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The role of lining materials in minimizing microleakage in class I cavities restored with nanohybrid composites: an in vitro study lining materials and microleakage in nanohybrid restorations

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Abstract

INTRODUCTION. The increasing demand for esthetic dental treatments has led to composite resin restorations becoming the primary material for posterior tooth restorations. However, polymerization shrinkage remains challenging, leading to secondary caries and postoperative discomfort. Liners like resin-modified glass ionomer cement, flowable composites, and Ionosit-Baseliner can mitigate this issue.

AIM. To compare the effectiveness of three base liner materials – Ionosit Baseliner, nano-filled flowable composite, and resin-modified glass ionomer cement – in reducing microleakage in Class I cavities restored with nano-hybrid composite resin.

MATERIALS AND METHODS. Sixty extracted premolars were prepared with standardized Class I cavities and randomly assigned to three groups ($n=20$) based on the applied liner: (1) Ionosit Baseliner, (2) nano-filled flowable composite, and (3) resin-modified glass ionomer cement. Following liner placement, all cavities were restored with a nano-hybrid composite in increments and light-cured. After thermocycling, specimens were coated with nail varnish except for a 1 mm margin around the restoration and immersed in 2.5% methylene blue dye for 24 hours. The teeth were then sectioned and examined under a stereomicroscope at ×40 magnification. Microleakage was scored according to dye penetration depth. Data were analyzed using the Kruskal–Wallis test and post-hoc Dunn's test ($p<0.05$).

RESULTS. Ionosit Baseliner demonstrated the lowest median microleakage score [0.00 (IQR: 0.00–0.75)], which was significantly less than both the flowable composite group [2.00 (0.00–3.00), $p=0.0291$] and the resin-modified glass ionomer group [2.50 (0.00–4.00), $p=0.0106$]. No significant difference was observed between the flowable composite and resin-modified glass ionomer groups ($p>0.9999$).

CONCLUSIONS. Although none of the tested liners completely eliminated microleakage, Ionosit Baseliner provided significantly better marginal integrity compared to the other liners tested. This suggests that material selection, particularly a liner with lower polymerization shrinkage and appropriate mechanical properties, can improve the longevity and success of posterior composite restorations.

Keywords: composite resins, dental cavity preparation, glass ionomer cements, microleakage, nanohybrid, polymerization

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Роль подкладочных материалов в снижении микропроницаемости в кариозных полостях I класса, восстановленных наногибридными композитами: лабораторное исследование. Подкладочные материалы и микропроницаемость при реставрациях наногибридными композитами

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Резюме

ВВЕДЕНИЕ. Растущий спрос на эстетические стоматологические процедуры привел к тому, что композитные смолы стали основным материалом для реставрации зубов в задних отделах. Однако полимеризационная усадка остается серьезной проблемой, вызывая развитие вторичного кариеса и послеоперационный дискомфорт. Подкладочные материалы, такие как модифицированный смолой стеклоиономерный цемент, текучие композиты и Ionosit Baseliner, могут помочь в решении этой проблемы.

ЦЕЛЬ. Сравнить эффективность трех подкладочных материалов – Ionosit Baseliner, текучего композита с нанонаполнителем и модифицированного смолой стеклоиономерного цемента – в снижении микропроницаемости в полостях I класса, восстановленных наногибридной композитной смолой.

МАТЕРИАЛЫ И МЕТОДЫ. Шестьдесят удаленных премоляров были подготовлены с использованием стандартных полостей I класса и случайным образом разделены на три группы ($n = 20$) в зависимости от применяемого подкладочного материала: (1) Ionosit Baseliner, (2) текучий композит с нанонаполнителем, (3) модифицированный смолой стеклоиономерный цемент. После нанесения подкладки все полости восстанавливались наногибридной композитной смолой послойно с последующей полимеризацией светом. После термоциклирования образцы покрывали лаком, оставляя 1 мм по краю реставрации, и погружали в 2,5 % раствор метиленового синего красителя на 24 часа. Затем зубы разрезали и исследовали под стереомикроскопом с увеличением ×40. Микропроницаемость оценивали по глубине проникновения красителя. Данные анализировали с использованием теста Крускала–Уоллиса и пост-хок теста Данна ($p < 0{,}05$).

РЕЗУЛЬТАТЫ. Ionosit Baseliner продемонстрировал наименьший медианный показатель микропроницаемости [0,00 (IQR: 0,00–0,75)], что было значительно ниже, чем в группе с текучим композитом [2,00 (0,00–3,00), $p = 0{,}0291$] и группе с модифицированным смолой стеклоиономером [2,50 (0,00–4,00), $p = 0{,}0106$]. Значимых различий между группами с текучим композитом и модифицированным стеклоиономерным цементом не выявлено ($p > 0{,}9999$).

ВЫВОДЫ. Несмотря на то, что ни один из протестированных материалов полностью не устранил микропроницаемость, Ionosit Baseliner обеспечил значительно лучшую краевую целостность по сравнению с другими подкладками. Это свидетельствует о том, что выбор материала, в частности подкладки с минимальной полимеризационной усадкой и соответствующими механическими свойствами, может повысить долговечность и успех реставраций задних зубов.

Ключевые слова: композитные смолы, подготовка зубных полостей, стеклоиономерные цементы, микропроницаемость, наногибрид, полимеризация

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INTRODUCTION

The growing demand for esthetic dental treatments has led to composite resin restorations becoming the preferred choice for replacing failed amalgam restorations and as the primary material for posterior tooth restorations. Recent advancements in composite resins have significantly enhanced their mechanical properties, wear resistance, and esthetic appeal [1]. However, one of the main challenges with composite resins remains polymerization shrinkage. During light curing, resin monomers shrink by 1.67% to 5.68%, generating internal stress within the material. This shrinkage stress can lead to cuspal deflection, enamel fracture, marginal discoloration, and microleakage, which are major factors contributing to secondary caries and postoperative discomfort. Minimizing polymerization shrinkage remains a critical area of research in restorative dentistry [2].

The use of liners has emerged as an effective strategy to mitigate the effects of polymerization shrinkage. Resin-modified glass ionomer cements, often used as a base, offer improved mechanical strength and quicker setting times while being less technique-sensitive. Their use as liners under composite restorations has been shown to reduce polymerization shrinkage, potentially minimizing microleakage and the risk of secondary caries [3]. Flowable composites are also commonly used as base or liner materials due to their higher organic matrix content, which improves their flow characteristics. However, this also leads to greater polymerization shrinkage compared to hybrid composites. Despite this, their lower Young's modulus allows them to absorb internal stresses more effectively, making them a viable option to help control shrinkage stress during curing which can in turn reduce the microleakage [4]. Ionosit-Baseliner, a newer base liner material, combines the beneficial properties of both glass ionomers and composites, also known as compomers. According to the manufacturer, Ionosit-Baseliner has an expansion rate of approximately 1%, which can counterbalance the shrinkage stress of overlying composite resins, potentially enhancing marginal integrity and reducing the microleakage [5].

This laboratory-based study seeks to compare the effectiveness of resin-modified glass ionomer cement, flowable composite, and Ionosit base liners in reducing microleakage in Class I cavities restored with nano-hybrid composite resins, using dye penetration tests to assess the marginal integrity. While few previous studies have examined the comparative effects of these three lining materials, this research seeks to provide insights into their relative performance in reducing microleakage.

MATERIALS AND METHODS

Selection of Teeth. Sixty premolars, extracted for orthodontic purposes, were chosen for this study. The teeth were thoroughly cleaned and preserved in a 0.5% chloramine solution at 4°C until required for experimentation. Each tooth was inspected under ×10 magnification with an optical microscope to confirm the absence of cracks, defects, or caries.

Cavity Preparation. Standardized Class I cavities were prepared on each tooth using a high-speed handpiece with water coolant. The cavity dimensions were approximately 4 mm in width, 2 mm in height, and 1.5 mm in depth. The cavosurface margins were designed with butt joint with rounded internal line. A new bur was employed after every five cavity preparations to maintain consistency. A William's periodontal probe was utilized to verify the cavity dimensions.

Restorative Procedure. The tooth samples were randomly divided into three groups ($n=20$) based on the liner materials applied as per the manufactures directions:

Group 1: A 1 mm layer of Ionosit Baseliner was applied to the pulpal floor and cured for 40 seconds.

Group 2: A 1 mm layer of nano-filled flowable composite was applied, then cured for 20 seconds.

Group 3: A 1 mm layer of light-cured resin-modified glass ionomer cement was applied and cured for 20 seconds.

After the liner was applied, each cavity was restored incrementally with a nano-hybrid composite, which was cured for 20 seconds per increment.

Marginal Microleakage Evaluation. The restorations were polished 24 hours after placement using finishing diamond burs and sequential abrasive disks (Sof-Lex, 3M ESPE). The specimens were subsequently stored in distilled water at 37°C for seven days before being subjected to 800 thermal cycles between 5°C and 55°C, with a 30-second dwell time for each cycle. Each specimen was coated with two layers of nail varnish, leaving a 1 mm margin around the cavity edges. Sticky wax was applied to the apex, and the specimens were then immersed in a 2.5% methylene blue dye solution for 24 hours at 37°C. After dye immersion, each specimen was rinsed with tap water, and the nail varnish was removed using a BP blade. The specimens were longitudinally sectioned through the center buccolingually of each restoration using a water-cooled, low-speed diamond disc. The sectioned halves of the teeth were then examined under a stereomicroscope at ×40 magnification to evaluate microleakage. The linear diffusion of the dye from the external margin was measured for each sample. The extent of microleakage was recor-/ded based on the penetration of dye between the tooth structure and the restoration, and scored according to the established criteria as follows:

Score 0: No leakage visible.

Score 1: Dye penetration along the cavity wall, less than half the cavity depth.

Score 2: Dye penetration along the cavity wall, more than half the cavity depth.

Score 3: Dye penetration reaching and spreading along the axial wall.

Figure 1 depicts the stereomicroscopic evaluation for the three study groups.

Statistical Analysis. The results were statistically analyzed using the Kruskal-Wallis test, followed by post-hoc Dunn's test for pairwise comparisons between groups, as the scores were ordinal. A significance level of $p<0.05$ was applied for the statistical analyses.

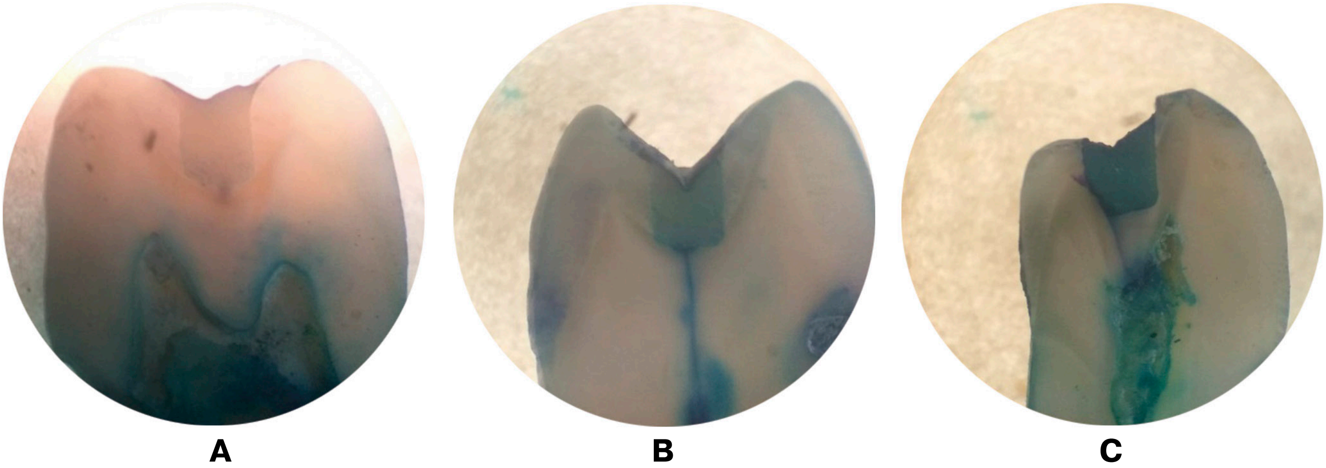

Fig. 1. Microleakage assessment using a stereomicroscope for: *A* – group I: Ionosit base liner; *B* – flowable composite; *C* – resin modified glass Ionomer cement

Рис. 1. Оценка микропроницаемости с использованием стереомикроскопа для: *A* – группы I: базового лайнера Ionosit; *B* – текучего композита; *C* – модифицированного смолой стеклоиономерного цемента

Table 1. Descriptive statistics (median and interquartile range) and Inter-Group comparisons of microleakage scores of the three study groups

Таблица 1. Описательная статистика (медиана и межквартильный размах) и межгрупповые сравнения показателей микропроницаемости в трех исследуемых группах

Groups	Microleakage scores	*p*-value†
I ($n = 20$)	0,00 (0.00–0.75)ᴬ	<0.001*
II ($n = 20$)	2.00 (0.00–3.00)ᴮ	
III ($n = 20$)	2.50 (0.00–4.00)ᴮ	

Note: n – number of samples per group; † – analyzed by the Kruskal Wallis test; § – analyzed by Friedman's ANOVA test. Different superscript letters indicate significant differences between the pairs of cross-sectional levels for each study group. * statistically significant ($p \leqslant 0.05$)

Примечания: n – количество образцов в группе; † – анализ проведен с использованием теста Краскала–Уоллиса; § – анализ проведен с использованием дисперсионного анализа Фридмана (ANOVA).

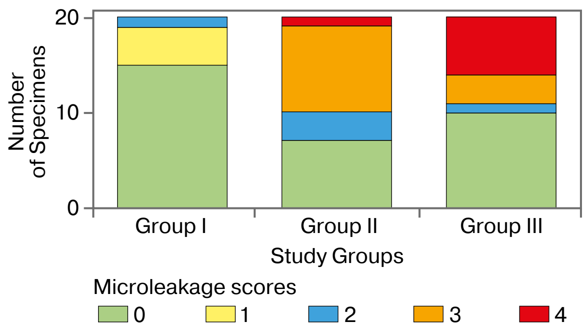

Fig. 2. Distribution of Microleakage scores for the study groups

Рис. 2. Распределение показателей микропроницаемости для исследуемых групп

RESULTS

Group I demonstrated the least microleakage scores with a median of 0.00 (IQR: 0.00–0.75), followed by Group II [2.00 (IQR: 0.00–3.00)] and Group III [2.50 (IQR: 0.00–4.00)]. Pairwise comparisons revealed significant differences between Group I and Group II ($p = 0.0291$) and between Group I and Group III ($p = 0.0106$), while no significant difference was observed between Group II and Group III ($p > 0.9999$). The median scores have been tabulated in Table 1 and the distribution of scores has been illustrated in Figure 2.

DISCUSSION

Composite materials have evolved from macrofilled to microfilled formulations, and more recently, hybrid and novel filler systems like nanohybrids, true nanocomposites, and nanoclusters have been introduced. During the curing of resin composites, polymerization shrinkage occurs, leading to the generation of contraction stresses. The extent of this shrinkage and the resulting stress are critical factors that lead to clinical problems like postoperative sensitivity, inadequate marginal fit, and the recurrence of caries. Polymerization shrinkage is affected by several factors, such as the filler content, the nature of the filler particles, and the type of monomer systems used [6; 7].

This study employed standardized Class I cavities, considering the "C-factor" – the ratio of bonded to unbonded surfaces, which has a significant impact on polymerization shrinkage. Additionally, all specimens were subjected to thermocycling to simulate oral environmental conditions, thereby enhancing the effectiveness of the study in detecting microleakage [8].

Incorporating an "elastic" base or liner material has been proposed as a potential solution overcome the limitation of composites Materials like resin-modified glass ionomer cement, flowable composites, and Ionosit base liner have a lower modulus of elasticity, which makes them more flexible and able to undergo plastic deformation, reducing the effects of polymerization shrinkage. The natural flow and capacity of these molecules to adjust their positions and orientations help offset the stresses from polymerization shrinkage, thus supporting the integrity of the adhesive bond. This study aimed to evaluate the effectiveness of these three base liners in mitigating microleakage under Filtek Z350XT, a nanofilled composite recognized for its high compressive strength with reduced polymerization shrinkage, was consistently used as the standard material across all groups [9].

Microleakage is generally examined using in vitro models rather than in vivo techniques. The methods employed for assessment can be categorized into traditional and modern approaches. Earlier techniques, including air pressure, fluid filtration, electrochemical analysis, neutron activation, bacterial penetration, and artificial caries creation, were inadequate in accurately replicating microleakage scenarios. Consequently, these have been largely replaced by more advanced methods. Contemporary approaches, such as dye penetration and radioisotope techniques, are often coupled with stereomicroscope analysis [10]. In this study, the dye penetration method was utilized to evaluate microleakage due to its advantages, including the absence of reactive chemicals or radiation exposure and the availability of various dye options, which make it both practical and dependable. Among the dyes, methylene blue is widely recognized for microleakage analysis because its low molecular weight allows it to penetrate even the most inaccessible areas effectively [11].

The current study employed a total-etch technique for groups 1 and 2, which is in accordance with the findings of a similar study by Pattama et al. Their research demonstrated that using a fifth-generation bonding agent resulted in the total-etch system exhibiting lower microleakage, with reduced dye penetration compared to the self-etch system. This aligns with several previous studies showing that functional stresses play a important role in the degradation of adhesive bonds. Repeated mechanical loading causes micro-fractures and cracks within the resin composite, and multi-step adhesive systems have been found to perform better in vitro tests than single-step adhesive systems [12].

The current study found that the Ionosit base liner exhibited the lowest degree of microleakage in comparison to the other groups. This reduced microleakage is likely due to the Ionosit base liner's diminished polymerization shrinkage, which leads to decreased stresses transmitted to the underlying dentin. The stress transferred to the dentin is influenced by the mechanical properties of the liner, particularly its stiffness. When the liner layer has a relatively high stiffness, it becomes less effective in mitigating the residual stress through deformation. Additionally, if the Poisson's ratio of the liner is excessively high, it may induce undesirable lateral deformation, increasing the residual stress transmitted to the dentin. Furthermore, Ionosit base liners possess antimicrobial properties comparable to other liners due to their fluoride release, which can potentially reduce bacteria in the prepared dental cavity walls [13; 14].

The present study found that none of the base liner materials were able to fully eliminate the occurrence of microleakage. This investigation corroborates previous research on microleakage associated with resin composite restorations, indicating that leakage is a common rather than exceptional finding. Furthermore, consistent with existing literature, variations in the intermediate materials employed were unable to completely mitigate microleakage [15; 16].

CONCLUSION

In conclusion, this study underscores the persistent challenge of microleakage in resin composite restorations, despite advancements in materials and techniques. While none of the tested liners could entirely eliminate microleakage, Ionosit demonstrated a relatively lower level of leakage, likely due to its reduced polymerization shrinkage and stress-transmitting properties. The results affirm that the mechanical properties and formulation of base liners significantly influence their performance in mitigating shrinkage-induced stresses. However, microleakage remains a prevalent issue, even with optimized filler compositions and advanced bonding systems. These findings highlight the need for continued research into innovative materials and techniques to further reduce microleakage and improve the long-term success of resin composite restorations in clinical practice.

REFERENCES / СПИСОК ЛИТЕРАТУРЫ

1. Mackenzie L., Shortall A., Burke T., Parmar D. Posterior composites: An update. *Dent Update*. 2019;46(4):323–343. https://doi.org/10.12968/denu.2019.46.4.323
2. Zhang N., Xie C. Polymerization shrinkage, shrinkage stress, and mechanical evaluation of novel prototype dental composite resin. *Dent Mater J*. 2020;39(6):1064–1071. https://doi.org/10.4012/dmj.2019-286
3. Elgezawi M., Haridy R., Abdalla M.A., Heck K., Draenert M., Kaisarly D. Current strategies to control recurrent and residual caries with resin composite restorations: Operator- and material-related factors. *J Clin Med*. 2022;11(21):6591. https://doi.org/10.3390/jcm11216591
4. Kalakijuybari F.Z., Pasdar N., Ahmadi G., Seyedmajidi A. Investigating the impact of flowable composite liner on the fracture strength and microleakage of large composite resin restorations of primary anterior teeth. *Eur Arch Paediatr Dent*. 2023;24(4):473–479. https://doi.org/10.1007/s40368-023-00812-3
5. Sun T., Shao B., Liu Z. Effects of the lining material, thickness and coverage on residual stress of class II molar restorations by multilayer technique. *Comput Methods Programs Biomed*. 2021;202:105995. https://doi.org/10.1016/j.cmpb.2021.105995
6. Prakash V., Kumar P., Banu S., Sukumaran V.G., Subbiya A., Vivekanandhan P. Comparision of true nano

with microhybrid and nanocluster composite before and after tooth brushing. *Biosci Biotech Res Asia*. 2016;13(4):2365–2370. https://doi.org/10.13005/bbra/2407

7. Münchow E.A., Meereis C.T.W., de Oliveira da Rosa W.L., da Silva A.F., Piva E. Polymerization shrinkage stress of resin-based dental materials: A systematic review and meta-analyses of technique protocol and photo-activation strategies. *J Mech Behav Biomed Mater.* 2018;82:77–86. https://doi.org/10.1016/j.jmbbm.2018.03.004
8. Singh T.V., Patil J.P., Raju R.C., Venigalla B.S., Jyotsna S.V., Bhutani N. Comparison of effect of C-factor on bond strength to human dentin using different composite resin materials. *J Clin Diagn Res*. 2015;9(8):ZC88–91. https://doi.org/10.7860/JCDR/2015/14026.6384
9. Rizk H.M., Al-Ruthea M., Habibullah M.A. The effect of three lining materials on microleakage of packable composite resin restorations in young premolars with cavity margins located on enamel and dentin/cementum – An In vitro study. *Int J Health Sci*. 2018;12(6):8–17.
10. AlHabdan A.A. Review of microleakage evaluation tools. *Journal of International Oral Health.* 2017;9(4):141–145. https://doi.org/10.4103/jioh.jioh_160_17
11. Kini A., Shetty S., Bhat R., Shetty P. Microleakage evaluation of an alkasite restorative material: An in vitro dye penetration study. *J Contemp Dent Pract*. 2019;20(11):1315–1318. https://doi.org/10.5005/jp-journals-10024-2720
12. Naga A.A., Yousef M., Ramadan R., Fayez Bahgat S., Alshawwa L. Does the use of a novel self-adhesive flowable composite reduce nanoleakage? *Clin Cosmet Investig Dent*. 2015;7:55–64. https://doi.org/10.2147/CCIDE.S80462
13. Kazeroonizadeh N., Kazemian M., Mirzakoochaki P. An in-vitro study of the antibacterial efficacy of cavity liners against streptococcus mutans and lactobacillus casei. *J Res Dentillofac Sci*. 2017;2(2):23–28. https://doi.org/10.29252/jrdms.2.2.23
14. Haifeng T., Bin X., Liangwen P., Mengmeng J., Guoxiu X. Comparison of the sensitivity of two filling materials for deep caries filling of posterior teeth. *Stomatology.* 2014;34:49–51.
15. Yantcheva S.M. Marginal adaptation and micropermeability of Class II cavities restored with three different types of resin composites – a comparative ten-month in vitro study. *Polymers*. 2021;13(10):1660. https://doi.org/10.3390/polym13101660
16. Gutierrez N.C., Batista G.R., Costa Perote L.C.C., Beber Kamozaki M.B., de Araújo M.A.M., Gomes Torres C.R. Effects of composite viscosity and adhesive curing mode on marginal sealing of restorations. *J Adhes Sci Technol*. 2017;31(21):2349–2359. https://doi.org/10.1080/01694243.2017.1301072

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