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A comparative evaluation of microleakage among newer composites FILTEK Z350 XT, TETRIC N-CREAM, and CLEARFIL AP-X: An *in vitro* study

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Abstract

Introduction: Modern composites promise to improve fracture resistance, reduce postoperative sensitivity and marginal discoloration. They have also been reported to reduce microleakage, which can lead to restoration failure and tooth loss. A comparative evaluation of microleakage among newer composites FILTEK Z350 XT, TETRIC N-CREAM, and CLEARFIL APX was carried out to assess their efficacy in reducing marginal microleakage. A comparative evaluation of microleakage among newer composites FILTEK Z350 XT, TETRIC N-CREAM, and CLEARFIL APX was carried out to assess their efficacy in reducing the marginal microleakage. **Methods**: The study's samples consisted of 45 upper maxillary premolar teeth. Class II were prepared in teeth under aseptic conditions. The specimens were divided into three experimental groups of fifteen teeth each and the prepared cavities were restored with nanocomposite Filtek Z350XT (Group-I), TETRIC N-CERAM (Group-II), and micro hybrid Clearfil AP-X (Group III). All the teeth were immersed in methylene blue stain to explore the microleakage. Specimens were sectioned buccolingually through the restoration using diamond disc. The restoration were assessed for presence of microleakage and examined under stereo-microscope of 40X magnification to assess the microleakage. One-way ANOVA and Unpaired student t-test analysis was carried out. **Results**: The mean scores of microleakage showed higher values at the gingival region for Group I and Group II, while Group III exhibited higher mean scores at the occlusal region. Further, the least microleakage was observed in TETRIC N-CERAM followed by FILTEK Z350XT followed by CLEARFIL APX. **Conclusion**: None of the composites tested completely prevented microleakage, but there were significant differences among them. Tetric N-Ceram was the most effective material in reducing microleakage compared to Filtek Z350XT and Clearfil AP-X.

KEYWORDS

Microleakage; Composite; Restoration; Nanomaterial; Resin; Teeth restoration

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1 | INTRODUCTION

A beautiful smile and confidence to shine is the demand of the present times. This lead to hunt for an ideal esthetic material that would help in restoring teeth with advancement in their replication properties and technique of application. Composites and acid-etch technique represent similar two major advances in esthetic restorative dentistry.[1,2] Composite present with colorful advantages over preliminary used restorative materials such as improved esthetics, further conservative procedure, versatility, reparability, lack of corrosion, insensitive to dehydration, easy to manipulate, reasonably inexpensive, micro-mechanical bonding with tooth structure, etc.[3] However, with every new advancement come some disadvantages. Similarly, some clinical problems with restoring tooth structure with resin composite came into consideration. One among them is polymerization shrinkage, which causes microleakage at the margins of composite restoration, which might lead to post-operative hypersensitivity, secondary caries and pulpal pathology.[1,2]

Microleakage in composite restorations can be a significant concern as it can lead to various complications and compromises the longevity of the restoration. Microleakage refers to the passage of bacteria, fluids, molecules, or ions between a dental cavity wall and the restorative materials placed to repair the tooth. It occurs when there is imperfect adhesion or bonding between the dental restoration (such as a filling or crown) and the natural tooth structure.[4] Dentists strive to minimize microleakage by using techniques and materials that promote strong adhesion between the restoration and the tooth structure.[1]

Recently, newer composite were introduced which include Filtek Z350 XT, Tetric N-Ceram, and Clearfil AP-X. Filtek Z350 XT is a nano hybrid composite material that is used for both anterior and posterior teeth restorations. It is a combination of nano fillers and micro fillers and has good aesthetic properties.[5] Clearfil AP-X is another light-curing micro hybrid resin composite. It is highly aesthetic due to its high clarity and excellent light diffusion. It has a high radiopacity, allowing for better visibility on radiographs.[4,6] Tetric N-Ceram is also a light-curing nano-hybrid composites specifically designed for restorative treatments and is available in syringes and cavifils. It is known for its excellent radiopacity, which aids in the identification of the restoration on radiographs.[7] All these newer generation composite claim to be effective in aesthetic and restorative, however, there is limited evidence on microleakage development in restored teeth. Therefore, present study was conducted to compare and evaluate the microleakage of Filtek Z350 XT, Tetric N-Ceram, and Clearfil AP-X.

2 | METHODS

The study involving 45 freshly extracted maxillary premolar teeth that were collected for evaluating microleakage (Fig.1). Standard Class II cavities were prepared on the teeth. The dimensions of the prepared cavities were 1.5 mm of occlusal depth, 2 mm occlusal width, 3 mm proximal width, 1.5 mm gingival cavosurface (where the cavity meets the gum line), 15 mm at the base of the cavity, and 3 mm depth of the axial wall (inner wall of the cavity. To ensure accuracy and consistency, the prepared cavities were checked using a calibrated Williams's periodontal probe. The preparations were completed using a straight fissure, round, and inverted cone diamond abrasive burrs, which was attached to a high-speed hand piece with water coolant. A new bur (drill) was used after every five preparations to maintain optimal cutting efficiency. These 45 teeth with Class II cavities were randomly divided into three groups based on composite restoration with 15 teeth in each group: Group I: nanohybrid Filtek Z350XT (3M ESPE), Group ii: nanohybrid TETRIC N-CERAM (Ivoclar), Group III: microhybrid CLEARFIL AP-X (Kuraray Noritake). The restorations were completed by applying resin composite material in stages under aseptic precautions. An incremental technique was employed, where the composite was placed in successive layers to ensure proper adaptation and reduce the risk of shrinkage. After completion of the restorations, the matrix band was remove and all the restorations underwent finishing and polishing using diamond burs and polishing disks, respectively.

Following the completion of the restorations, the teeth from each group were placed in separate Petri dishes. These specimens then underwent thermocycling, which involved subjecting them to temperature fluctua-

tions between 5°C, 37°C, and 55°C for 1000 cycles. Thermocycling helps simulate the stresses and strains that dental restorations may experience in the oral environment. After the thermocycling process, the apices (root tips) of each tooth were sealed with clear self-cure acrylic resin. The entire specimen, except for the area of the restoration and 2 mm margin around it, was coated with nail varnish (Fig.2). This coating serves to protect the tooth surface and direct any subsequent dye penetration tests to focus on the restoration area and its immediate surroundings.

The teeth in the study were sectioned buccolingually, meaning they were cut from the front of the tooth to the back, creating cross-sectional samples (Fig.3). These samples were then observed under a stereomicroscope with a 40x resolution (Fig 4,5,6,7). The purpose of observing the samples under the stereomicroscope was to evaluate the depth of penetration of a 1% methylene blue dye. To evaluate microleakage, a three-point severity scale was used, as stated by Araujo et al.[8] and Munro et al.[9] This scale allows for the categorization of microleakage into different levels of severity. The observations made under the stereo-microscope were compared to this scale. The microleakage scores (mean and standard deviation) three groups were compared using a one-way analysis of variance (ANOVA) and student-unpaired t-test.

3 | RESULTS

The results of the study compared the mean microleakage (dye penetrations) between Group I, Group II, and Group III at the gingival and occlusal levels (Fig.8). The mean scores of microleakage showed higher values at the gingival region for Group I and Group II, while Group III exhibited higher mean scores at the occlusal region (Table 1). The inter-group comparison of microleakage scores showed a statistically significant difference between the groups. Particularly, Group II (Tetric N-Ceram) showed less microleakage than Groups I (Filtek Z350XT) and III (Clearfil AP-X), demonstrating higher marginal sealing capabilities of the Tetric N-Ceram resin composites.

4 | DISCUSSION

The field of aesthetic dentistry has evolved from the old concept of "extension for prevention" to the modern concept of "restriction with conviction".[2] Modern dentistry has introduced better restorative materials that aim to improve both function and appearance. With a growing emphasis on achieving natural-looking results, there is a greater demand for restorations that closely mimic the appearance and characteristics of natural teeth.[2] However, there is increase chance of failure of composite restoration due to microleakage. Last few decades, several newer generation composite materials were introduced in market; however, there is limited evidence on its efficacy in limiting the microleakage.

In present study, all three types of resin composites evaluated demonstrated a low degree of marginal microleakage in most cases. However, the Tetric N-Ceram resin composite exhibited a lower degree of microleakage in both the occlusal (biting surface) and cervical (gum line) areas compared to the Filtek Z350 XT resin composite and the CLEARFIL AP-X resin composite. While the difference in microleakage between the Filtek Z350 XT resin composite and the Tetric N-Ceram resin composite was not statistically significant, it suggests a potential trend or pattern worth considering. It highlights the importance of proper handling techniques, including adequate removal of air bubbles and effective layering strategies, to minimize the formation of microbubbles and optimize the marginal sealing of the restoration. The potential formation of microbubbles between resin composite layers can contribute to micro-gaps and affect marginal integrity, potentially leading to increased microleakage.[10]

One of the factors that affects marginal microleakage is the temperature variation of composite resin during and after curing. Temperature variation can cause thermal expansion and contraction of composite resin, resulting in gaps and cracks at the interface.[11] Therefore, it is important to understand how temperature variation influences marginal microleakage and to find ways to minimize it.[12] To mimic the temperature variations experienced in the oral cavity over the course of a year, the study applied 10,000 thermocycles to the specimens. This is a higher number of cycles compared to the typical range of 500 to 5,000 thermocycles used in most studies analyzing marginal sealing in class II restorations.[13] The increased number of thermocycles aimed to mimic a

more rigorous clinical aging process.[10]

The Tetric N-Ceram resin composite utilized in the study contains camphoroquinone as the main photo-activator, which absorbs blue wavelengths ranging from 420 to 495 nm, the Tetric N-Ceram resin composite is classified as a nano-hybrid, medium viscosity bulk fill material. "Nano-hybrid" indicates that the composite contains nanoscale filler particles dispersed within the resin matrix. [7] The Tetric N-Ceram resin composite contains a patented light activator called Ivocerin. Ivocerin ensures the complete curing of the filling material when exposed to the appropriate curing light. As a result, the Tetric N-Ceram resin composite developed several advantages such as efficient curing, esthetic properties, and good handling characteristics for class II restorations.[7,10]

Microleakage in resin-based materials is often associated with polymerization shrinkage. When resin composites are polymerized, they undergo a volumetric shrinkage as the monomers react and form a solid material. This shrinkage can create gaps or voids at the restoration-tooth interface, leading to microleakage.[3,4] The relationship between marginal leakage of a dental restoration and the type of restorative material used has been a topic of discussion for quite some time in dentistry. The choice of restorative material can indeed have a significant impact on the degree of marginal leakage. One important factor that influences the performance of a restorative material is filler particles incorporated into it.[1] The amount of filler particles incorporated into a restorative material can influence its strength, modulus of elasticity, and ability to reduce polymerization shrinkage. These factors, in turn, can impact the degree of marginal leakage observed in dental restorations.[5] Microleakage is three-dimensional phenomenon and is important to control and reduce its extent which can done with help of nanomaterial.[4]

Nanocomposites are materials that consist of nanoparticles embedded in a polymer matrix. Nanoparticles are particles with at least one dimension between 1 and 100 nanometers. Nanocomposites have been shown to improve the mechanical, optical, and thermal properties of resin-based materials, which are widely used in dentistry.[14] One of the main challenges of resin-based

materials is the occurrence of microleakage, which is the passage of fluids, bacteria, and ions between the tooth and the restoration. Microleakage can cause secondary caries, pulp inflammation, and restoration failure.[15] Nanocomposites can reduce microleakage by enhancing the adhesion, sealing, and marginal integrity of resin-based materials.[16] Nanoparticles can also act as fillers to reduce the polymerization shrinkage and stress of resin-based materials, which are major factors contributing to microleakage.[17] Furthermore, nanoparticles can modify the surface characteristics and wettability of resin-based materials, which can improve their interaction with bonding agents and tooth structures.[18] Therefore, nanocomposites have a significant role in reducing microleakage in resin-based materials and improving their clinical performance and longevity.

Nanocomposites have been shown to exhibit reduced polymerization shrinkage and consequently lower microleakage compared to traditional composite resins.[19] The use of nanocomposites with filler particles in the nanometer range represents an exciting development in restorative dentistry, offering the potential for enhanced mechanical properties, improved aesthetics, and reduced shrinkage-related issues.[1] In the present study, microleakage was seen to some variable extent with nearly all three dental restorative materials used which usually inherent to the composite materials.[20]

One of the methods to evaluate marginal microleakage in dental restorations is to use dyes that can penetrate the gaps between the tooth and the restoration. Methylene blue dye is a simple and reliable technique to assess the marginal microleakage in dental restorations. It is suitable stain owing to its molecular size of approximately 1 nm, which is smaller than the diameter of dentinal tubules present in tooth structure.[7] However, it has some disadvantages such as dissolution during the demineralization and clearing processes, and difficulty to observe its maximum penetration point in some cases. A possible alternative to methylene blue is Rhodamine B, which has been suggested by some studies to have better staining properties and less interference with the histological analysis.[21] These alternatives may provide more reliable and accurate results for assessing the quality of

dental restorations in terms of microleakage.

5 | CONCLUSION

All the restorative systems tested had some degree of microleakage, but the levels varied significantly among them. Tetric N-Ceram performed better than the other materials (Filtek Z350XT and Clearfil AP-X) in terms of minimizing microleakage.

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Conflict of interest

The authors have no conflicts of interest to declare.

Supporting Information

Additional supporting information may be found at the journal's website.

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FIGURE 1 45 cleaned normal teeth used for cavity preparation and restoration

FIGURE 2 The teeth were coated with nail varnish

FIGURE 3 The teeth were sectioned bucco-lingually in to two portion to observed the microleakage at tooth-composite interface
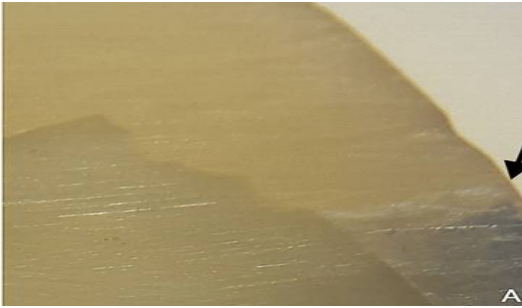
FIGURE 4 The stereo microscope image reveals no dye penetration, indicating a successful composite application on the tooth surface.
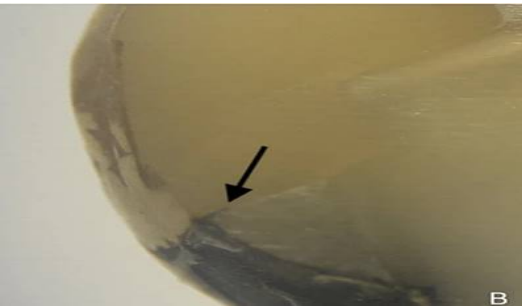

FIGURE 5 Stereomicroscope image reveals minimal dye penetration, indicating low microleakage development.

FIGURE 6 The stereomicroscope examination shows a limited amount of dye that has penetrated the interface between the restoration and the tooth, suggesting that the microleakage development is low and the seal is adequate.
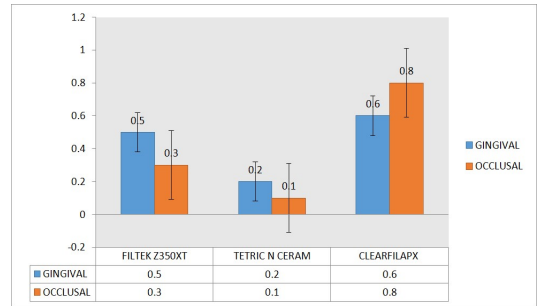

FIGURE 7 Dye penetrated from the edge of the materials to deeper depth

FIGURE 8 The graph shows the mean microleakage scores for three groups of resin composites. The groups differed significantly in their microleakage scores (p < 0.05). Group II (Tetric N-Ceram) had the lowest microleakage score, indicating better marginal sealing than Group I (Filtek Z350XT) and Group III (Clearfil AP-X)

TABLE 1 Mean values of microleakage for various groups of restorative materials used in the study

Groups	Gingival (mean ± SD)	Occlusal (mean ± SD)
Group I (Filtek Z350XT)	0.5 ± 0.55	0.5 ± 50
Group II (TET-RIC N-CERAM)	0.2 ± 0. 42	0.1 ± 23
Group III (CLEARFILL APX)	0.6 ± 0.51	0.8 ± 45