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Microleakage in lithium disilicate veneers cemented with resin cement and thermally modified resin*

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ABSTRACT

Objective: To determine *in vitro* microleakage in lithium disilicate veneers cemented with resin cement and thermally modified resin. **Materials and methods:** An *in vitro* study was conducted using 20 maxillary premolars, on which lithium disilicate veneers were cemented. The specimens were divided into two groups of ten samples each. Each tooth was prepared on the vestibular surface for subsequent veneer fabrication. In Group 1, veneers were cemented with resin cement (Nexus-3), whereas in Group 2, thermally modified resin (Herculite PrécisTM) was used. Subsequently, the teeth underwent a thermocycling process and were immersed in a 2% methylene blue solution for five days, after which sagittal sections were performed for observation under an optical microscope. **Results:** A higher percentage of microleakage was observed in the group cemented with resin cement (47.5%; n = 19) compared to the group treated with thermally modified resin (32.5%; n = 13), with a p-value = 0.018. Additionally, greater microleakage was detected at the cervical and mid-levels in the resin cement group compared to the thermally modified resin group, with a p-value = 0.046. **Conclusion:** Microleakage was observed in both groups. When comparing the two luting agents, resin cement showed significantly greater microleakage than thermally modified resin.

Keywords: resin cements; dental cements; microleakage; dental porcelain.

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INTRODUCTION

Aesthetic veneers are a widely used therapeutic alternative in restorative dentistry, aimed at covering the buccal surface of teeth to correct issues such as caries, defective restorations, fractures, discolorations, and morphological anomalies. However, some patients have been reported to experience dental sensitivity after the placement of these restorations, which may be related to various clinical factors, including the cementation protocol, the type of luting agent used, and the condition of the dental substrate. These factors directly influence the occurrence of marginal microleakage, a phenomenon associated with the loss of sealing between the restoration and the prepared tooth, with potential unfavorable clinical implications (1).

Regarding cementation protocols for indirect restorations such as veneers, the specialized literature primarily distinguishes two types of materials: resin cement and thermo-modified resin. The former, composed of an organic matrix similar to that of composite resins, albeit with a different monomer ratio, primarily functions to ensure adhesion between the dental substrate and the restorative material. In contrast, thermo-modified resins feature a distinctive characteristic: they contain polymers whose viscosity decreases when exposed to heat, allowing better flow and adaptation to the dental substrate. Several studies have shown that this property improves the seating of the restoration and, consequently, enhances clinical outcomes in terms of marginal fit and durability (2-6). The parameters used for preheating composite resins vary, as this technique reduces viscosity, increases the degree of conversion and microhardness, and promotes improved marginal adaptation in both direct and indirect restorations. In general, preheating can optimize both handling and the physicochemical properties of composite resins (7).

On the other hand, microleakage represents one of the main challenges in adhesive cementation of aesthetic restorations. According to Crespo Requeni et al. (8), a critical factor is the nature of the dental substrate. Their study demonstrated a higher incidence of microleakage at the cervical margins of restorations, where dentin predominates, compared to areas where the margin terminates on enamel. This finding reinforces the recommendation that the marginal finish of veneers should preferably be placed on enamel to optimize adhesion. Furthermore, the adhesive system used during cementation significantly influences the clinical behavior of restorations. In addition, Barbosa et al. (9) compared different adhesive protocols and concluded that total-etch, when used in combination with resin cement, provides lower microleakage than self-adhesive cements, highlighting the importance of selecting an appropriate adhesive protocol.

In line with these findings, Buchelli (10) previously evaluated microleakage in indirect restorations cemented with preheated resin versus conventional luting resin. Their study showed that using preheated resin improves the adaptation of the restoration to the tooth, significantly reducing microleakage. In this context, the present study aimed to determine *in vitro* the microleakage in lithium disilicate veneers cemented with two types of materials: resin cement and thermo-modified resin.

MATERIALS AND METHODS

An *in vitro* study was conducted on human teeth to evaluate microleakage using two cementation techniques: one with resin cement (NX3 Nexus®) and the other with thermo-modified resin (Herculite Précis®), with the aim of determining which of these restorative systems exhibits lower microleakage. The established inclusion criteria comprised upper first premolars with intact buccal surfaces, free of restorations or carious lesions, with sound enamel, and similar crown shape and dimensions. Regarding the exclusion criteria, posterior teeth and those presenting enamel developmental defects were discarded.

Sample acquisition

A non-probabilistic sample was employed, selected according to the previously established inclusion and exclusion criteria. No prior sample size calculation was performed due to the exploratory nature of the experimental design and the complexity of the evaluated system. According to Jain et al. (11), in pilot or feasibility studies, such calculations are not always mandatory, as the aim is to generate preliminary data rather than conclusive results. In this context, a pragmatic approach was adopted, focusing on the analysis of microleakage in lithium disilicate veneers cemented with resin cement and thermo-modified resin.

The sample consisted of 20 lithium disilicate veneers cemented on 20 upper first premolars, which were specifically prepared for the placement of these restorations. Teeth were collected following extractions indicated for orthodontic reasons and were in optimal condition, with a minimum of two months since extraction. Specimens came from patients of both sexes, aged between 20 and 30 years, treated at dental clinics in the district of Wanchaq, Cusco, Peru.

The teeth were cleaned using Gracey curettes 1/2 (Hu-Friedy®, UK) and hydrogen peroxide to remove debris, and subsequently stored for one week in a sealed plastic container with physiological saline solution. After storage, the teeth were numbered from 1 to 20 with a blue indelible marker and divided into two groups with an equal number of teeth.

Sample preparation

For the preparation of the dental specimens, a condensation silicone guide (Zhermack®, Zeta Plus, Italy) was fabricated, which allowed for standardized tooth preparation and served as a reference during the reduction of the vestibular surface of each tooth. The preparation for the placement of the vestibular veneers was performed using the 1898-Veneers kit (physician Roberto Tello), executing a three-plane reduction with a cylindrical-tipped truncated cone bur, code 881.010 (JOTA®, Switzerland), respecting the original anatomy of the vestibular surface and guided by reference grooves.

The finish line was placed on enamel, adopting a 0.5 mm chamfer that extended to the interproximal areas without compromising the contact points. The preparation was extended only as necessary to conceal the interface between the veneer and the enamel. At the cervical margin, an orientation groove was traced, calibrated to 0.5 mm, using a round-tipped truncated cone bur, code 810F.010 (JOTA®, Switzerland) of medium grit. The incisal reduction was 1.5 mm in depth, performed with a wheel-shaped diamond bur, code 815.023FG (JOTA®, Switzerland), forming a finish line on the palatal side and creating a smooth bevel. All sharp angles on the prepared surfaces were removed using fine-grit burs (code 810F.010), and the preparations were polished with abrasive discs (Super Snap®, Shofu).

The impressions of the dental specimens were taken in a single step, following a four-handed technique, using addition silicone (Silagum®, DMG Dental, Germany). Impressions were taken directly from each tooth mounted in a plaster typodont. After one hour, the impressions were poured with type IV dental stone (Elite HD+®, Zhermack, Italy) to obtain the definitive models, which were sent to the laboratory for the fabrication of the lithium disilicate veneers.

The fabrication of the veneers was carried out at the SOLIS dental prosthetics laboratory, located in Cusco. The wax patterns were placed in sprues and invested before injecting lithium disilicate ingots in HT A1 shade (IPS e.max Press®, Ivoclar Vivadent), using a specialized furnace (Ivoclar Vivadent AG®, Schaan, Liechtenstein). Once the injection process was completed, the veneers were glazed and subjected to ultrasonic cleaning, making them ready for the cementation stage.

Cementation process

During the cementation phase of group 1, resin cement (NX3 Nexus®) was used. The procedure began with the conditioning of the internal surface of the porcelain veneers by applying 5% hydrofluoric acid (Condac Porcelana®, FGM, Brazil) for 20 seconds. After etching, the surface was thoroughly rinsed with water, followed by an additional cleaning with 37% phosphoric acid (Condac 37®, FGM, Brazil) for one minute. Once the surface was dry, silane (Monobond®, Ivoclar) and adhesive (Tetric N-Bond Universal®, Ivoclar) were applied, without immediate photopolymerization.

Regarding the treatment of the dental enamel surface, a 37% phosphoric acid etching was performed for 15 seconds, followed by rinsing with water and drying with a triple syringe. Subsequently, a layer of adhesive (Tetric N-Bond Universal®, Ivoclar) was applied for 20 seconds, without photopolymerization at that moment.

The resin cement was placed on the internal surface of the 10 veneers, which were seated on the previously prepared vestibular surfaces under digital pressure. Excess cement was carefully removed, and photopolymerization was performed on all sides of the restoration using a light-curing lamp (VALO®, Ultradent, USA) at an intensity of 14,000 mW/cm^2, for 20 seconds, at a distance of 1 cm. Finally, polishing was carried out using fine-grit diamond burs and abrasive rubbers (Figure 1).

For group 2, a thermo-modified resin (Herculite Précis®) was used. This resin was preheated in a thermo-modification oven (A Dent®) at setting 3, reaching a temperature of 68 °C. Subsequently, Centrix tips were loaded with the preheated resin for 10 minutes. At the same time, the veneers were conditioned following the same protocol used for group 1.

The thermo-modified resin was applied to the internal surface of the 10 veneers, which were then seated on the prepared teeth. Excess material was removed using a microbrush, and the same photopolymerization protocol used for group 1 was applied (Figure 2).

Figure 1. Cementation of veneers with resin cement (NX3 Nexus®)

Figure 2. Cementation with thermo-modified resin (Herculite Précis®).

Thermocycling procedure

In the final stage of the procedure, the apices of the teeth from both groups were sealed using self-curing acrylic to prevent microleakage from the pulp chamber. Subsequently, the specimens were stored for seven days at room temperature in labeled containers, after which they were subjected to a thermocycling process to simulate the clinical aging of the restorations. This process consisted of 500 thermal cycles in water, alternating between 5 °C and 55 °C, with a dwell time of 20 seconds in each bath. The procedure was repeated twice daily for five consecutive days. After thermocycling, the samples were immersed in a 2 % methylene blue solution for 72 hours, then rinsed with water for 5 minutes and dried in an oven at room temperature for 24 hours.

Sectioning of the samples

For microleakage evaluation, the samples were sectioned sagittally using a diamond disc attached to a low-speed micromotor. The sections were made along the buccal surface, passing through the middle portion of each of the 20 cemented veneers, yielding two halves per specimen. These were sent to the laboratory for analysis under a polarization microscope (Axio Imager®) to observe the degree of microleakage present.

Data were collected using a specifically designed form based on the study's variables and indicators. Microleakage was assessed qualitatively, assigning absolute and relative frequencies according to the depth of dye penetration. The established categories included: absence of microleakage, microleakage in the middle third, and microleakage in the cervical third. For bivariate statistical analysis, the chi-square (χ^2) test was employed, with a significance level set at 5% ($p < 0.05$). Data were processed and analyzed using the statistical software SPSS, version 17.0.

It should be noted that the conduct of this *in vitro* study was approved by the Faculty of Health Sciences of Universidad Andina del Cusco in 2018.

RESULTS

Regarding the results obtained for microleakage in veneers cemented with resin cement (NX3 Nexus®), it was observed that 95.0% of the sample (n = 19) exhibited some degree of microleakage. In contrast, in the group of veneers cemented with thermo-modified resin (Herculite Précis®), 65.0% of the sample (n = 13) showed microleakage. The observed difference was statistically significant according to the chi-square test (p = 0.017) (Table 1; Figures 3 and 4).

When comparing the incidence of microleakage between the two cementing materials, a higher percentage of microleakage was observed in the group cemented with resin cement (47.5%; n = 19) compared to the group cemented with thermo-modified resin (32.5%; n = 13). These differences were statistically significant according to the chi-square test (p = 0.018) (Table 2).

Table 1. Presence of microleakage in lithium disilicate veneers cemented with resin cement and thermo-modified resin.

Microleakage in lithium disilicate veneers	Yes		No		Total	
	n	%	n	%	n	%
Resin cement	19	95.0	1	5.0	20	100.0
Thermo-modified resin	13	65.0	7	35.0	20	100.0

Chi-square test (p = 0.017).

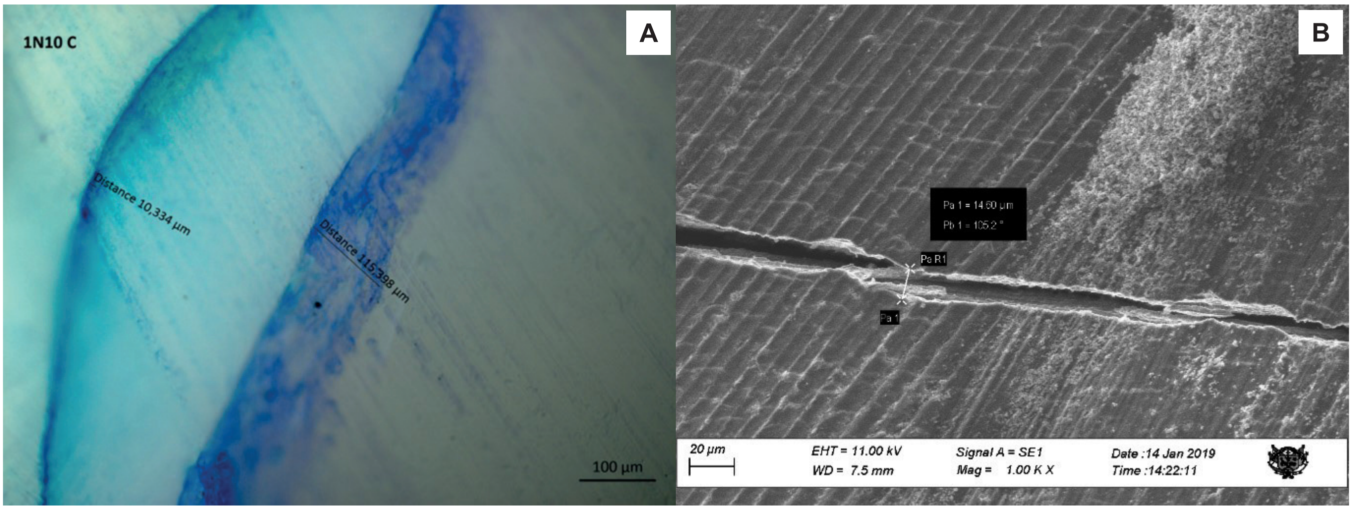

Figure 3. A) Microleakage observed under a polarization microscope in a veneer cemented with resin cement. B) Electron microscopy of the resin cementing agent.

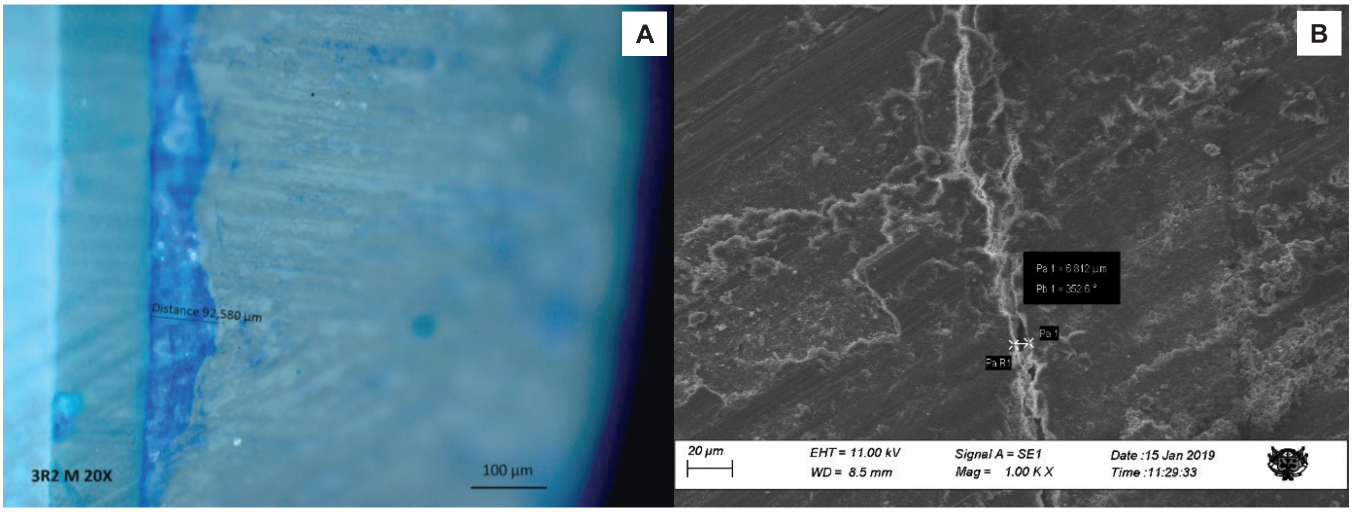

Figure 4. A) Microleakage observed under a polarization microscope in a veneer cemented with thermo-modified resin. B) Electron microscopy of the thermo-modified resin cementing agent.

Table 2. Microleakage in lithium disilicate veneers according to the cementing agent.

Cementing agent	Yes		No		Total	
	n	%	n	%	n	%
Resin cement	19	47.5	1	2.5	20	50.0
Thermo-modified resin	13	32.5	7	17.5	20	50.0
Total	32	80.0	8	20.0	40	100.0

Chi-square test (p = 0.018).

Regarding the location of microleakage according to the cementing agent, it was observed that in the group cemented with resin cement, the highest frequency occurred in the cervical area (35.0%; n = 14) and to a lesser extent in the middle area (12.5%; n = 5). In contrast, in the group treated with thermo-modified resin, microleakage was lower in both the cervical area (27.5%; n = 11) and the middle area (5.0%; n = 2). This difference was statistically significant according to the chi-square test (p = 0.046) (Table 3).

Table 3. Microleakage in lithium disilicate veneers according to microleakage area

Cementing agent	Microleakage area						Total	
	Cervical area		Middle area		No microleakage			
	n	%	n	%	n	%	n	%
Resin cement	14	35.0	5	12.5	1	2.5	20	50.0
Thermo-modified resin	11	27.5	2	5.0	7	17.5	20	50.0

Chi-square test (p = 0.046).

DISCUSSION

A cementing material must possess the ability to adhere to both the dental substrate and the restoration while simultaneously ensuring an adequate marginal seal. These properties are essential to guarantee the retention of the restoration and prevent undesirable phenomena such as microleakage. To evaluate the efficacy of marginal sealing, the present study compared microleakage in lithium disilicate veneers cemented with two different materials: resin cement (NX3 Nexus®) and thermo-modified resin (Herculite Précis®).

The results showed that veneers cemented with resin cement exhibited a higher percentage of microleakage (47.5%; n = 19) compared to those cemented with thermo-modified resin (32.5%; n = 13), a statistically significant difference ($p = 0.018$; $p < 0.05$). These findings suggest that thermo-modified resin provides better clinical performance in terms of marginal sealing, more effectively reducing infiltration at the restoration-tooth interface.

Regarding the cementation technique using thermo-modified resin, studies such as the one conducted by Magne et al. (12) support the feasibility of using restorative composites for this purpose. Their research compared the film thickness of different restorative materials used in thermo-modified cementation, revealing a range between 6 and 200 µm. The lowest thicknesses were recorded for composites such as AP-X®, Z250®, and Herculite XRV® Incisal LT® (6-8 µm), whereas other materials, including Gradia Direct®, flowable resins, and even designated cements, showed thicknesses between 15 and 27 µm; products such as Inspiro®, Ultradent Transcend Universal®, and ENA Hri Dentin® remained below 50 µm.

Magne et al. (12) concluded that the initial viscosity of restorative composites does not determine the final film thickness when used in thermo-modified cementation techniques. This finding is clinically relevant, as it demonstrates that certain restorative composites can form extremely thin films, making them a viable alternative to traditional dual-cure or flowable cements, offering significant advantages such as better marginal adaptation and lower risk of microleakage. These results are consistent with the findings of the present study, reinforcing the efficacy of thermo-modified resin as the material of choice for cementing esthetic restorations.

In contrast, Albaheli et al. (13) evaluated microleakage in lithium disilicate veneers bonded to different substrates (enamel, dentin, and composite resin) using photopolymerizable resin cements (Variolink Esthetic LC®, Ivoclar Vivadent) and dual-cured cement (Variolink Esthetic

DC®, Ivoclar Vivadent). They employed 48 human maxillary central incisors, randomly assigned into three groups according to the substrate at the finish line (n = 16). Each group was further subdivided randomly into two subgroups (n = 8) based on the type of cement used. Their results showed a statistically significant difference in microleakage among the different substrates ($p = 0.001$); however, no statistically significant differences were observed between the types of cement ($p = 0.907$), nor was there an interaction between substrates and cements ($p = 0.983$). Similar microleakage indices were observed with both photopolymerizable and dual-cured resin cements, which differs from the findings of the present study.

When comparing our results with the study conducted by Bucheli (10), certain similarities were observed. In that research, restorations cemented with preheated resin exhibited lower microleakage, whereas those treated with a self-adhesive cement showed higher levels of leakage. This finding supports the results of the present study, where a lower degree of microleakage was also observed when using thermo-modified resin. However, it is important to note that Bucheli's study focused on a different type of indirect restoration.

Similarly, the study by Barbosa et al. (9) analyzed microleakage in lithium disilicate inlays using different resin cements. In their investigation, the total-etch cement Variolink N® presented lower levels of microleakage (mean value 135.59) compared to the self-adhesive cement Multilink S® (mean value 183.49), with a statistically significant difference ($p = 0.001$). These results differ from those obtained in the present study, where the resin cement NX3 Nexus® showed higher microleakage. This discrepancy may be attributed to differences in the composition of the cements used in both studies. Additionally, it is worth noting that the aforementioned authors evaluated inlay-type restorations, whereas this study focused on veneers, which may influence how the cement interacts with the dental substrate.

In contrast to several studies highlighting the benefits of preheating composite resins to improve their mechanical and adhesive properties, the study by Goulart et al. (14) presents a more moderate perspective. According to their findings, the use of preheated composite resin as a cementing agent for indirect restorations did not result in a significant improvement in microtensile bond strength (μTBS). This observation suggests that merely increasing the material's temperature does not guarantee stronger adhesion between the resin and dentin. However, the authors did identify relevant advantages of preheating, such as reduced resin viscosity and better adaptation to cavity walls, which can promote marginal sealing and dimensional stability of the restoration.

In the present study, no prior sample size calculation was performed due to the exploratory nature of the experimental design and the complexity of the system under evaluation. According to Jain et al. (11), in pilot or feasibility studies, such calculations are not always essential, as the goal is to generate preliminary data rather than conclusive results. In this context, a pragmatic approach was adopted, focusing on the analysis of microleakage in lithium disilicate veneers cemented with resin cement and thermo-modified resin. Despite the small sample size, the findings provide relevant information on the behavior of these materials, which can serve as a basis for future research. However, a significant limitation of the study was the number of samples, mainly constrained by the high costs of the procedure, which was entirely self-funded, potentially affecting the precision of the results. Therefore, it is suggested that future studies consider appropriate sample size planning and external funding to increase the validity and reliability of the data obtained.

Other limitations include the lack of a university laboratory equipped for experimental studies using electron microscopy, which caused delays in sample analysis. The evaluation of microleakage was performed using *in vitro* dye penetration techniques, which are influenced by factors such as dentin permeability, the type of restorative material, and the characteristics of the dental tissue. These variables make it difficult to reproduce the exact conditions of the oral environment. Elements such as pH fluctuations, the presence of enzymes, and masticatory forces are typically excluded from *in vitro* models, which mainly focus on simulating thermal stress. This limitation may introduce bias and affect the interpretation of results. Furthermore, there is limited comparable scientific evidence, highlighting the need to promote similar research that evaluates other types of cements and resins with larger sample sizes, aiming to optimize clinical practice and establish cementation protocols that minimize microleakage and enhance restoration success.

This study is fully justified, as it is essential to determine whether microleakage occurs during the cementation of lithium disilicate veneers and which cement is most appropriate for this procedure. By identifying the material that generates higher microleakage, analyses and adjustments can be made in educational settings, contributing to improved clinical approaches in the treatment. Therefore, it is crucial to have an adequate cementation protocol that allows to understand the properties and characteristics of the different cements used in this type of restoration.

CONCLUSIONS

The study results show that the thermo-modified resin exhibits lower levels of microleakage compared to the resin cement, suggesting better clinical performance and behavior of this material. Nevertheless, microleakage was observed in both evaluated groups, predominantly in the cervical area. Additionally, the resin cement showed higher percentages of microleakage, particularly in the cervical and middle areas, compared to the thermo-modified resin.

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GABI: visualization, writing – original draft, writing – review & editing.
MPM: conceptualization, methodology, research.

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