity, and ease of application, the dye penetration test is a well-established and commonly used method for the determination of microleakage in vitro.

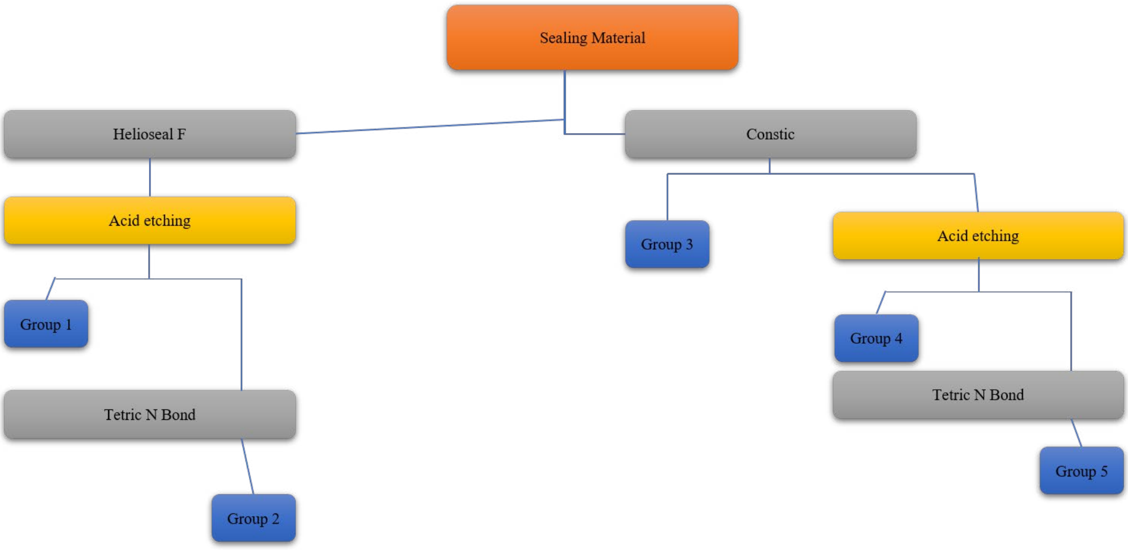
Sealant application technique is one of the main factors influencing the longevity of sealant. There still can be controversy in the effect of application technique on microleakage of different sealants. The objective of the present study was to evaluate the effect of three different enamel treatments on the microleakage of self-adhesive flowable composites (Constic, DMG, Hamburg, Germany) in comparison with a conventional resin-based sealant. The null hypothesis was no significant difference in microleakage of various sealants upon application methods and materials.

2. Methos and Materials

2.1 Sample Preparation

A total of 100 intact, non-carious human maxillary premolars, extracted for orthodontic reasons, were included in this study. To remove organic residues, teeth were cleaned under running water prior to the experiment, decontaminated with 0.5% Chloramine-T compound, and stored in distilled water.

Teeth were randomly divided into five equal groups (n = 20), according to the tested materials and application methods (Flow Chart 1). The control group (group 1) was sealed with conventional resin-based sealant (Helioseal F, Ivoclar Vivadent AG, Schaan, Liechtenstein) with prior enamel etching (37% phosphoric acid) (Figure 1). The Group 2 conventional resin-based sealant was applied with bonding agent (Tetric N Bond, Ivoclar Vivadent AG, Schaan, Liechtenstein). The Group 3 specimens were sealed with self-adhesive composite resin (Constic, DMG, Hamburg, Germany) without enamel pre-treatment according to the manufacturer's instructions. In Group 4, the enamel was etched with 37% phosphoric acid and sealed with the Constic. Finally, Group 5 was sealed with the Constic with prior bonding agent application after enamel was etched with 37% phosphoric acid. Table 1 present sealant application methods for different groups.



Flow Chart 1: Experimental Groups

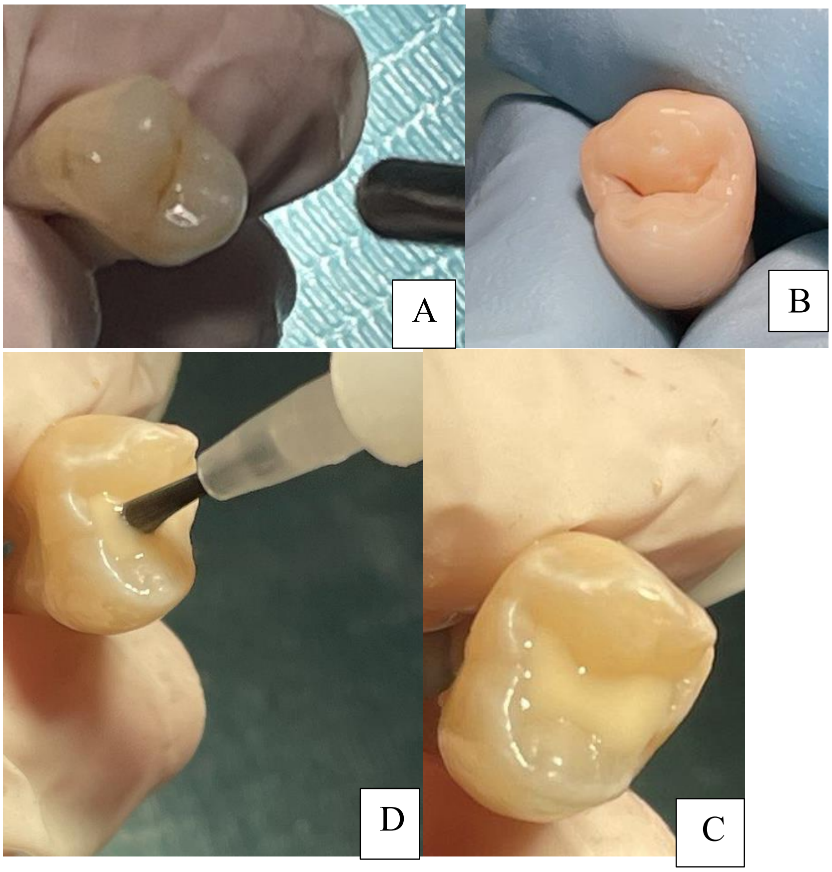


Figure 1: Application of Sealant Materials

A, B: air-dried; C: samples sealing with Helioseal F; D: samples sealing with Constic

Group	Etching	Bonding agent	Light-curing	Sealant	Light-curing
1	37% phosphoric acid for 20s	-	-	Helioseal F	10s using JR-CL 17 (classic) (Foshan JERRY Medical Apparatus CO., LTD, Foshan, China).
2	37% phosphoric acid for 20s	Tetric N Bond	20s	Helioseal F	10s
3	-	-	-	Constic	20s

4	37% phosphoric acid for 20s	-	-	Constic	20s
5	37% phosphoric acid for 20s	Tetric N Bond	20s	Constic	20s

Table 1: Sealant application procedures for the experimental groups

3. Marginal Seal Measurement

After 1-day of storage in distilled water, teeth were simultaneously thermos-cycled under following thermodynamic conditions: 5-55 C, with a dwell-time of 10 seconds and a transfer time of 5 seconds for 1800 cycles. After that the teeth were stored in distilled water at room temperature.

Samples were kept in Methylene blue with concentration of 2% for 24 hours, after coated with two layer of nail polish expect the occlusal surface. Additionally, wax was used to close the apexes of the teeth in order to prevent secondary microleakage. After that samples were kept in distilled water for 24 hours to remove dye remnant.

To record the microleakage, every premolar was sectioned bucco-lingually with a slow speed saw (Isomet®, Buehler, Lake Bluff, Illinois, USA), then samples were examined under x40 using stereomicroscope (Nikon Stereo Microscope SMZ800, Japan) (Figure 2).

The following Marginal Microleakage Index (MMI) was used to record marginal microleakage:

- I: no dye penetration.
- II: dye penetration to less than one third from the margin.
- III: dye penetration up to two thirds from the margin.
- IV: dye penetration up to bottom of fissure.

4. Statistical Analysis

Statistical analysis was performed using the Kruskal–Wallis non-parametric test and the Mann–Whitney U test ($p < 0.05$) for post-hoc analysis.

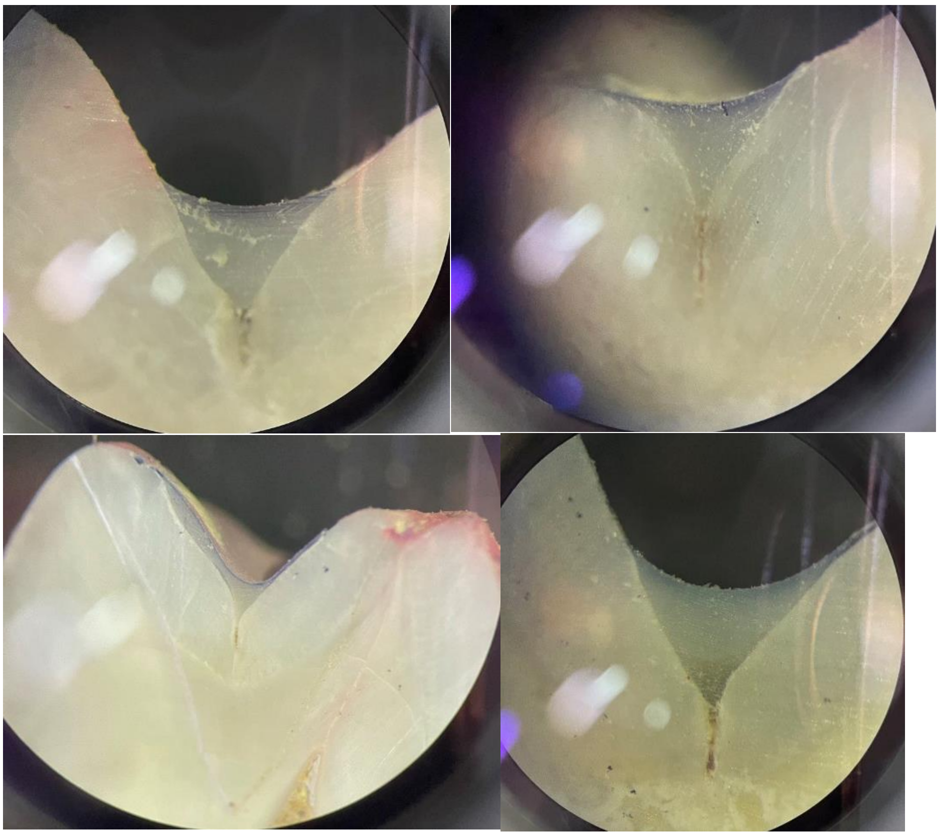


Figure 2: Marginal microleakage measurement

5. Results

All tested fissure sealant showed 100% retention rate after the thermocycling procedure. Distribution of the worst score per sealant is reported in Table 2. The best marginal adaptation was shown in the Helioseal F group. The difference between groups sealed with Constic with and without etching of enamel was significantly different ($p = 0.000$) (Table 2). Comparing the self-adhesive composite resin and conventional composite resins for fissure sealing, better marginal adaptation was obtained in the conventional composite group ($p < 0.05$). Regarding the depth of dye penetration, significant differences were recorded between Helioseal F and Constic ($p < 0.05$). The null hypothesis was rejected (significant difference in marginal microleakage is observed among sealants materials and application methods) (Table 3).

Maximum Dye Penetration Score	Group 1	Group 2	Group 3	Group 4	Group 5	Total
I*	17	14	0	7	4	42
II**	3	3	0	5	7	18
III***	0	3	4	5	5	17
IV*****	0	0	16	3	4	23
Total	20	20	20	20	20	100
*No evidence of dye penetration; **dye penetration to less than one third from the margin; ***dye penetration up to two thirds from the margin; ****dye penetration up to bottom of fissure.						

Table 2: Frequency table of the worst score per sealant

Multiple comparison				P-value
First group	**Average of ranks**	**Secund group**	**Average of ranks**	
1	18.78	2	22.23	0.200
	10.50	3	30.50	0.000
	14.90	4	26.10	0.001
	13.33	5	27.68	0.000
2	10.80	3	30.20	0.000
	16.55	4	24.45	0.020
	15.05	5	25.95	0.002
3	28.20	4	12.80	0.000
	27.60	5	13.40	0.000
4	19.15	5	21.85	0.449
Kruskal–Wallis revealed significant differences in marginal microleakage values (Chi-square = 56.30; *df* = 4; p = 0.000).				

Table 3: Mann–Whitney U test post-hoc analysis of multiple comparisons of different experimental groups.

6. Discussion

Presently, there are two broad categories of fissure sealants based on light-cured, resin-based fissure sealants and glass ionomer sealants. In this study, the microleakages of two resin-based materials used as fissure sealants were compared. Resin-based sealants prevent caries development through forming a mechanical barrier between the grooves of teeth and the oral environment interrupting metabolic exchange. Thus, the efficacy of resin-based sealants is dependent on retention and integrity [19]. Sealant placement is very technically sensitive. Microleakage is still a major problem, and the primary reason for failure of composite resin restorations [20]. Hence, in this study, microleakage, as one of the most important indicators of success or failure of sealant therapy has been investigated. In the present study, no anatomical distinction was made between groove depths. The reason was that studies have shown that there is no significant difference in microleakage in anatomically different groove, All specimens were received the same amount of output energy because the device used for curing was a blue phase LED. Since the device has a built-in radiometer [21].

The first marketed self-adhesive composite has shown improved benefits by treatment using phosphoric acid [22]. The literature provides limited information on the microleakage characteristics of available SAS and the effect of additional enamel pretreatment on sealing ability. The aim of this study was to evaluate the effect of enamel etching and bonding agent application on the microleakage of SAS in comparison with a conventional resin-based sealant with an etch-and-rinse system.

The Mann-Whitney test showed there was a significant difference between a number of the groups in microleakage. The results of the test revealed the least microleakage existed in groups where conventional resin-based sealant had been used, regardless of bonding agent application. It also showed microleakage was maximum in groups where SAS had been applied. Acid etching of the enamel before SAS application had been improved marginal sealing. However, marginal sealing had not affected with bonding agent application. These results are not in agreement with the finding of studies which suggest the use of bonding agents following etching positively affects the sealant therapy [23].

Considering the results, it is seen that in Groups 1 and 2 in which conventional resin-based sealant were applied, a high percentage of the specimens (77.5%) showed no microleakage and complete microleakage did not occur in any of the specimens. Therefore, it could be concluded that acid etching positively affects sealant therapy. The application of SAS for sealing of occlusal surfaces (in Groups 3, 4 and 5) was not efficient, which is similar to the findings of other similar studies. Furthermore, the findings of a study conducted by Hannig et al. in 2004, in accordance with our findings, suggest the application of self-etching primers does not promote sealant therapy [24].

It has been found that there was no significant difference detected when a self-adhering flowable composite was applied, according to the manufacturer's instructions, without pretreatment [20]. However, Bektas et al. suggested that using an adhesive resin with self-etching flowable composite could reduce microleakage and increase dentin bond strength to hard dental tissue [25]. In the present study, differences between groups sealed with Constic with and without etching of enamel were significantly different.

Etching of the enamel, proposed in etch and rinse systems, increases the surface energy of the enamel surface by removing the smear layer. This step is not necessary when SAS is applied and it does not have an influence on marginal adaptation [13]. However, this fact was not proven in the current study. The results of the current study do not agree with Gorseta et al. who observed that Helioseal F produce the greatest leakage in an in-vivo study [26]. Self-adhering materials have become popular due to easier application and fewer working steps. This is very important in pediatric dentistry as poor cooperation of children and more steps in the application lead to greater possibility of failure. These reasons could possibly explain the difference between the findings of our study.

In the present study, microleakage was expressed as the score of dye penetration along the enamel-sealant interface of fissures, and a validated scoring system was used [27]. However, studies have been suggested that evaluating the percentage of penetration of the dye along the enamel-sealant interface of pits and fissures would be more accurate than the use of dichotomous or numerical scales, which is a matter for future studies [28]. Thus, there is no standardized method for the in vitro evaluation of microleakage of fissure sealants. Additionally, no fissure sealant retains the sealing ability over time, and all eventually show some degree of microleakage [29]. This is partly due to differences between the coefficient of thermal expansion of sealants and that of enamel [29]. Therefore, long-term clinical trials are needed to recommend the best sealant. Under the limitations of this study, it can be concluded that there was no beneficial effect of SAS application as pits and fissures sealant. Otherwise, when money matters, the conventional sealant therapy approach is recommended.

Conclusion

Under the limitations of present study, it can be drawn that:

1. Conventional resin-based sealant provides better marginal sealing than SAS.
2. Additional enamel pretreatment with 37% phosphoric acid reduces marginal microleakage of SAS.
3. Bonding agent application do not enhance the marginal sealing of resin-based sealant.

References

1. Simonsen, R. J., & Neal, R. C. (2011). A review of the clinical application and performance of pit and fissure sealants. *Australian dental journal, 56*, 45-58.
2. IyER, R. R., GoPAlAKRISHNAPIllAI, A. C., & KAlANTHARAKATH, T. (2013). Comparisons of in vitro penetration and adaptation of moisture tolerant resin sealant and conventional resin sealant in different fissure types. *Chin J Dent Res, 16*(2), 127-36.
3. Khidir, H. S., & Suleman, H. M. (2021). Evaluation of microleakage of three different types of pit and fissure sealants using invasive and non-invasive techniques (An in-vitro study). *Erbil Dental Journal (EDJ), 4*(1), 40-49.
4. Khanna, R., Pandey, R. K., & Singh, N. (2015). Morphology of pits and fissures reviewed through scanning electron microscope. *Dentistry, 5*(4), 1.
5. Kumaran, P. (2013). Clinical evaluation of the retention of different pit and fissure sealants: a 1-year study. *International journal of clinical pediatric dentistry, 6*(3), 183.
6. Celiberti, P., & Lussi, A. (2007). Penetration ability and microleakage of a fissure sealant applied on artificial and natural enamel fissure caries. *Journal of dentistry, 35*(1), 59-67.
7. Sridhar, L. P., Moses, J., Rangeeth, B. N., & Sivakumar, S. (2016). Comparative evaluation of the marginal sealing ability of two commercially available pit and fissure sealants. *Journal of Clinical and Diagnostic Research: JCDR, 10*(9), ZC01.
8. Do Rego, M. A., & De Araujo, M. A. (1999). Microleakage evaluation of pit and fissure sealants done with different procedures, materials, and laser after invasive technique. *The Journal of clinical pediatric dentistry, 24*(1), 63-68.
9. Schneider, C. A., Rasband, W. S., & Eliceiri, K. W. (2012). NIH Image to ImageJ: 25 years of image analysis. *Nature methods, 9*(7), 671-675.
10. Derelioglu, S. S., Yilmaz, Y., Celik, P., Carikcioglu, B., & Keles, S. (2014). Bond strength and microleakage of self-adhesive and conventional fissure sealants. *Dental materials journal, 33*(4), 530-538.
11. Salama, F. S., & Al-Hammad, N. S. (2002). Marginal seal of sealant and compomer materials with and without enameloplasty. *International Journal of Paediatric Dentistry, 12*(1), 39-46.
12. Vichi, A., Margvelashvili, M., Goracci, C., Papacchini, F., & Ferrari, M. (2013). Bonding and sealing ability of a new self-adhering flowable composite resin in class I restorations. *Clinical oral investigations, 17*, 1497-1506.
13. Rangappa, A., Srinivasulu, J., Rangaswamy, V., Eregowda, S., Lakshminarasimhaiah, V., & Lingareddy, U. (2018). Comparative evaluation of bond strength of self-adhering flowable composites to the dentin prepared with different burs: An in vitro study. *Journal of Conservative Dentistry: JCD, 21*(6), 618.
14. Geiger, S. B., Gulayev, S., & Weiss, E. I. (2000). Improving fissure sealant quality: mechanical preparation and filling level. *Journal of dentistry, 28*(6), 407-412.
15. Barata, J. S., Casagrande, L., Pitoni, C. M., De Araujo, F. B., Garcia-Godoy, F., & Groismann, S. (2012). Influence of gaps in adhesive restorations in the development of secondary caries lesions: an in situ evaluation. *Am J Dent, 25*(4), 244-8.
16. Güçlü, Z. A., Dönmez, N., Tüzüner, T. A. M. E. R., Odabaş, M. E., Hurt, A. P., & Coleman, N. J. (2016). The impact of Er: YAG laser enamel conditioning on the microleakage of a new hydrophilic sealant—UltraSeal XT® hydro™. *Lasers in medical science, 31*, 705-711.
17. Hevinga, M. A., Opdam, N. J. M., Frencken, J. E., Bronkhorst, E. M., & Truin, G. J. (2007). Microleakage

and sealant penetration in contaminated carious fissures. *Journal of dentistry, 35*(12), 909-914.
18. Joshi, K., Dave, B., Joshi, N., Rajashekhara, B. S., Jobanputra, L. H., & Yagnik, K. (2013). Comparative evaluation of two different pit & fissure sealants and a restorative material to check their microleakage–An In Vitro Study. *Journal of International Oral Health: JIOH, 5*(4), 35.
19. Corona, S. A. M., Borsatto, M. C., Garcia, L., Ramos, R. P., & Palma-Dibb, R. G. (2005). Randomized, controlled trial comparing the retention of a flowable restorative system with a conventional resin sealant: one-year follow up. *International journal of paediatric dentistry, 15*(1), 44-50.
20. Rengo, C., Goracci, C., Juloski, J., Chieffi, N., Giovannetti, A., Vichi, A., & Ferrari, M. (2012). Influence of phosphoric acid etching on microleakage of a self-etch adhesive and a self-adhering composite. *Australian dental journal, 57*(2), 220-226.
21. Hannig, M., Gräfe, A., Atalay, S., & Bott, B. (2004). Microleakage and SEM evaluation of fissure sealants placed by use of self-etching priming agents. *Journal of dentistry, 32*(1), 75-81.
22. Pavan, S., Dos Santos, P. H., Berger, S., & Bedran-Russo, A. K. B. (2010). The effect of dentin pretreatment on the microtensile bond strength of self-adhesive resin cements. *The Journal of prosthetic dentistry, 104*(4), 258-264.
23. Tehrani, M. H., Birjandi, N., Nasr, E., & Shahtusi, M. (2014). Comparison of microleakage of two materials used as fissure sealants with different methods: an in vitro study. *International journal of preventive medicine, 5*(2), 171.
24. Celiberti, P., & Lussi, A. (2005). Use of a self-etching adhesive on previously etched intact enamel and its effect on sealant microleakage and tag formation. *Journal of dentistry, 33*(2), 163-171.
25. Ozel Bektas, O., Eren, D., Akin, E. G., & Akin, H. (2013). Evaluation of a self-adhering flowable composite in terms of micro-shear bond strength and microleakage. *Acta Odontologica Scandinavica, 71*(3-4), 541-546.
26. Gorseta, K., Borzabadi-Farahani, A., Vrazic, T., & Glavina, D. (2019). An in-vitro analysis of microleakage of self-adhesive fissure sealant vs. conventional and GIC fissure sealants. *Dentistry journal, 7*(2), 32.
27. Oberholzer, T. G., Du Preez, I. C., & Kidd, M. (2005). Effect of LED curing on the microleakage, shear bond strength and surface hardness of a resin-based composite restoration. *Biomaterials, 26*(18), 3981-3986.
28. Germán-Cecilia, C., Gallego Reyes, S. M., Pérez Silva, A., Serna Muñoz, C., & Ortiz-Ruiz, A. J. (2018). Microleakage of conventional light-cure resin-based fissure sealant and resin-modified glass ionomer sealant after application of a fluoride varnish on demineralized enamel. *PloS one, 13*(12), e0208856.
29. Ak, A. T., & Alpoz, A. R. (2010). Effect of saliva contamination on microleakage of three different pit and fissure sealants. *Eur J Paediatr Dent, 11*(2), 93-6.