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EVALUATION OF GINGIVAL MICROLEAKAGE IN CLASS II COMPOSITE RESTORATIONS: AN IN VITRO STUDY

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Abstract: Introduction: Evaluation of microleakage is important for assessing the success of new restorative materials and methods. The aim of this study was to assess the microleakage of class II restorations with different flowable composites as liners and two different polymerization techniques classic and soft start.

Materials and Methods: 40 extracted human premolars teeth with class II cavity preparation medial and distal (80 cavities) were divided into four groups: 1.Vertise Flow (VF)+micro hybrid composite Herculite 2.Surefil SDR Flow (SDRF)+micro-hybrid composite Herculite 3.Tetric Flow (TF)+micro-hybrid composite Herculite 4.control group micro-hybrid composite Herculite. Mesial cavities are polymerized with classic and distal cavity with soft start technique of polymerization. After that, the samples were immersed in 0.5% $AgNO_3$ solution and sectioned into the mesiodistal direction. Using a stereomicroscope (Nikon - Japan), with a magnification of 40x, the gingival microleakage of cavities was examined. Data were analyzed using Fisher's and Student's tests.

Results: After using the classical polymerization technique, all three used flowable composites VF+Herculite, SDRF+Herculite, TF+Herculite showed less gingival microleakage than the control group. This difference was statistically significant. After the application of the soft-start technique of polymerization, VF+Herculite and SDRF+Hercules showed a statistically significant reduction in gingival microleakage, while TF+Herculite showed a comparable result with control group, without a statistically significant difference. There was no statistically significant difference between classical and soft start polymerization techniques.

Conclusion: Flowable composites in this study have reduced gingival microleakage and can be used as liners in the restoration of II class cavities.

Keywords: Microleakage, class II restoration, flowable composite, polymerization.

1. INTRODUCTION

Composite materials were introduced in clinical practice in the mid-twentieth century. From that period until today, they gradually assumed dominance in the restoration of lost tooth substances. Direct composite restoration is one of the most common medical interventions in the human body with more than five hundred million composite restorations annually worldwide [1].

Despite the numerous advantages of the composite, an important drawback is the polymerization shrinkage that causes marginal leakage, postoperative sensitivity, and secondary caries [2,3].

Flowable composite resins have gained popularity in the last decade. The viscosity of the flowable composites is smaller due to the lower percentage distribution of fillers in their composition [4]. Therefore, it is easy to apply, especially in areas that do not suffer from a high physiological load during the chewing function [5].

Some authors recommend the use of flowable composites as a liner to overcome the problem of microleakage [6,7].

It is believed that flowable composites due to the low modulus of elasticity (from 14.14 to 15.78 GPa) can compensate for the stress created under the action of occlusal forces and contribute to reducing contraction stress [8,9].

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Studies have shown different results in the application of flowable composites as a first layer since there was no significant difference after application of the flowable composite [10] and that the flowable composite had no effect on the reduction in microleakage formation [11,12], to the assertion that the use of flowable composite materials improves the marginal integrity of posterior composite restoration and reduces gingival microleakage [13].

Recently, in a dental practice, a new flowable composite has been introduced which has combined properties of self-adhesion and fluids, Vertise Flow. Which introduced a new category of restorative materials called "self-adhering flowable composites [14-16].

Vertise Flow (VF) differs from conventional composites because it eliminates the need for a separate application and binding step, thus simplifying a direct restorative procedure.

It is based on a binding technology that uses glycerophosphate methacrylate (GPDM) for enameling of enamel and dentine, and hydroxyethyl methacrylate (HEMA) to improve moisture and penetration of the resin into dentine. This composite resin achieves a chemical bond between phosphate groups of GPDM monomers and hydroxyapatite of the tooth structure. The micromechanical bond between the polymerized monomers of the adhesive flowable composite resin and the collagen fibers and the smear layer of dentine also contributes to adhesion [14-17].

Surefil SDR Flow (SDRF) is a flowable composite resin with 68% of fillers in a composition that has been introduced recently from the market. It is thought to possess a lower modulus of elasticity, as well as a smaller polymerization contraction compared to a traditional flowable composite. The material is intended for mass application in direct composite restorations [18,19].

This study’s aim was to compare gingival microleakage in class II composite restorations using different flowable composite linings and two different polymerization techniques classic and soft start.

2. METHODS

In this study, a total of 40 non- carious human premolars, extracted from orthodontic reasons, were used. The teeth were purified from dental calculus and organic tissue residues by an ultrasound instrument and then stored in 0.05% timolol for no longer than 6 months. The teeth are randomly divided into 4 groups. The first three involved the application of the first layer of a flowable composite as a liner (VF Herculite, SDRF+ Herculite, TF+Herculite), and then definitely restored with the Herculite micro-hybrid composite (Kerr Corporation, Orange, CA, USA) while the fourth group was controlling only the Herculite micro-hybrid composite (Kerr Corporation, Orange, CA, USA) was used here. On the mesial and distal surfaces of each tooth, using 0.8 fissure drill (RENDELL + ZWILLING, Quezon City, Philippines), standardized cavities of the II class using a high-impact drill (Kavo to Brasil Ind. Com. Ltda, Joinville, SC, Brazil), with mandatory guided cooling. A total of 80 cavities were dimensioned: 3 mm wide buckling, axial depth 1.5 mm and gingival 0.5 mm below CEJ. Since Vertise Flow contains acid and binding agent during its setting, 37% orthophosphoric acid cavity and binder application were not corroded. The procedure involved the following:

Cavities I groups (VF +Herculite)

1. preparation of cavities II class mesial and distal
2. washing and drying cavities
3. application of Vertise Flow material in a layer thickness of 0.5 mm
4. distribution of material with a brush for a duration of 15 to 20 seconds
5. polymerization of the material with the Bluephase C8 (Ivoclar Vivadent) LED lamp for 20 seconds.
6. definitive restoration of cavities with Herculite

Cavities II groups (SDRF + Herculite) and Cavities III groups (TF+Herculite)

1. preparation of cavities II class mesial and distal
2. etching 37% orthophosphoric acid (Ivoclar Vivadent, Schaan, Liechtenstein) 30s enamel, 15s dentin
3. wash the cavity with water and air drying
4. application of the adhesive OptiBond Solo Plus (Kerr Corporation)
5. polymerization of the adhesive agent with the Bluephase C8 (Ivoclar Vivadent) LED for 10 sec
6. application of suitable flowable composites (SDRF and TF) as liners and their polymerization for 20 sec.
7. definitive restoration of cavities with Herculite.

Cavities IV groups (control group, Herculite)

1 preparation of cavities II class mesial and distal

2. etching 37% orthophosphoric acid (Ivoclar Vivadent, Schaan, Liechtenstein) 30s enamel, 15s dentin

3. wash the cavity with water and air drying

4. application of the adhesive OptiBond Solo Plus (Kerr Corporation)

5. polymerization of the adhesive agent with the Bluephase C8 (Ivoclar Vivadent) LED for 10 sec

6. definitive restoration of cavities with Herculite.

For the polymerization of all cavities from the medial side, a conventional polymerization technique is applied, while the cavities are distally polymerized soft start with the polymerization technique by the Bluephase C8 LED lamp (Ivoclar Vivadent).

After polymerization, all the teeth were stored in a thermostat at a temperature of 37 °C under relative humidity conditions (the teeth were wrapped in a wet cotton wrap) for seven days. After this period, each surface of the teeth is coated with two layers of nail polish, except the filling and the adjacent belt around it, 1 mm wide. The microleakage test was carried out semiconductively by the colorant solution using a silver solution. The teeth were immersed in a 50% solution of $AgNO_3$ over six hours. After that, they were rinsed under a jet of water for 60 seconds and then immersed in the photoconductor for two hours. After removing the lacquer with a sharp instrument, the teeth are diamond disc (Nemov, Mashad, Iran) crossed in a mesiodistal direction. The color penetration is read by a stereomicroscope (Nikon - Japan) with a magnification of 40x.

For the evaluation of gingival microleakage, a scale was applied per *Leevaloj C, Cochran MA et al*.:

0 - no dye penetration

1- dye penetration of paint up to ½ of the gingival wall

2. dye penetration> ½ gingival wall

3 - dye penetration the entire length of the gingival wall

4 - dye penetration the entire length of the gingival wall plus an axial wall.

The data were statistically analyzed using the Fisher and Students tests.

3. RESULTS

After the application of the classical polymerization technique, all three used flowable composites VF + Herculite, SDRF + Herculite, TF + Herculite have been shown to have less gingival microleakage compared to the Herculite micro-hybrid. This difference was statistically significant (Graph 1, Table 1).

After the application of the soft-start technique of polymerization, only VF + Herculite and SDRF + Herculite showed a statistically significant reduction in gingival microleakage compared to Hercules. TF + Herculite showed a comparable result with Herculite, with no statistically significant difference (Graph 2, Table 2).

The soft-start technique proved to be better than the conventional polymerization technique. The total static analysis of the classic concerning the soft-start technique shows that these two techniques differ statistically for $p < 0.05$, however, if we look individually for all five parameters per groups, we see that there is no statistical significance (Graph 3).

The greatest reduction in gingival micro-permeability and the highest statistical significance was observed after the application of VF + Herculite and SDRF + Herculite polymerized soft-start method (Graph 3).

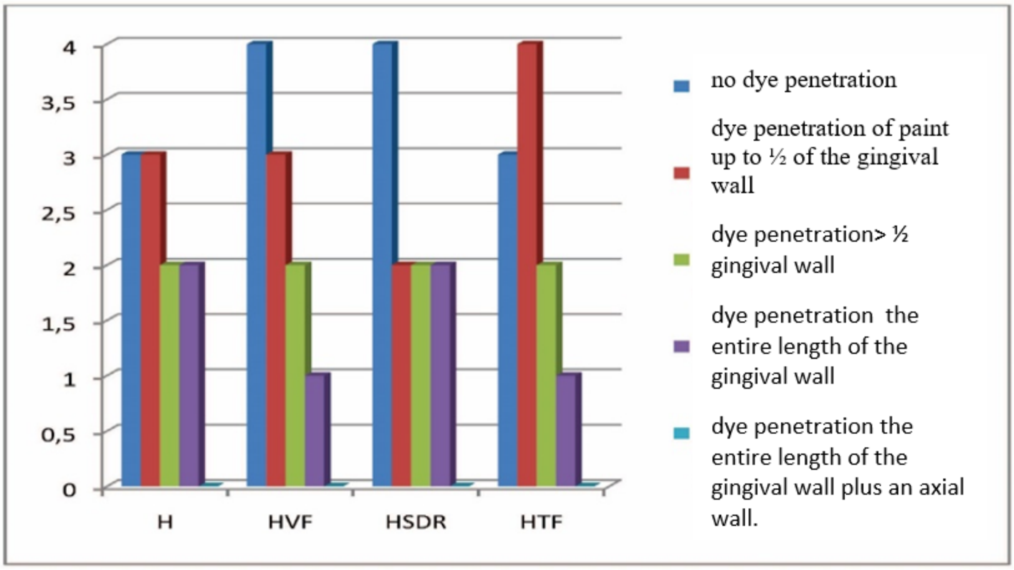
Table 1. Description of dye penetration into gingival and axial walls in classical technique with applied tests

parameters / groups (n = 10)	no dye penetration	dye penetration of paint up to ½ of the gingival wall	dye penetration> ½ gingival wall	dye penetration the entire length of the gingival wall	dye penetration the entire length of the gingival wall plus an axial wall.	Fisher's test (2.22)	Student's test (1.3)
H	3	3	2	2	0		
HVF	4	3	2	1	0	0.0247*	0.0309*
HSDR	4	2	2	2	0	0.0261*	0.0278*
HTF	3	4	2	1	0	0.0235*	0.0376*

Statistically significant for $p < 0.05$

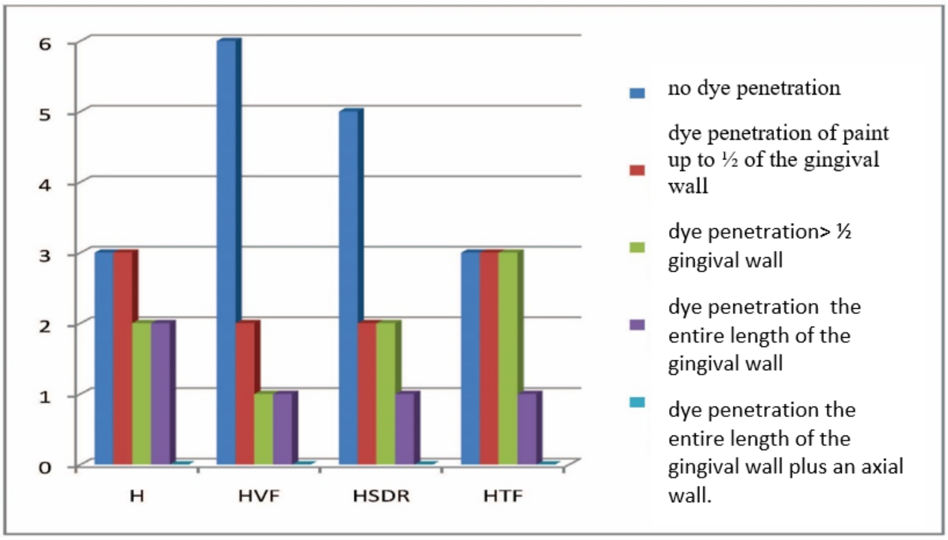
*H-Herculite; *HVF-Vertise Flow+Herculite; *HSDR-SDR Flow+Herculite; *HTF-Tetric Flow+Herculite.

1. Classic technique



Graph 1. Dye penetration in the gingival and axial wall with classical techniques

2. Soft start technique

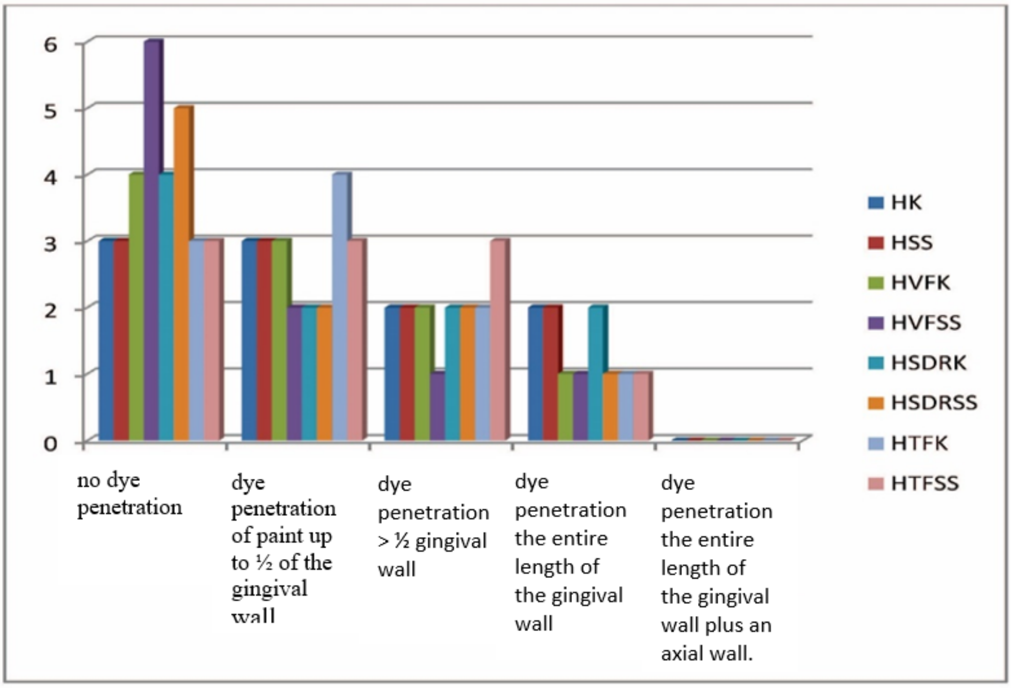


Graph 2. Dye penetration in the gingival and axial wall with soft start techniques

Table 2. Description of dye penetration into gingival and axial walls in soft start technique with applied tests

parameters / groups (n = 10)	no dye penetration	dye penetration of paint up to ½ of the gingival wall	dye penetration> ½ gingival wall	dye penetration the entire length of the gingival wall	dye penetration the entire length of the gingival wall plus an axial wall.	Fisher's test	Student's test
H	3	3	2	2	0		
HVF	6	2	1	1	0	0.0145*	0.0252*
HSDR	5	2	2	1	0	0.0171*	0.0187*
HTF	3	3	3	1	0	0.0848	0.0735

Statistically significant for $p < 0.05$
*H-Herculite; *HVF-Vertise Flow+Herculite; *HSDR-SDR Flow+Herculite; *HTF-Tetric Flow+Herculite.



Graph 3. A comparison of classic and soft start techniques with applied tests

*HK-Herculite, classic technique; *HSS-Herculite, soft start; *HVFK-Vertise Flow +Herculite, classic technique; *HVFSS-Vertise Flow +Herculite, soft start; *HSDRK-SDR Flow+Herculite, classic; *HSDRSS- SDR Flow+Herculite, soft start; *HTFK-Tetric Flow+Herculite, classic technique; *HTFSS-Tetric Flow+Herculite, soft start

4. DISCUSSION

Inadequate marginal adaptation of the fill and occurrence of microcrack is one of the most intriguing and challenging problems of conservative dentistry. Contrary to the fact that the bond between the enamel and the contemporary composites is generally achieved satisfactorily, the quality of the bonding of composite materials for dentin is still inferior compared to the visage, due to the structural characteristics of the dentin, but also the better micromechanical connections of the riveted enamel and the composite material. The reasons for this study were only gingival microleakage [20].

Some authors recommend the use of flowable composite resins as the first layer underneath the composite, due to the lower modulus of elasticity, which can compensate for contraction stress and act as a shock absorber [6,7].

According to the results of this in vitro study, all three used flowable composites reduced gingival micro-permeability after the application of the conventional polymerization technique. Following the application of soft start techniques, Vertise Flow, and Surefil SDR Flow significantly reduced gingival micro-permeability, while Tetric Flow showed a comparable control result, with no statistically significant difference.

Indeed, the best result, the greatest reduction in gingival micro-permeability and the highest statistical significance, was observed after the application of VF + Herculite and SDRF + Herculite, a polymerized soft start method.

A significant reduction in gingival micro-permeability following the application of Vertise Flow (VF) can be explained by good adhesion to dental structures, thanks to the special binding mechanism of this self-adhering flowable composite resin, but also by the simplified application.

These results are consistent with studies in the cavity restoration of *Class V* on the side teeth with VF (vestibular), and TF (orally) with the use of three light-cure techniques: classical, soft start and pulse. Smaller microleakage (occlusal and gingival) after the application of VF material was confirmed both on intact and on carious teeth, after applying all three techniques of light polymerization [21,22].

In the study *Abdelrahman et al.* (2016) Vertise Flow has also confirmed good adhesion to dental tissue, causing significantly less occlusal and gingival micro-permeability in *Class V* cavities compared to the Filtek flow bulk-fill composite [23].

Less gingival micro-permeability in *Class V* cavities after the application of Vertise Flow was confirmed in comparison with the traditional

Optibond all-in-one and Optibond S adhesives in the study *Lia at al.* (2018) [24].

Contrary to the results of this study is the study *Gayatri et al.* (2018) in which the marginal adaptation of the self-adhering flowable Vertise Flow composite, when used as a liner in class II restorations, was comparable to the conventional flowable Tetric N-flow composite. In the 44 extracted premolars, the cavities of the II class were prepared. They are divided into two groups: Group I - Gingival coated with Tetric N-Flow and restored with Tetric N-Ceram; Group II - Gingival coated Vertise Flow and restored Herculite Precis. After thermocycling, the cross-sections of the teeth were tested using the SEM at 200 x magnification [25].

In the study *Balcatioglu et al*. (2017), the use of self-adhering flowable composites Vertise Flow and Fusio Liquid Dentin, as a liner, in the restoration of cavity class II showed similar performances to those of universal flowable composites in terms of marginal microleakage [26].

The differences in the results of studies as mentioned above concerning the results of this study can be attributed to different assessment methods. In the first marginal adaptation assessment study, Scanning Electron Microscope (SEM) was used, and in another micro-computed tomography (micro-CT) analysis of high resolution, which could provide better visualization.

The results obtained by this study for SDR Flow are following the study of *Lotfi et al*. (2015) in which the SDR Flow in combination with the hybrid Z 250 composite reduced gingival micro-permeability in class II cavities [12].

The lower microleakage of the SDR Flow composite is also confirmed by the findings of some other researchers [27-29].

Illie et al. (2011), comparing the SDR flow with two traditional flowable methacrylate composites, confirmed that the SDR has the lowest level of stress in collecting, the longest pre-gel and the slowest collection speed. In the Surefil SDR flowable composite polymerization voltage decreases with time as a result of the SDR patented urethane methacrylate structure in this composite [27]. Urethane with built-in photo-active groups can control the polymerization kinetics, which is consistent with previous knowledge of *Burgess et al* and *Jan et al*. The polymerization of the SDR Flow composite is therefore 3-4 times less compared to other flowable composites [28,29].

Koltisko et al also found that the SDR polymerization voltage was lower than in other flowable composites, while differences in the bending module and volumetric shrinkage (3.5% volume) of the investigated composites were not found [30].

Contrary to the results obtained for SDR Flow, *Arslan et al*. (2013) study in which no differences in micro-leakage between teeth restored with SDR Flow and conventional flowable composite resin although SDR had the lowest shrinkage stress [31].

Composite Tetric Flow (TF), a light-weight polymerizing hybrid nanotechnology composite, according to the results of this study, reduced the gingival microleakage after classical polymerization, and after the soft-start, it had a comparable control result. A poorer TF result is possibly a consequence of a slightly lower percentage of fillers in this material (64.6%) compared to SDR flow (68%) and VF (70%). It is known that an increase in inert materials in composites (organic and inorganic fillers) can reduce the total shrinkage of the composite, due to the lower availability of the monomer for the polymerization reaction. Compared to VF, somewhat higher gingival microleakage TF is likely to be associated with ease of application of VF, without etching, washing, drying, and bonding, thus reducing the possibility of any mistake of the therapist to a minimum.

In this study, the soft-start technique of polymerization resulted in better results than the conventional technique, since in the initial period of the polymerization cycle it engages irradiance of lower values followed by polymerization of full intensity. However, there were no statistically significant differences, which are following the findings of *Chan et al* (2008), where restoration of class I and II polymerized soft-start technique did not show significant changes in terms of minor marginal leakage and postoperative sensitivity compared to restorations polymerized with classical techniques [32].

5. CONCLUSION

Flowable composites in this study have reduced gingival microleakage and can be used as liners in the restoration of cavities of class II.

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ПРОЦЈЕНА ГИНГИВАЛНЕ МИКРОПРОПУСТЉИВОСТИ У КОМПОЗИТНИМ РЕСТАУРАЦИЈАМА КАВИТЕТА II КЛАСЕ: ИН ВИТРО СТУДИЈА

Сажетак: Увод: Евалуација микропропустљивости важна је за процјену успјешности нових рестауративних материјала и метода. Циљ ове студије био је да се провјери гингивална микропропустљивост кавитета II класе употребом различитих течних композита као лајнера и двије различите технике полимеризације класичне и софт старт.

Материјал и методе: 40 екстрахованих људских премолара са испрепарисаним кавитетима II класе мезијално и дистално (80 кавитета) подијељено је у четири групе: 1. Vertise Flow + микрохибридни композит Herculite 2. Surefil SDR Flow + микрохибридни композит Herculite 3. Tetric Flow + микрохибридни композит Herculite 4. контролна група, микрохибридни композит Herculite. Мезијални кавитети су полимеризовани класичном, а дистални софт старт техником полимеризације. Након тога, узорци су уроњени у 0,5% раствор сребро-нитрата и пресјечени у мезио-дисталном правцу. Помоћу стереомикроскопа (Никон – Јапан) при увеличању 40x испитивана је гингивална микропропустљивост кавитета. За статистичку анализу је примијењен Fisherov и Student-ов тест.

Резутати: Након примјене класичне технике полимеризације, сва три употријебљена течна композита, VF+Herculite, SDRF+Herculite, TF+Herculite показали су мању гингивалну микропропустљивост у односу на контролу. Ова разлика је била статистички значајна. Након примјене софт старт технике полимеризације VF+Herculite и SDRF+Herculite су показали статистички значајну редукцију гингивалне микропропустљивости, док је TF+Herculite показао упоредив резултат са контролом, без статистички значајне разлике. Није било статистички значајне разлике између класичне и софт старт технике полимеризације.

Закључак: Течни композити у овој студији редуковали су гингивалну микропропустљивост и могу се користити као лајнери у рестаурацији кавитета II класе.

Кључне ријечи: микропропустљивост, II класа, течни композити, полимеризација.

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