International Clinical and Medical Case Reports Journal
Research Article (ISSN: 2832-5788)

Salient Visionary Publications

Evaluation of Class V Cervical Marginal Microleakage Following Restoration by Different Types of Composite Resins

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Citation: *Azheen Mohamad Mohamad Kharib. Evaluation of Class V Cervical Marginal Microleakage Following Restoration by Different Types of Composite Resins. Int ClincMed Case Rep Jour. 2024;3(5):1-13.*

Received Date: 30 April, 2024; **Accepted Date:** 07 May, 2024; **Published Date:** 09 May, 2024

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ABSTRACT

Background and Objectives: Microleakage surrounding cavities restored with the composite resin materials, particularly in class V cavities, is a challenge in the field of restorative dentistry. For this reason, the study's objectives were to assess the class V cervical marginal microleakage restored with nano-filled composite resin using two different types of liners (flowable nanocomposite material resin and SDR).

Methods: Forti fif healthy human premolars had standardized box-shaped class V cavities (3 x 2 x 2) mm created on them. Three groups (n=15) of teeth were selected for each group. Restoration techniques used in compliance with manufacturer guidelines. The teeth underwent a series of procedures including thermocycling, immersion in 2% methylene blue dye, sectioning, and stereomicroscope observation.

Results: Nanofilled composite lined with nanoflowable liner showed less microleakage than when lined with SDR liner and then followed by the control group (without liner), this difference was statistically highly significant $p<0.05$.

Conclusion: When compared to the control group (without a liner), the use of flowable composite as a liner reduces microleakage, although the difference is statistically insignificant.

Keywords: Liner; Nanocomposite; Cl V cavity; Microleakage

Key Messages:

- Microleakage control is one of the most crucial characteristics of restorative dental materials, and any leakage of restoration indicates defective or old materials.
- The goal of aesthetic dentistry is to combine function as well as beauty with the patient's values and specific requirements.

INTRODUCTION

The undetectable passage of liquids, germs, chemicals, or ions between the cavity and the restoration is known as microleakage, and it can result in pulpal issues, tooth color change, hypersensitivity, recurring caries, and restorative failure. Several compounds with deproteinizing properties were proposed to lessen the impact of the tooth organic matrix on the adherence of composites to the dentin substrate.[1]

The issue of microleakage surrounding cavities filled with cosmetic materials remains a challenge in the area of restorative dentistry. Microleakage remains a problem despite the development of adhesive methods and acid etching, which have both improved marginal sealing.[2]

Microleakage surrounding cavities treated with attractive materials remains a challenge in the area of restorative dentistry. Microleakage has not been eradicated, despite the development of adhesive methods and acid etching, which have both improved marginal sealing.[3] A dental restoration's main goal is to form an ideal seal and stop impurities from leaking into the oral environment. However, all repairs have long-term microleakage.[4]

Dentists have always faced a hurdle when it comes to restorative dentistry: cervical lesions. The intricate structure of Class V cavities, which have edges made of both dentin and enamel, poses a difficult situation for the restorative material. Microleakage along the cervical wall in class V composite resin restorations is a significant issue. This phenomenon is known as marginal leakage and is regarded as a serious issue in restorative dentistry.[5]

Nowadays, resin-based composite restorative materials are used in at least half of posterior direct restoration placements. Their extraordinary aesthetic value, little requirement for dental preparation, micro-mechanical bonding with the tooth structure, and strong retention are the reasons behind their widespread appeal.[6] All resin-based composites, even with the significant advancements in new restorative materials, exhibit some degree of volume contraction as a result of polymerization shrinkage. This contraction causes internal stress to arise, which jeopardizes the mechanical and chemical stability of the restoration and may impair its marginal integrity. Marginal salivary leakage along with its constituents will therefore happen.[7,8]

The degree of microleakage is said to be influenced by several factors, including the shape of the cavity preparation, the variation in the thermal expansion coefficient between the tooth and the restorative material, and the restoration's absorption of water when exposed to the oral environment.[3] Additionally, some factors like acid-etching duration, bonding methods, cavity designs, and C-factor may influence microleakage. Several studies have shown that cervical margins of teeth have greater microleakage scores than occlusal edges.[9] This is because the bonding to dentin is erratic; the tubular structure, high organic content, inherent wetness, and low surface energy of dentin are the variables linked to the hampered dentin bonding.[10]

One of the most significant and recent developments in composite resin restorative materials is the use of nano-composites. They use nanotechnology to include Nanofillers, which are between 1 and 100 nm in size.[11] However, great translucency, high polish, and polish retention are provided by nanocomposites. By allowing filler levels to be as high as 90–95% by weight, nanofillers can greatly lessen the effects of polymerization shrinkage and enhance physical qualities.[12]

One of this material's distinguishing characteristics is its flowability. Between products, there are large differences in the degree of flowability. Therefore, the flow properties and viscosity of flowable resin composites may impact how they behave clinically during handling and, therefore, what applications they may be used for. Flowable composites differ significantly in stiffness, polymerization shrinkage, and other physical characteristics due to variations in viscosity.[13] Achieving the best possible seal between composites and tooth structure is essential for the restoration to last clinically and will greatly enhance oral health in the general population.[10]

For a considerable amount of time, researchers have been studying microleakage under composite restorations. Their findings have been inconsistent, and since smart dentin replacement has entered the dental materials market as a material with low volumetric shrinkage, this in-vitro study was designed to assess the class V cervical marginal microleakage that was restored using nanofilled composite and lined with both smart dentin replacement and nanoflowable resin. The flow rates of the two liners were measured in order to determine whether microleakage and flowable liners are correlated.

The aims of the study: Evaluation of Cl V cervical marginal microleakage of nanofilled composite (Filtek Z350 xt) lined with nanoflowable (Filtek Z350 xt) and smart dentin replacement (SDR).

METHODS AND MATERIALS

Restorative materials used in this study

Two types of liners were chosen for the nanofilled composite resin (Filtek Z-350 xt) shade A2: nanoflowable composite (Filtek Z-350 xt) and SDR (smart dentin replacement). Table 1 lists the properties and details of the materials utilized.

Table 1: Restorative materials used in this study.

Materials	Composition	Manufacturer
Filtek™ Z350 XT Nanfilled composite resin	The resin contains bis-GMA, UDM A, TEGDMA, and bis-EMA resins. The fillers are a combination of 20 nm silica filler and 4 to 11 nm zirconia filler, The inorganic filler loading is about 78.5% by weight.	3M ESPE USA
Filtek™ Z350 XT Flowable nanocomposite resin	Contains bis-GMA, TEGDMA, and Procrylat resin. The filler is a combination of ytterbium trifluoride filler, silica filler, and zirconia /silica cluster filler. The inorganic filler loading is about 65% by weight	3M ESPE USA
SDR(smart dentin replacement	Contains a polymerization modulator, dimethacrylate resin, UDMA, and EBPDMA. The filler is Ba-B-F-Al silicate glass, Sio2, amorphous Sr-AL silicate glass, Tio2. About 68% by weight	DENTSPLY Germany

Specimens preparation

Forti fif healthy human upper and lower first and second premolars that had been obtained for orthodontic purposes were utilized. Using a curing light to identify fractures, teeth that were carious, cracked, abraded, eroded, or had any other flaw were not included. Using a revolving brush and dental scalar to remove dirt and polishing pumice, soft tissue remains were removed from the teeth. To prevent dehydration during the investigation, the teeth were kept in distilled water after being immersed in hypochlorite for disinfection.[14]

To aid handling during the test method, the roots of the samples were mounted in blocks of chemically cured acrylic resin. The acrylic blocks measured 2 cm in diameter and 2 cm in height, and they covered the roots at a level approximately 2 mm below the CEJ. Dental wax was used to mount the teeth in the acrylic block so that, following the filling treatment, the acrylic could be readily removed.

Cavity Preparation

Class V cavities in the form of standardized boxes with dimensions of 3 mm in width, 2 mm in height, and 2 mm in depth, and about 0.5 mm occlusal to the cementoenamel junction, on each tooth's buccal surface, were prepared. Using a pencil marker and a matrix band with a pre-cut hole that was secured to the tooth with a retainer, the cavity's outline was traced on the tooth's surface. The pre-designed class V cavities were prepared using a flat-end fissure diamond bur in a high-speed handpiece and an air/water spray; each bur was utilized for five preparations,[15] the high-speed handpiece was fastened to the dental surveyor such that the bur's long axis was consistently perpendicular to the tooth's buccal surfaces. Using a periodontal probe, the cavities' depth was measured to make sure they fit the dimensions; if not, they were discarded. Using a butt joint, the cavities were produced in compliance with the international guideline.[16]

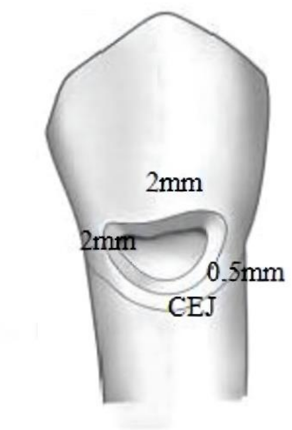

Figure 1: Dimensions of the Cl V cavity (Buccal view).

Restoration Procedure

Following cavity preparation, the teeth were split into three groups at random, with 15 teeth in each group, as shown in Figure 2. After 15 seconds of etching with a 36% phosphoric acid gel (enamel and dentin), the cavities were gently dried for 5 seconds before being cleaned with an air/water spray for 20 seconds. As directed by the manufacturer, a bonding agent was applied to the tooth surface that had been etched, then gently dried for five seconds and cured for ten seconds.

The restorative substance was applied following the manufacturer's instructions. The identical light curing unit a light-emitting diode LED was utilized for all groups, employing a continuous photocuring approach and a light source with an intensity of 1200 mW/cm^2.

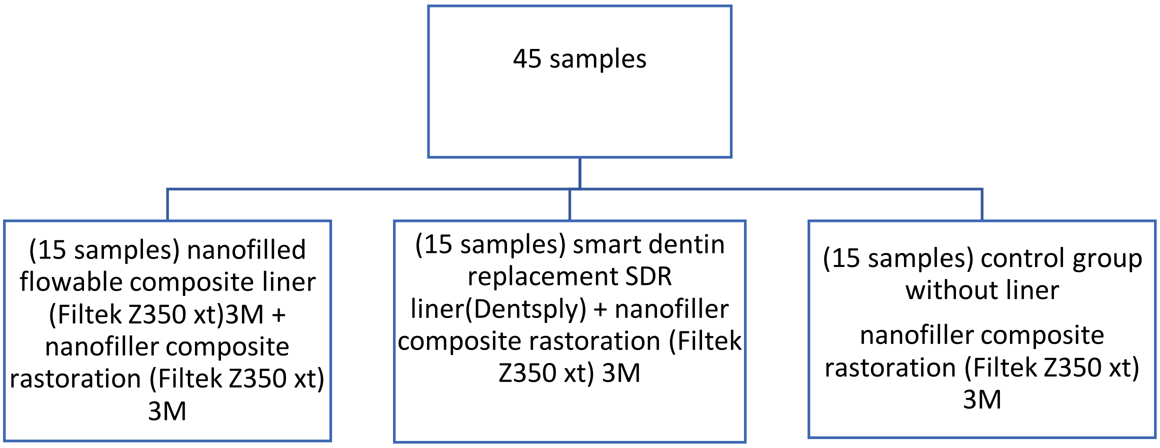

Figure 2: Distribution of the specimens.

Group I: The pulpal wall was lined with a 0.5 mm layer of flowable nanocomposite material (FiltekTM Z 350 Flowable Restorative), which was light-cured for 20 seconds to maintain its thickness through a groove on the delivery needle. To achieve sufficient adaption of the restorative material, the cavity was then filled with nanofilled composite (Filtek Z350 Universal Restorative) in one increment (1.5 mm) bulk fill method using a plastic instrument and celluloid strip band, and it was light cured for 20 seconds.

Group II: As a cavity liner, a 0.5 mm layer of smart dentin replacement (SDR, flowable resin composite) was applied to the pulpal wall. The delivery needle's groove helped to preserve the layer's thickness, and it was light-cured for 20 seconds. To achieve sufficient adaption of the restorative material, the cavity was then filled with nanofilled composite (Filtek Z350 Universal Restorative) in one increment (1.5 mm) bulk fill method using a plastic instrument and celluloid strip band, and it was light cured for 20 seconds.

Group III: For the control group, no liner was used while restoring the cavities using nanofilled composite material (Filtek Z350 Universal Restorative). To ensure sufficient adaption of the restorative material, a plastic tool and celluloid strip band were used to fill the cavities in one increment (2 mm) bulk-fill technique. The cavities were then light-cured for 20 seconds following the manufacturer's instructions.

Following the filling process, the restorations were polished with abrasive discs and completed with fine-grit finishing diamond burs. Following a careful removal of the teeth from the acrylic block to prevent damage to the restorations, the teeth were kept in an incubator at 37 degrees Celsius for a week in distilled water.[12]

Thermocycling procedure and dye immersion

Every specimen underwent 500 thermocyclers, with a 30-second dwell period at each temperature between 5 and 55 degrees Celsius,[12] each tooth's apex was sealed using an acrylic resin that self-cured, and all tooth structure, except for the 1 mm around the cervical edge of the restoration, was coated with two coats of fingernail varnish. As soon as the nail polish dried, teeth were put in distilled water to reduce the dehydration of composite restorations. The samples were then submerged in 2% methylene blue dye for a whole day.[14] Following the samples' extraction from the dye, the samples were cleaned with tap water, the nail paint was removed using a nail polish remover, and they were then placed in bottles with distilled water until sectioning time. To section the teeth longitudinally in the buccolingual direction through the center of the restoration, the roots of the samples were embedded in acrylic resin blocks at a level approximately 4mm from the apex. A low-speed diamond disc was used with abundant water irrigation and a surveyor for standardization, resulting in the creation of two sections.[17]

Statistical analysis

SPSS (Statistical Package for Social Service) version 19 for Windows was used to examine the data that had been gathered (SPSS, Chicago, Illinois, USA). Used the analysis of variance one way (ANOVA) test to see if the group means differ significantly from one another. A P-value of less than 0.05 was deemed statistically significant. as well as the Post hoc test for multiple group mean comparisons.

RESULTS

The purpose of this study was to examine the cervical marginal microleakage of Filtek Z350 nanofilled composite with liners made of SDR flowable composite resin and Filtek Z350 nanoflowable composite.

The cervical microleakage of three groups of tested materials was measured, and the descriptive statistics for the mean value, standard deviations, and standard error were displayed. Group III, which was nanofilled composite without a liner, had the highest mean value (2.70 ±0.830), while group I, which was nanoflowable liner + nanofilled composite, had the lowest mean value (1.80 ±1.414), and group II, which was SDR liner + nanofilled composite, had a mean value (2.40 ±1.10), which was higher than group I and lower than group III.

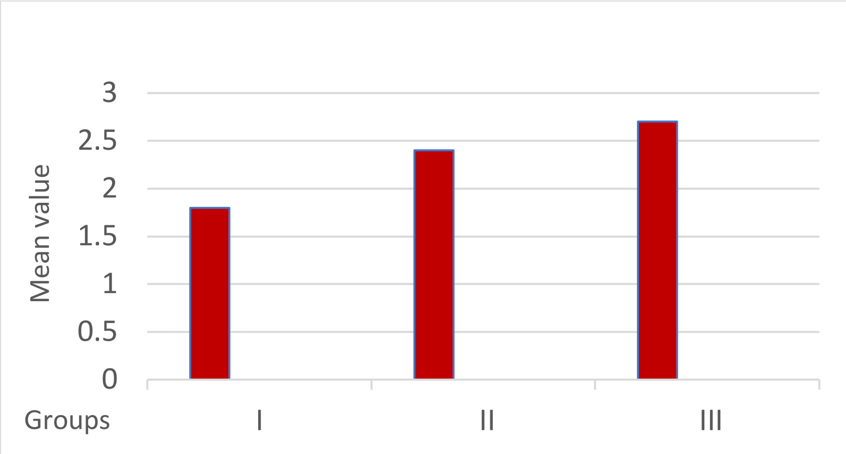

Figure 2: The comparison of the three groups under study's mean values for cervical microleakage.

DISCUSSION

The most significant issue with restorative materials is microleakage, which is the term used to describe the clinically undetectable movement of molecules, ions, fluids, or bacteria between the repair and the cavity walls.[18] The main factor affecting how long composite resin restorations last is the marginal adaptability of restoration materials to cavity walls. The primary drawbacks of composite resins include stress and shrinkage during polymerization, which can result in insufficient cavity closure and raise the risk of subsequent carious lesions, dentinal hypersensitivity, or marginal discoloration.[19]

The process of polymerization Resin-based materials' tendency to shrink encourages the material's deformation. Stress develops because these materials are linked to cavity walls in a way that restricts deformation in clinical settings. Concentrated at the adhesive interface, these pressures have the potential to rupture the interface and lead to the creation of gaps, marginal leakage and discoloration, postoperative sensitivity, and recurrent caries.[20]

It is recognized that contraction stress generated during the polymerization process is a complex phenomenon that results from more than just the composite shrinkage process; in addition, the elastic modulus plays a critical role in predicting the potential for contraction stress generation at the bonded interface that such resin materials can produce. As polymerization shrinkage occurs, internal stresses are predicted to decrease more with a lower Young's modulus composite than with a higher modulus one.[21]

Any restorative material used on a class V lesion faces unique challenges since the chosen material must attach to both enamel and dentin/cementum. Enamel is a more suitable substrate for resin bonding than dentin,[22] because the structure of enamel is uniform, and adhesion to the enamel should be predictable and easy to achieve. However, because of its nonuniformity, the dentin liquid's migration toward the dentin's outside surface, and its high organic content, it is more difficult to attach to the dentin appropriately.[23] To provide a clean, sufficiently wet surface for the bonding agent to be applied, the smear layer must be removed with acids, rinsed, and dried.[24]

As in previous microleakage investigations, thermocycling was applied to the experimental teeth. Thermocycling is a common procedure used to assess the microleakage of bonded restorative materials in vitro. It involves periodically exposing these materials to hot and cold temperatures, mimicking in vivo aging.[11,25]

An established in vitro technique for examining marginal leakage at tooth-restoration surfaces is dye penetration, which is often measured following longitudinal tooth cutting.[26] One of the most often used tracers is methylene blue, which is available in quantities ranging from 0.5% to 5%. It was noted that methylene blue may produce an overestimation of leakage at the tooth-restoration interface due to the tiny surface area of the particles (about 0.52 nm^2), especially with self-etch adhesives due to their enhanced hydrophilicity.[27]

The goal of this study was to examine, in class V cavities with cervical margins above the CEJ, the cervical marginal microleakage of nanofilled composite resin (Filtek Z350) with and without flowable liners (Filtek Z350 nano flowable and SDR smart dentin replacement). since of the chemical makeup of the tooth and the use of an acid etching and bonding method with composite filling materials, which necessitates the existence of enamel rods and dentinal tubules since the acid etch acts on them, removed teeth were employed in this investigation.

The results of this study indicate that using flowable composite as an intermediate layer between the cavity wall and the restoration reduces microleakage because of their low viscosity, increased elasticity, and wettability, which results in an intimate union with the cavity walls and floors. Group I (Filtek Z350 nanofilled composite resin lined with Filtek Z350 nanofilled flowable liner) showed less microleakage than group III control group (Filtek Z350 nanofilled composite resin without liner), and group II (Filtek Z350 nanofilled composite resin lined with SDR flowable liner) showed less microleakage than group III control group (Filtek Z350 nanofilled composite resin without liner). this presents that the use of flowable composite as an intermediate layer between the cavity wall and the restoration reduces microleakage, due to their low viscosity, increased elasticity, and wettability, this results in an intimate union with the floors and walls of the cavity.[24] according to research showing that using flowable composite as a separating layer between the repair and the hollow wall lowers microleakage.[28] Additionally, the impacts of the Cfactor are lessened when flowable materials are used as liners, which lowers polymerization stress and related issues.[29,30]

The creation of an elastic layer that might potentially offset the stresses caused by polymerization shrinkage is the primary justification for the application of flowable composites.[30,31] In comparison to composites with high filler content, flowable composites with low filler content and low elastic modulus have demonstrated superior sealing performance in Class V restorations.[32] Flowable composites absorb the shock caused by functional load and thermal stresses later on and withstand the early polymerization shrinkage stress of the overlaying resin composite. The capacity to absorb stress is contingent upon a reduced elastic modulus in comparison to traditional highly-filled materials.[33] Despite the flowable composite's low elastic modulus, the contraction stress produced during the curing process pulls the material away from the tooth wall, causing gap formation and microleakage. Despite this, there were variations in the microleakage assessments among the tested groups, but these differences were statistically non-significant.[34]

This finding is consistent with the findings of research conducted by.[35] They looked at the microscopic leakage of flowable liner-equipped packable composites as experimental groups and packable composites without liners as control groups. They discovered no appreciable differences. Additionally, it aligns with another study conducted by,[36] Another study that used flowable composite and resin-modified glass ionomer as intermediary layers to illustrate the cervical marginal microleakage of packable composite resin repair discovered no statistically significant difference between the groups. It also aligns with research conducted by,[37] Researchers examined the impact of using both traditional and new-generation flowable composite resin as an intermediary material between dental substrates and composite resin on microleakage in Class V composite restorations. They discovered that there was no discernible difference in dye penetration between the experimental and control groups. demonstrated that SDR flow composites had reduced microleakage compared to the liner-free control group, however the statistical difference was not significant. The findings of this investigation are similarly consistent with an additional in vitro research conducted by.[38]

However, the findings of this investigation do not support a research conducted by,[34] The study examined the microleakage of nanocomposite restoration with and without a liner, concluding that placing a liner underneath the restoration significantly reduces microleakage. This disagreement may be explained by the fact that the samples were thermocycled for fewer cycles (250 cycles) and at a lower concentration of methylene blue dye (0.5%) in the previous study than in the current one.

Also, group I (Filtek Z350 nanofilled composite resin lined with Filtek Z350 nanofilled flowable liner) exhibited lower microleakage scores than group II (Filtek Z350 nanofilled composite resin lined with SDR flowable liner) in the current study. This difference may have resulted from the fact that SDR had a higher flow rate than Filtek Z 350 nanoflowable composite, as determined in the second section of the study. As flowability increases, filler concentration decreases, polymerization shrinkage increases and deformation resistance decreases.[39] On the other hand, group I and group II's differences in microleakage were not statistically significant.

This result is in line with a study conducted by,[8] who examined the effects of Filtek Z 350 nanoflowable composite and Smart Dentin Replacement (SDR) resinbased composite as liners under Class II nano hybrid resin composite restorations. They came to the conclusion that all three types of nanohybrid restorations those lined with nano flowable composites, those lined with SDR, and those without performed well and did not differ statistically. However, the results of this study conflict with a study by,[40] which found that SDR as a liner showed significantly lower microleakage scores. This disagreement may be explained by the application of a thicker layer of SDR and the use of Esthet_X HD, a different type of composite, rather than Filtek Z 350 restorative composite.

CONCLUSION

Microleakage is reduced when flowable composite resins are used as an intermediate layer between the dental substrate and restoration, however, this effect was statistically insignificant when compared to the control group (which did not utilize a liner).

RECOMMENDATIONS

1. Examine the cervical marginal microleakage scores following the use of various flowable liner thicknesses using a silorane-based composite.
2. Cervical microleakage of CI V cavity with cervical margin situated at various cementum levels and other kinds of designs evaluated.
3. Extended clinical trials utilizing several kinds of flowable liners and nanofilled resin composite.

4. Examine the two tested liners' flowability in comparison to other types of flowable liners.
5. Examine the flexural strength and elastic modulus of composites made of nanohybrids, microhybrids, and microfills.

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