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Comparative Evaluation of Microleakage in Class V Restorations Using Contemporary Adhesive Systems – A Stereomicroscopic Study

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Abstract

Aim & background: Microleakage is the major cause for the failure of restorations, especially in class V cavities, as margins of these cavities are generally located in dentin/cementum leading to microleakage at the tooth restoration interface. It is the precursor of secondary caries, staining of restorations, tooth discoloration, marginal deterioration, postoperative sensitivity, and pulpal pathology. The present study was done to evaluate and compare the microleakage of two superior restorative materials namely Cention-N and Zirconomer Improved in class V cavities under stereomicroscope.

Methods: In this in-vitro experimental study, 28 class V cavities were prepared on the buccal surface of posterior teeth. The prepared samples were divided into the two test groups randomly for restoration with Cention N (Group I) and Zirconomer Improved (Group II). All the samples were thermocycled for 500 cycles between 5-55°c initially and then immersed in 0.5% methylene blue for 24 hours before sectioning. All the sectioned samples were observed for microleakage under a stereomicroscope.

Results: Statistical analysis was performed using SPSS software (Version 20, SPSS, IBM, Armonk, NY, USA). Independent t test was used to compare mean microleakage between the two groups. Cention N showed lesser microleakage which was statistically significant when compared to Zirconomer Improved.

Conclusion: Cention N exhibited significantly lower microleakage and better adaptation when compared to Zirconomer Improved.

Clinical significance: To address the consequences of marginal leakage, there is a pressing need for improved restorative materials, and Cention-N demonstrates potential in enhancing longevity and preventing secondary caries. However, further in-vivo studies with larger sample sizes are essential to evaluate the influence of additional factors that may affect microleakage.

Keywords: Cention N, microleakage, stereomicroscope, zirconomer improved

Introduction

Dr. G.V. Black's "extension for prevention" maneuver has significantly advanced restorative dentistry, evolving from traditional dental amalgam fillings to minimally invasive techniques that utilize micro-retention for adhesive composite fillings and chemically bonded restorations like glass ionomers. Recent innovations in adhesive dentistry have led to a more conservative approach in cavity size and shape, focusing on minimally invasive methods. This minimal removal of sound tooth structure extends the longevity of the restorative material, ensuring better endurance over time.[1]

One of the critical attributes of adhesive restorative materials is their marginal adaptability, which is pivotal for the successful restoration of Class V cavities. Inadequate marginal adaptability can result in the formation of gaps at the tooth-restorative interface, leading to microleakage—a predominant factor in the failure of restorations, particularly in Class V cavities where the margins typically reside in dentin or cementum. Microleakage can be defined as the clinically undetectable passage of bacteria, fluids, molecules, or ions between the cavity walls and the applied restorative material. This phenomenon serves as a precursor to various complications, including secondary caries, restoration staining, tooth discoloration, marginal deterioration, postoperative sensitivity, and pulpal pathology. [2,3]

The emergence of various restorative materials provides the modern dentist with an array of options for effectively restoring cervical cavities. Among the materials considered suitable for Class V restorations are composite resins (in diverse formulations), glass ionomer, resin-modified glass ionomer (RMGI), alkaline fillers, and compomers. Despite these advancements, it is noteworthy that Class V restorations often exhibit reduced durability than other classes of restorations. [1]

One significant challenge associated with Class V cavities is achieving adequate tooth isolation, largely due to the morphological characteristics of the cervical region, which complicate the placement of rubber dams and clamps. Furthermore, if the restorative material fails to adhere adequately to dentin or cementum, microleakage can occur. This allows bacteria to infiltrate the gap between the cavity wall and the resin composite, potentially leading to adverse outcomes such as secondary caries and restoration failure.[4] Recently introduced materials, such as Cention N and Zirconomer, offer superior properties that may address some of these limitations, enhancing the overall effectiveness and longevity of Class V restorations.

Cention N is classified as an "alkasite" restorative material, renowned for its ability to release acid-neutralizing ions during acid attacks, which are integrated into its resin matrix. This innovative material exhibits exceptional mechanical and physical properties, including aesthetics, adhesion, and fluoride release.[5] According to Sahadev et al.[6], the inclusion of isofiller in Cention N functions as a shrinkage stress reliever, effectively minimizing shrinkage forces during polymerization.

On the other hand, Zirconomer represents a novel restorative option, consisting of a ceramic and zirconia-reinforced glass ionomer cement (GIC). Developed as a reliable and durable self-adhesive, tooth-colored bulk-fill restorative material for posterior teeth, it incorporates nano-sized zirconia fillers that enhance both handling characteristics and aesthetic appeal.[5] Dhivya et al.[1] noted that the integration of zirconia fillers interferes with the chelating reaction between the carboxylic group (-COOH) of polyacrylic acid and calcium ions (Ca^{2+}) from tooth apatite, resulting in minimal microleakage.

The present study aims to evaluate and compare the microleakage of these two advanced restorative materials, Zirconomer and Cention N, in Class V cavities utilizing the dye penetration method under a stereomicroscope.

Materials and Methods

The study was conducted in the Department of Pediatric & Preventive dentistry, in collaboration with the Department of Oral and maxillofacial pathology, after obtaining clearance from the Institutional Ethical Committee.

The sample size was determined as 28 using G*power 3.1.9.2 software with an effect size of 1.05, alpha 5% and power 85%. A total of 28 teeth extracted human permanent posterior teeth without caries, cracks and no previous restorations were used for the study. The collected samples were cleaned and stored in distilled water until use. Class V cavity was prepared using high-speed flat end straight diamond bur (SF-41 ISO 109/010 Mani Dia burs) with water coolant on the buccal surface of each sample with standardization of 3 mm width, 3 mm height, and 1.5 mm depth. A graduated William's probe was used to measure the dimensions of the cavities. The preparations were randomly divided into two equal groups of 14 cavities in each- Group I – Cention N; Group II – Zirconomer. Samples in Group I were etched using Scotchbond multi-purpose etchant (3m ESPE), washed with water jet and dried with gentle stream of air leaving a moistened surface. A layer of bonding agent Tetric N bond (IvoclarVivadent) was applied using a disposable microbrush, and light cured for 10s and samples were restored using Cention-N (Ivoclar, Vivadent). Dosing, mixing and restoration of the cavity were strictly according to manufacturer's instructions.

For group II (Zirconomer improved), powder and liquid ratio for each sample was 3.6 / 1.0 (2 scoops: 1 drop), dispensed on the mixing pad with working time: 1min 30 sec (from start of mixing) and then it was placed on the cavity by means of plastic instrument incrementally and condensed. The samples were then subjected to thermocycling of 500 cycles between 5-55 degree celsius with a dwell time of 30sec to simulate oral conditions. The samples were then prepared for dye immersion by coating each sample with finger nail varnish, with the exception of a 0.5-1.0 mm window around the restoration margins. The teeth were immersed in 0.5% methylene blue dye for 24 hours. Later the samples were split longitudinally in a buccolingual direction (Figure 1) and the microleakage was assessed by viewing all the samples under stereomicroscope (Figure 2, 3, 4).

The scoring criteria for the microleakage assessment was followed according to Vinay S and Shivanna V [7] and the scores obtained were tabulated.

0 = no dye penetration.

1 = dye penetration up to 1/3rdcavity depth

2 = dye penetration up to 2/3rdcavity depth

3 = dye penetration to full depth of cavity

The procedure of random allocation of samples to the three groups, cavity preparation, restoration and associated measurements were standardized for all groups and performed by a single researcher to avoid bias. To avoid bias in the results, a second investigator who was unaware of the prior results randomly evaluated the samples. As the inter examiner variability was not significant, the scores given by the first investigator were only considered and subjected to statistical analysis using independent t test by using SPSS software (Version 20, SPSS, IBM, Armonk, NY, USA).

Results

The results of the study comparing microleakage between Cention-N and Zirconomer for Class V cavity restorations provide valuable insights into the performance of these materials.

The descriptive analysis highlights the variability in microleakage between the two groups. In the Zirconomer group, a significant portion of the samples (64.3%) showed dye penetration up to two-thirds of the cavity depth. This suggests a higher degree of microleakage, which compromises the seal between the restorative material and the tooth structure. In comparison, 57.1% of the Cention-N group exhibited dye penetration limited to only one-third of the cavity depth, indicating better marginal sealing in these samples.(Table 1)

An important finding was that 14.3% of the samples (two out of fourteen) in the Cention-N group showed no microleakage, suggesting excellent adhesive properties and cavity sealing in a subset of the restorations. In contrast, none of the samples in the Zirconomer group demonstrated complete sealing without microleakage. Furthermore, while the Cention-N group had no samples with full-cavity dye penetration, the Zirconomer group had three samples with dye penetration extending to the entire depth of the cavity, further highlighting the superior sealing capacity of Cention-N.

When the mean microleakage values were observed, Zirconomer group exhibited the highest mean microleakage score of 2.07. This reflects a higher overall tendency for microleakage in samples restored with Zirconomer. In contrast, the Cention-N group displayed a significantly lower mean microleakage score of 1.14, indicating better sealing performance and less penetration of dye, suggesting a more effective restoration. The difference in mean values between the two groups was statistically significant, reinforcing the conclusion that Cention-N outperforms Zirconomer in minimizing microleakage. (Table 2)

Graph 1 further emphasizes these findings by visually comparing the microleakage scores of the two test groups. In the Cention-N group, two samples exhibited no microleakage (score of 0), confirming that Cention-N can achieve optimal cavity sealing in some cases. On the other hand, none of the samples in the Zirconomer group achieved a score of 0, indicating that microleakage was present in all Zirconomer samples to varying degrees.

A microleakage score of 1, which corresponds to dye penetration up to one-third of the cavity, was observed in eight samples from the Cention-N group and two samples from the Zirconomer group. This reinforces Cention-N's superior marginal adaptation and sealing compared to Zirconomer, which showed a much lower occurrence of this minimal microleakage score.

However, a score of 2, indicating dye penetration up to two-thirds of the cavity, was noted in four samples from the Cention-N group and nine samples from the Zirconomer group, further illustrating the greater degree of microleakage in the Zirconomer group. Finally, while none of the Cention-N samples exhibited full-cavity dye penetration (score of 3), three samples in the Zirconomer group showed complete dye penetration, which is a clear indicator of inferior marginal sealing and a higher likelihood of clinical failure in Zirconomer restorations.

From the results, it is evident that Cention-N demonstrated superior performance in terms of marginal adaptability and microleakage resistance compared to Zirconomer when used in Class V cavity restorations. Cention-N not only had a lower mean microleakage score but also a higher percentage of samples showing minimal or no microleakage, suggesting it provides a more durable and effective seal against bacterial ingress. Zirconomer, while still functional, exhibited significantly more microleakage, particularly in samples with full-cavity dye penetration, indicating potential long-term issues like secondary caries, marginal deterioration, or restoration failure. Therefore, Cention-N may be a more reliable material for achieving long-term clinical success in Class V restorations.

Discussion

A healthy oral cavity is vital for maintaining long-term quality of life. Over the past decade, dentistry has experienced more rapid advancements and innovations than in the entire previous century, with progress continuing to accelerate. Despite these developments, dental caries remains the most prevalent oral disease and a significant contributor to the global burden of oral health issues. The primary objective of caries restoration is to precisely prepare and fill the cavity using materials that not only restore the tooth's form, function, and aesthetics but also prevent the recurrence of caries. Consequently, the pursuit of the ideal restorative material—one that offers superior physical properties and long-term durability—remains ongoing.[3,8]

In the current era of minimally invasive dentistry, the focus has shifted from the traditional "extension for prevention" to a more conservative "restriction with conviction" approach, particularly in the restoration of Class V lesions.[8] These lesions, located at the cervical aspect of buccal or lingual tooth surfaces, are prone to **microleakage** due to their proximity to dentin and cementum, where bonding is inherently weaker than to enamel. This is compounded by thermal changes in the oral cavity, which cause volumetric fluctuations in restorative materials, leading to marginal gaps.[1]

Additional factors contributing to microleakage include inadequate adhesion, polymerization shrinkage, moisture control challenges, and incomplete removal of the smear layer. Other influences, such as high C-factor, cyclic flexure, lack of enamel beveling, and dentin's complex composition, further increase the likelihood of leakage in Class V restorations.[3]

Microleakage is a known precursor to complications such as marginal staining, secondary caries, postoperative sensitivity, and pulpal pathology, which often result in restoration failure. Despite improvements in materials and techniques, reducing microleakage at the gingival margins remains a critical challenge in operative dentistry.[1,9]

The ideal restorative material should offer strong adhesion, durability, ease of manipulation, moisture tolerance, and excellent sealing properties, while being resistant to wear and dislodgement.[10] Recent advancements, including **Cention N** and **Zirconomer**

Improved, represent significant strides in restorative dentistry, aiming to reduce microleakage and enhance both esthetics and minimally invasive outcomes.

Cention N, introduced in 2016, is an "alkasite" restorative material known for its dual-cure capabilities and bulk-filling application. It can be optionally light-cured using blue light (400–500 nm) and incorporates an alkaline filler that releases acid-neutralizing ions. A patented isofiller minimizes polymerization shrinkage, and the material offers radiopacity for enhanced visibility. Cention N is composed of distinct powder and liquid components. The powder includes glass fillers, initiators, and pigments, while the liquid consists of dimethacrylates that form cross-links during the polymerization process.[1,11] This cross-linking imparts high mechanical strength and long-term stability, while the material also releases fluoride, calcium, and hydroxide ions to combat demineralization, offering superior protection compared to traditional GIC.[2]

Zirconomer Improved, introduced by Shofu, is a zirconia-reinforced glass ionomer cement, also referred to as "white amalgam." Zirconia, a high-strength ceramic, enhances the compressive strength, flexural strength, and resistance to wear, erosion, and marginal breakdown. Zirconomer Improved also offers sustained fluoride release and aesthetic advantages with its translucent zirconia nano-fillers, mimicking natural tooth color. Its formulation eliminates the health hazards associated with mercury in traditional amalgams while maintaining durability.[1]

Microleakage is a widely utilized method for evaluating the bonding performance of restorative materials. The clinical success of a restoration depends on the material's ability to form a strong bond with tooth surfaces and effectively seal them from the external environment, thereby preventing the development of secondary caries.[5] In this study, intact non-carious Class V cavities were selected for microleakage evaluation due to their low configuration factor, ease of preparation, and reduced technique sensitivity. To minimize polymerization shrinkage, the cavities were restored in two steps with resin composites, a method widely supported by practitioners.[4]

Aging restorations at body temperature, followed by thermocycling and/or mechanical loading, are standard practices to simulate the intraoral service life of restorations before in-vitro microleakage testing. Thermocycling mimics the thermal fluctuations experienced in the oral cavity.[4] In this study, specimens were subjected to 500 thermocycles between 5°C and 55°C with a 30-second dwell time, simulating one year of clinical service, as per Dhivya et al. (2022).[1]

Various methods have been employed to evaluate microleakage, including air pressure, bacterial activity, SEM, radioactive isotopes, and microcomputed tomography. However, many earlier techniques have become obsolete due to their inability to accurately replicate the complexity of microleakage.[4] Among contemporary methods, dye penetration using methylene blue remains a reliable choice due to its simplicity, cost-effectiveness, and reproducibility. In this study, 2% methylene blue was selected due to its low molecular weight that enables it to detect leakage in areas that are inaccessible to bacteria.[1,5]

Microleakage was assessed with a stereomicroscope, which offers a straightforward and effective way to observe objects in three dimensions. This method enables live viewing of samples on monitors and provides a broad range of resolution and magnification options while enhancing visibility through advanced illumination. It ensures precise and detailed observation, making it ideal for accurate evaluation.[8]

The present study revealed varying degrees of microleakage in both groups, with a statistically significant difference between them. Zirconomer Improved exhibited significantly higher microleakage scores (P = 0.005) compared to Cention-N, which demonstrated lower microleakage. This could be attributed to Cention N's incorporation of a shrinkage stress reliever and its low modulus of elasticity, which effectively minimizes polymerization shrinkage and microleakage.[5]

These findings align with previous research, such as Sardhana et al. (2022) [5], who found that Cention N had less microleakage than Zirconomer and Solaresculpt, and Samanta et al. (2017) [12], who reported that Cention N outperformed flowable composite resin and GIC in minimizing microleakage. George et al. (2018) [13] also noted lower microleakage in Cention N compared to GIC and composite restorations. Additionally, Chole et al. (2019) [14] observed that Cention N exhibited the highest flexural strength, which is likely due to its high filler loading and unique monomer composition, including urethane dimethacrylate (UDMA), tricyclodecan-dimethanol dimethacrylate (DCP), and polyethylene glycol 400 (PEG-400) DMA.

Cention-N's superior performance stems from its use of cross-linking methacrylate monomers and an efficient self-cure initiator, which ensures a uniform degree of polymerization throughout the restoration. [14] A key innovation is the incorporation of Isofillers—partially silane-functionalized fillers designed to relieve shrinkage stress. These Isofillers, with a low elastic modulus (10 GPa), act like springs among the standard glass fillers (71 GPa), expanding slightly during polymerization to reduce shrinkage force. This, combined with a carefully optimized organic/inorganic ratio, results in minimal volumetric contraction and allows for bulk placement without polymerization shrinkage.[2, 11]

Zirconomer exhibited increased microleakage in this study, potentially due to inadequate bonding with tooth tissue, polymerization shrinkage, and air entrapment during placement. Consistent with these findings, Sahadev et al. (2018) [6] also reported significant microleakage in Zirconomer, likely attributed to zirconia fillers enhancing mechanical properties but compromising marginal integrity. Similarly, Salman et al. (2019) [15] found Zirconomer to have the highest microleakage compared to RMGIC and Nano-ionomer but lower than Giomer, likely due to zirconia fillers interfering with the chelation between Ca^{2+} ions of hydroxyapatite and polyacrylic acid. The results also align with prior studies by Shameera Asafarlal (2017) [16], Lagesetti et al. (2018) [17], and Patel et al. (2015) [18] all of which reported high microleakage in Zirconomer compared to other tested materials.

Bhullar et al. (2019) [19] reported contradictory findings, showing greater microleakage in Cention-N compared to Biodentin and GIC, while Wetam et al. (2023) [20] found the highest microleakage in Cention-N, followed by conventional GIC and least with Ormocer. Similarly, Albesti et al. (2018) [21] concluded that Zirconomer Improved exhibited minimal microleakage, attributed to zirconia fillers causing phase shifts from monoclinic to tetragonal, counteracting polymerization shrinkage.[1]

However, the in-vitro nature of this study limits its clinical relevance. Firstly, the artificial conditions may not accurately reflect the complex oral environment, including variations in temperature and pH. A limited sample size reduces the statistical power of the results, while static testing fails to account for dynamic masticatory forces. Additionally, the short duration of the study does not capture long-term microleakage effects, and the absence of biological factors such as saliva and oral bacteria limits the relevance of the findings. Variability in cavity preparation and material handling can further influence results, alongside environmental factors like humidity and temperature during material setting. These limitations highlight the need for further in-vivo studies to validate the findings and assess the clinical performance of the restorative materials.

Legend Figures

Figure 1: Sectioning of the samples for stereomicroscopic evaluation

Figure 2: Stereomicroscopic evaluation of the samples

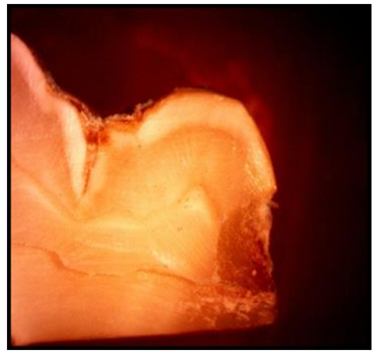


Figure 3: Stereomicroscopic image of Cention-N sample showing dye penetration

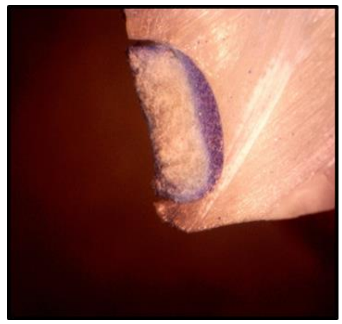


Figure 4: Stereomicroscopic image of Zirconomer sample showing dye penetration

Tables and Graphs

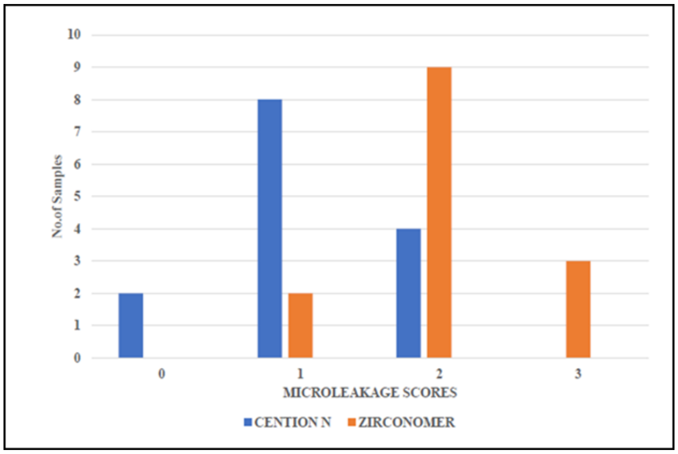
Table 1: Descriptive analysis of microleakage of cention group and zirconomer group in class v cavity restorations

Microleakage Score	Cention Nn (%)	Zirconomer N (%)
0- No microleakage	2 (14.3)	0 (0)
1- Upto 1/3rd of the cavity	8 (57.1)	2 (14.3)
2- Upto 2/3rd of the cavity	4 (28.6)	9 (64.3)
3- full cavity	0 (0)	3 (21.4)
Total	14 (100)	14 (100)

Table 2: Distribution of mean values of microleakage in the test groups

Test Material	N	Mean	Standard Deviation	t-value	p value*
Cention (Group I)	14	1.1429	0.066299	3.840	0.001*
Zirconomer (Group II)	14	2.0714	0.61573	3.840	0.001*

Graph 1: Graphical representation of the microleakage scores of the test groups



Conclusion

Within the limitations of this in-vitro study, Cention-N demonstrated superior marginal adaptation, positioning it as a promising alternative for mitigating postoperative complications like postoperative sensitivity, secondary caries and pulpitis. Further in-vivo studies with larger sample sizes are necessary to assess the impact of masticatory forces, humidity variations, salivary enzymes, and bacterial by-products on microleakage values to better evaluate the long-term clinical behavior of these restorative materials.

Understanding the microleakage characteristics of various restorative materials is essential for clinicians in their selection process, as this understanding significantly influences patient outcomes and the durability of dental restorations. Ultimately, the study's findings can inform clinical decision-making and contribute to the advancement of more effective restorative materials within dental practice.

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