Original Research

Microleakage in Premolar Class I Restorations Between Nanohybrid and Microhybrid Composites: A Comparative *In Vitro* Study

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Abstract

Aim: To compare microleakage in premolar class I restorations between nanohybrid and microhybrid composites in an *in vitro* study. **Materials and Methods:** Overall, 32 healthy premolar permanent teeth extracted for reasons unrelated to the study were used. Class I Black restorations were performed and divided into two groups. Group A: microhybrid resin, Group B: nanohybrid resin. Both groups were subjected to manual thermocycling (300 cycles at 5, 37, and 55°C), and they were then immersed in 2% methylene blue during 24 h. Subsequently, the samples were washed, dried, sectioned, and observed under a stereoscopic microscope. **Results:** In the microhybrid resin composite (MRC) group, only two teeth (28.8%) did not show filtration (Grade 0), whereas eight of the specimens evaluated (80%) showed Grade 3 filtration (dye penetration to the pulpal floor). On the other hand, in the nanohybrid resin composite (NRC) group, the highest prevalence was found in Grade 1 (no dye penetration) in eight specimens (66.7%). There was no statistically significant association between the degree of filtration and the type of resin composite used ($P = 0.089$). **Conclusions:** Both materials showed microleakage, but the microhybrid resin presented a higher degree of filtration compared with the nanohybrid resin. No statistically significant association was found with the degree of microleakage between the resins.

Keywords: In Vitro, Microhybrid Composite, Microleakage, Nanohybrid Composite

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Introduction

The use of composite resins for the restoration of carious lesions is one of the clinical options most commonly used by many oral health professionals, due to its aesthetic characteristics, biocompatibility, and durability. One of the main goals of correct restoration with composite resin is to prevent the presence of recurrent caries and avoid the progress of the carious process toward pulp damage, but microleakage can occur due to the interface between empty spaces formed during the placement of composite resin.[1-4]

One of the major causes of failure in resin restorations is marginal maladaptation and polymerization shrinkage that occurs when the monomers in the matrix cross to form a polymer mesh and the coefficient of thermal variation typical of resins. Therefore, by decreasing the volume of the polymerized composite resin, internal stress occurs within the restoration, leading to detachment of the interface, thereby giving rise to the formation of voids. This causes the development of marginal gaps through which bacteria from the oral microbiota can penetrate.[5-8]

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Currently, new materials and operative techniques have been developed to reduce microleakage problems, by increasing the filling load, and changing the monomer formulation of the matrix, giving rise to new formulas in composite resins such as nanofillers, microhybrid, and nanohybrid, among others. Hybrid resins have better polymerization shrinkage, low water absorption, a range of colors for better mimicry with the tooth structure, and various levels of translucency and opacity in many shades, all of which provide an excellent polishing and a good coefficient of thermal variation.[9-12]

To carry out this type of test, the thermocycling process is used, which is one of the most commonly used methods for aging dental restorations in *in vitro* studies. The thermocycling process consists of different temperature cycles that seek to simulate the thermal changes it undergoes resin restoration in the oral cavity. These thermal changes influence the coefficient of thermal expansion, which, over time, leads to aging and the formation of gaps between the tooth and the restoration.[6,8,12,13]

The aim of the present study was to compare microleakage in premolar class I restorations between nanohybrid and microhybrid composites in an *in vitro* study.

Materials and Methods

Sample size and design

The research was a prospective, *in vitro* experimental study in which (n = 16) premolar teeth for each group that had been previously disinfected with 0.9% sodium hypochlorite solution were evaluated. The sample size was established in relation to data from a previous pilot study by using a formula for comparing means with an alpha of 0.05 and a beta of 0.8 by using the Statistical Software Stata® 15 (Texas, USA).

Inclusion criteria were: premolars with coronary integrity, freshly extracted premolars for orthodontic reasons, and upper or lower premolars of both sexes. Exclusion criteria were: premolars with enamel and/ or dentin defects, premolars with carious lesions, and premolars with previous restorations.

Allocation

The teeth were randomly distributed into two groups (Group A and Group B) consisting of 16 premolars each. Class I cavities were then prepared in each tooth in the two groups [Figure 1].

Group A: 16 teeth restored with Te-Econom Plus® resin, Ivoclar, Vivadent (Microhybrid).

Group B: 16 teeth restored with Tetric® N-Ceram resin, Ivoclar, Vivadent (Nanohybrid).

Cavity preparation

Initially, the calibration of the limits of the cavity preparations was performed with a metal caliper. For the cavity preparation, 125 µm medium-grain round-tip cylindrical burs (B001-018) (Kulzer México S.A.) were used to shape the cavity floor. Diamond burs that had undergone abundant refrigeration were used, and they were changed every five preparations. The preparation measurements were 2 mm deep at the occlusal and labial face.

Restoration

After the elaboration of the cavities, the preparations were washed; they were then etched by using orthophosphoric acid 37% Gel Etch-37™ w/BAC (Illinois, USA) for 15 s, followed by washing with distilled water for 15 s, and finally drying. Subsequently, the adhesive was applied for 10 s, to then light cure perpendicular to the axial axis of the tooth for 30 s in Group A (Te-Econom Plus®) and Group B (Tetric® N-Ceram) following the manufacturer's instructions. After completing these steps, both nanohybrid and microhybrid resins were applied in their respective groups and light cured for 30 s in both groups. Resin polishing rubber (Jiffy® Polishers, Ultradent Spain) was used for polishing the restorations.

Thermocycling

The teeth were stored in physiological saline at 37°C during 24 h. After this time, the manual thermocycling process was carried out. In this process, the teeth of each group were placed on a base for thermocycling with the aim of aging the properties of the restorative material for 300 cycles between 55°C ±5 s, 37°C ± 30 s, and 5°C ± 5 s, with an interval of 3 s, with 5°C and 55°C being the minimum and maximum temperatures used. Nail polish was then placed on all the samples except the occlusal surface, and they were placed in a 2% methylene blue solution ($C_{16}H_{18}ClN_3S$* x H_2O) (C.I. 52015, Merck, Darmstadt, Germany) for 24 h at room temperature. The samples were then washed with water for 5 min to undo the remains of dye in the samples. Afterward, the nail polish was removed with acetone.

Microleakage

With the use of a biactive metal disk, longitudinal cuts were made in the vestibule-lingual direction and

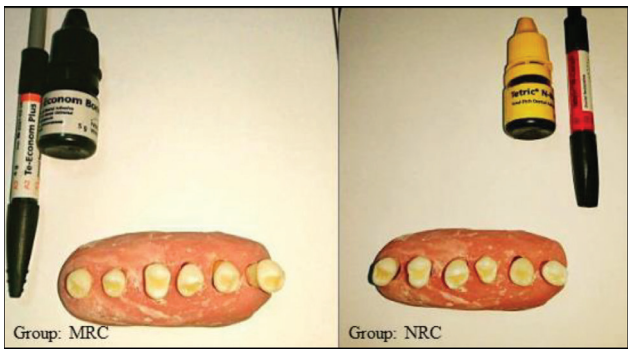


Figure 1: Restored premolar teeth in both groups (MRC and NRC)

transverse cuts were made at the level of the third of the root in the teeth at the level of the occlusal surface. The samples were placed on a slide and examined under the SZX7 Olympus stereomicroscope 50×, (Miami, USA) to evaluate the degree of penetration of the marker agent. The classification system[1] used to evaluate dye penetration was: Grade 0 = No dye penetration; Grade 1 = Dye penetration only into enamel; Grade 2 = Dye penetration to dentin, but not to pulp floor; and Grade 3 = Penetration of the dye into the pulp floor or axial wall [Figure 2].

Statistical analysis

The frequencies and percentages were obtained to show the microleakage among all the groups evaluated. To perform the inferential analysis, the Fisher's exact test was used to determine the association between the degree of filtration and the type of material restored with a significance level of $P < 0.05$. All analyses were performed by using Stata® v15 statistical software (Texas, USA).

Results

It was found that according to the grading system used to evaluate penetration in the MRC group, only two teeth (28.8%) did not show filtration (Grade 0), whereas the majority of specimens evaluated (8: 80%) had Grade 3 filtration (dye penetration to the pulpal floor). On the other hand, in the NRC group, Grade 1 filtration had the highest prevalence (dye penetration only into enamel) in eight teeth (66.7%) [Table 1 and Graph 1].

The Fisher's exact test showed no significant association between the degree of filtration and the type of composite used ($p = 0.089$) [Table 1].

Discussion

At present, teeth restoration with composite resins is the option most frequently used for the treatment of dental caries. However, certain characteristics of the composite resins present limitations, with the coefficient of thermal variation being of great influence because it is in proportion to the amount of organic material and inverse to inorganic filler content.[12-15] As the enamel coefficient is different from that of the resin, thermal changes occur at the interface between the tooth and fillings, generating a percolation phenomenon that facilitates marginal microleakage.[9-12]

Nanohybrid and microhybrid resins have a decreased organic matrix to thus reduce the coefficient of thermal variation in resin and attempt to resemble that of the tooth to reduce marginal microleakage. According to previous studies, the most widely used method to evaluate the consequences of changes in the coefficient of variation is the thermocycling process.[13] This process seeks to resemble as much as possible the changes in tooth temperature by going through different cycles of temperature, since the presence of hot water stimulates hydrolysis and elution of interface elements, generating stress in the material, resulting in repetitive contraction and expansion as a consequence of this process.

Marginal microleakage is one of the most important causes of the formation of recurrent caries, and various factors of composite resins can give rise to the formation of small gaps in the tooth–resin interface.[1,3,6,9,11] One of the most important factors is the coefficient of thermal variation, which, as it differs between the tooth and the resin, produces the percolation phenomenon. Previous clinical studies have described a decrease in the effectiveness

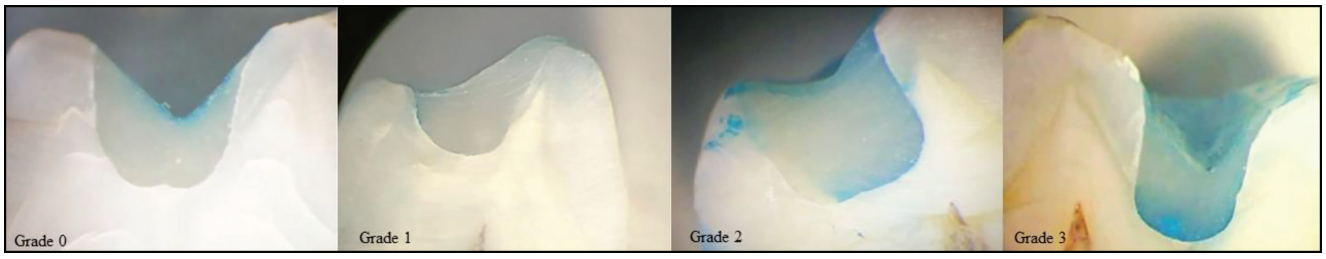


Figure 2: Degree of coronal microleakage (Grade 0 and 1= MRC; Grade 2 and 3: NRC)

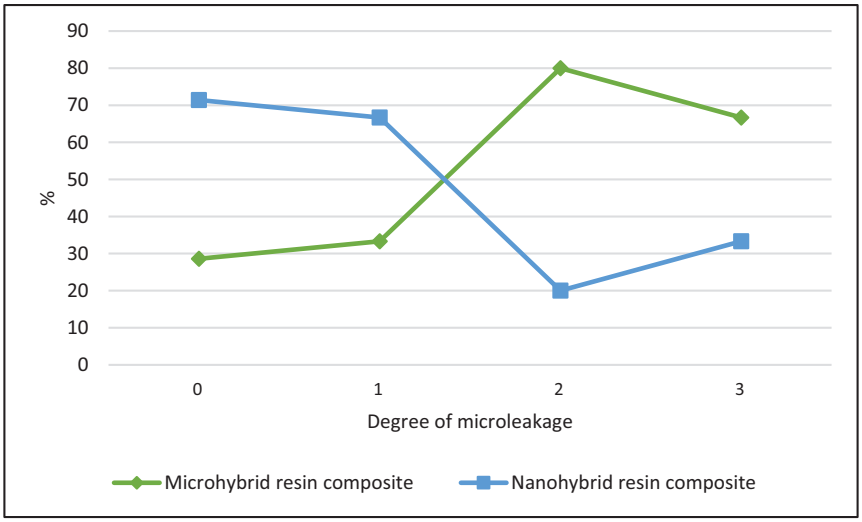
Table 1: Degree of microleakage between nanohybrid and microhybrid resins

Groups	Grade										*P**
	0		1		2		3		Total		
MRC	2	28.6%	4	33.3%	8	80%	2	66.7%	16	50%	
NRC	5	71.40%	8	66.7%	2	20%	1	33.3%	16	50%	0.089
Total	7	100%	12	100%	10	100%	3	100%	32	100%	

An analysis was previously carried out to observe the concordance between the measurement of the researcher and the specialist in the area, Kappa = 0.98.

MRC = Microhybrid resin composite; NRC = nanohybrid resin composite.

*Fisher's exact test $P < 0.05$.



Graph 1: Comparison of the degree of microleakage between nanohybrid and microhybrid composites

of some dental materials, whereas other studies have reported greater stability. We, therefore, sought to evaluate the degree of marginal microleakage between two types of resin, nanohybrid and microhybrid resin, since in most cases the effectiveness of restorative and adhesive systems with these resins has shown to be very favorable.

In a study using the same methodology as our research, Shih[1] reported that microleakage can cause tooth sensitivity, secondary cavities, discoloration, and even restoration failure. They compared microleakage in amalgam (Am), composite resin, and glass ionomer, in the class II restoration of primary molars and found that restorations using glass ionomer performed better than the other dental materials evaluated. However, absence of filtration was not observed with any of the materials analyzed. In another study showing similar results, Punathil *et al.*[4] evaluated microleakage in primary teeth restored with tooth-coloring materials by using the stain penetration method. This study showed significantly less microleakage in the nano-filled resin-modified glass ionomer group than the group with nanocomposite resin. Therefore, they suggested that interdisciplinary treatment is the most appropriate option in the management of decayed teeth involving gingival recession and cervical extension.

Similarly, according to the study by Hussain *et al.*,[6] when a composite is used to restore tooth decay, stresses are generated at the edges of the restoration. If these forces are too tense, they could cause micro cracks in the tooth–composite interface. They concluded that with respect to microleakage in class V cavities, Z350 resin was superior on the occlusal surface. However, in general, there was no statistically significant difference in the microleakage of the two materials evaluated. On the other hand, according to Kasraei *et al.*,[16] microleakage in the cementum–dentinal margins is one of the most important causes for the failure of restorations. This investigation measured microleakage at the margins of class II restorations by using resin-modified glass ionomer and flowable composite. They found that the resin-modified glass ionomer decreased microleakage in class II composites.

Zhu *et al.*[17] compared microleakage in the occlusal and cervical wall in class V by using the Ivoclar Tetric N Ceram composite, the Tetric N Flow composite, and the N Ceram nanocomposite. They found that the Tetric Bulk Fill resin presented significantly lower microleakage in the cervical margins than the other groups ($P < 0.05$). This study, like ours, is important because they explain the presence of marginal microleakage as a major factor for the formation of recurrent caries. It should be taken into account that if the coefficient of variation of the resin properties is different from that of the tooth, this will cause problems at the resin–tooth interface.

The new nanohybrid and microhybrid resins present a greater inorganic filler that is able to lower the coefficient of thermal variation, approaching that of the tooth. The present study aimed at expanding the knowledge of these two types of resins by comparing the percentage in which one avoids greater microleakage than the other in class I restorations in premolars, which are the most indicated in superficial caries. The results of the present study provide information of the important role that biomaterials play in obtaining good results in teeth restoration in the clinical setting. Since each dental material has its own indications, handling and temperature, these must be taken into account to avoid any subsequent problems such as marginal microleakage, thus reducing recurrent caries formations.

The main limitation of this research was access to material resources for its execution. Another limitation was that it can only be evaluated with a single microleakage method;

however, it has been shown that the dye penetration method provides a quick and real visualization. Further studies are needed to carry out the same measurements of microleakage evaluation over a longer period. Therefore, it is recommended to expand this research by increasing and varying thermocycling cycles to achieve a more accurate simulation of the conditions of restorations in the mouth, considering temperature as an important factor. In addition, similar studies are needed involving other types of restoration to evaluate whether the degree of microleakage increases or varies with these resins. Similar studies should be carried out in deciduous dentition, considering that they are more susceptible to recurrent caries.

Conclusion

Within the limitations of this *in vitro* study it was determined that both of the materials tested showed microleakage, with the microhybrid resin showing a higher percentage compared with the nanohybrid resin. Finally, no statistically significant association was found in the degree of microleakage between the nanohybrid and microhybrid resins.

Future scope/clinical significance

The clinical significance of the study consists of the applicability based on evidence of nanohybrid resins in the oral cavity due to the fact that they present an adequate degree of microleakage.

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Nil.

Conflicts of interest

None to declare.

Author contributions

Study conception (GS, GA, RW, DSM), data collection (GS, GA, RW), data collection and analysis (GS, GA, DSM), data interpretation (FMT, DAT, RW), and article writing (DAT, RW, GA, DSM, FMT).

Ethical policy and institutional review board statement

Not applicable.

Patient declaration of consent

Not applicable.

Data availability statement

The data that support the study results are available from the author (Dr. Gerardo Ayala, e-mail: gayala@unmsm.edu.pe) on request.

References

1. Shih WY. Microleakage in different primary tooth restorations. J Chin Med Assoc 2016;79:228-34.
2. Omidi BR, Naeini FF, Dehghan H, Tamiz P, Savadroodbari MM, Jabbarian R. Microleakage of an enhanced resin-modified glass ionomer restorative material in primary molars. J Dent (Tehran) 2018;15:205-13.
3. Khoroushi M, Karvandi TM, Kamali B, Mazaheri H. Marginal microleakage of resin-modified glass-ionomer and composite resin restorations: Effect of using etch-and-rinse and self-etch adhesives. Indian J Dent Res 2012;23:378-83.
4. Punathil S, Almalki SA, AlJameel AH, Gowdar IM, Mc VA, Chinnari K. Assessment of microleakage using dye penetration method in primary teeth restored with tooth-colored materials: An in vitro study. J Contemp Dent Pract 2019;20:778-82.
5. Ruiz S, Díaz-Soriano A, Gallo W, Perez-Vargas F, Munive-Degregori A, Mayta-Tovalino F. Assessment of structural changes in translucency and opacity of tooth enamel against a direct demineralization process: An in vitro study. J Int Soc Prev Community Dent 2020;10:473-80.
6. Hussain SM, Khan FR. In-vitro comparison of micro-leakage between nanocomposite and microhybrid composite in class V cavities treated with the self-etch technique. J Ayub Med Coll Abbottabad 2016;28:445-8.
7. Khosravi K, Mousavinasab SM, Samani MS. Comparison of microleakage in class II cavities restored with silorane-based and methacrylate-based composite resins using different restorative techniques over time. Dent Res J (Isfahan) 2015;12:150-6.
8. Bagis YH, Baltacioglu IH, Kahyaogullari S. Comparing microleakage and the layering methods of silorane-based resin composite in wide class II MOD cavities. Oper Dent 2009;34:578-85.
9. Sharma RD, Sharma J, Rani A. Comparative evaluation of marginal adaptation between nanocomposites and microhybrid composites exposed to two light cure units. Indian J Dent Res 2011;22:495.
10. Yalçin F, Korkmaz Y, Başeren M. The effect of two different polishing techniques on microleakage of new composites in class V restorations. J Contemp Dent Pract 2006;7:18-25.
11. Hardan LS, Amm EW, Ghayad A, Ghosn C, Khraisat A. Effect of different modes of light curing and resin composites on microleakage of class II restorations–part II. Odontostomatol Trop 2009;32:29-37.
12. Tavangar M, Zohri Z, Sheikhnezhad H, Shahbeig S. Comparison of microleakage of class V cavities restored with the embrace wetbond class V composite resin and conventional opallis composite resin. J Contemp Dent Pract 2017;18:867-73.
13. Guéders AM, Charpentier JF, Albert AI, Geerts SO. Microleakage after thermocycling of 4 etch and rinse and 3 self-etch adhesives with and without a flowable composite lining. Oper Dent 2006;31:450-5.
14. Behery H, El-Mowafy O, El-Badrawy W, Nabih S, Saleh B. Gingival microleakage of class II bulk-fill composite resin restorations. Dent Med Probl 2018;55:383-8.
15. Shafiei L, Mojiri P, Ghahraman Y, Rakhshan V. Microleakage of a self-adhesive class V composite on primary and permanent dentitions. J Contemp Dent Pract 2013;14:461-7.
16. Kasraei S, Azarsina M, Majidi S. In vitro comparison of microleakage of posterior resin composites with and without liner using two-step etch-and-rinse and self-etch dentin adhesive systems. Oper Dent 2011;36:213-21.
17. Zhu Z, Zhu YQ. [Comparative evaluation of marginal microleakage of three different resins in class V composite restorations]. Shanghai Kou Qiang Yi Xue 2017;26:241-5.