ORIGINAL RESEARCH

Comparison of Intra-orifice Sealing Ability of Three Materials Placed after Endodontic Treatment: *In Vitro* Study

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Abstract

Aim and objective: The aim of this study was to evaluate and compare the intra-orifice sealing ability of Cention N, packable bulk fill composite, and Zirconomer as an intra-orifice barrier in endodontically treated teeth under a stereomicroscope.

Materials and methods: Thirty-three single-rooted teeth were decoronated at cementoenamel junction (CEJ). Following root canal treatment, 3 mm of the coronal gutta-percha was removed and the experimental material [group I (n = 11)—packable bulk fill composite, group II (n = 11)—Zirconomer, and group III (n = 11)—Cention N] was placed as an intra-orifice barrier. A dye penetration test was performed and observed under a stereomicroscope. The extent of dye penetration was measured and statistical analysis using analysis of variance (ANOVA) and *post hoc* Tukey test was done.

Results: The mean values of microleakage (in mm) for groups I, II, and III were 1.18, 0.81, and 0.74, respectively. Tukey–Kramer multiple comparison test showed no significant difference between mean values of microleakage when groups I, II, and III were compared at 5% and 1% level of significance. Student's unpaired t-test showed a significant difference between mean values of microleakage between group I and group III as well as group I and group II. No significant differences were seen between group II and group III.

Conclusion: Among all the groups checked, group III (Cention N) showed the highest sealing ability as an intra-orifice barrier.

Clinical significance: Intra-orifice barrier acts as a double seal and minimizes the amount of microleakage coronally in root canal-treated teeth. Immediate placement of additional material in the orifices acts as a secondary line of defense along with temporary filling after obturation.

Keywords: Bulk fill composite, Cention N, Microleakage, Stereomicroscope, Zirconomer.

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Introduction

Periapical infection is mainly caused by bacteria and their toxin.[1,2] Hence, the main goal of endodontic treatment is to entirely remove microbes from the root canal space, thus averting infection from reoccurring.[3,4] Obturation was frequently assessed on the basis of a successful apical seal only.[5] Nowadays, the significance of coronal restoration is more focused on.[6] 3D obturation of root canal space prevents reinfection of periapical tissues *via* a root canal. Improper coronal restoration causes more loss of root canal treated teeth than actual failure of root canal therapy as stated by Weine.[7] Gutta-percha along with root canal sealer alone resisted leakage for a shorter period of time, thus the placement of an intra-orifice barrier is a must.[8] Swanson and Madison[9] stated that whenever there is a loss of coronal seal, reinfection occurs within 3 days. Ray and Trope[10] studied that the standard of coronal restoration was much more significant than the quality of apical seal in maintaining the periapical status.

The intra-orifice barrier is a recent method in reducing the microleakage coronally in root canal-treated teeth. It involves the removal of the coronal part of the obturation and immediate placement of additional material in the orifices.[11] Use of an intra-orifice barrier acts as a secondary line of defense along with temporary filling after obturation.[12] Studies have proved that temporary materials like ProRoot™ MTA, Cavit™, IRM®; Composite; Super-EBA® act as an intra-orifice barrier and prevent microleakage coronally when being placed at a depth between 1 and 4 mm.[12] Nowadays, composites are considered as permanent filling material after obturation for better esthetic appearance, good bonding, and reinforcing the remaining tooth structures.[13] Continuous research by different manufacturers has improved the chemical structure of glass ionomer cements (GICs). A new formulation of GICs (Zirconomer) by SHOFU, Japan, incorporated zirconia filler particles which lead to good abrasive resistance with a fast setting reaction. It also improved the masticatory as well as the bending strengths of the set cement.[14]

Although various materials have been described and studied, Cention N has not been studied sufficiently as an intra-orifice barrier. Cention N is an esthetic, bulk replacement material being placed with or without any bonding system.[15] It is a subclass of composite and an alkasite in nature. The inclusion of isofillers reduces the polymerization shrinkage and leakage relatively.

So, taking into account, the importance of intra-orifice barrier in preventing coronal microleakage, the need for finding a material

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with optimal properties for use as an intra-orifice barrier is clear. Hence, the novelty of this study is aimed to evaluate and compare the sealing ability of Cention N, packable bulk fill composite, and Zirconomer as an intra-orifice barrier in endodontically treated teeth under a stereomicroscope.

Materials and Methods

Methodology

Specimen Preparation

After extraction of mobile teeth of a patient under complete ethical approval, 33 intact single-rooted teeth with type I canal system were collected for the study and stored in 0.5% thymol until use. After removal of debris, calculus, and soft tissues from the root surface, crowns were decoronated at CEJ using diamond disk under copious water cooling. A #10K file (Dentsply, Maillefer, Ballaigues) was introduced until it reaches the apex of the tooth. The 1 mm to be reduced from this length and working length was established. Instrumentation with ProTaper SX was used to enlarge the orifice, followed by S1, S2, F1, F2, and F3 in a sequential manner in a crown-down technique. Irrigation with 3% NaOCl and 17% EDTA was done simultaneously. After instrumentation, the canals were rinsed following the standardized irrigation protocol, and a final rinse with 2% chlorhexidine was done. Canals were dried with paper points and obturated with AH sealer and 6% gutta-percha by lateral compaction technique. After drying the access, 3 mm of gutta-percha was removed using a heated endodontic hand plugger of ISO size #30. The depth was confirmed using a periodontal probe. Excess sealer was removed with cotton pellets soaked in 70% isopropyl alcohol. These 33 samples were divided into three experimental groups containing 11 samples each.

Group I: Packable bulk fill composite (Ivoclar Vivadent)
Group II: Zirconomer (Shofu)
Group III: Cention N (Ivoclar Vivadent)

The materials mentioned above were placed into an orifice, according to the manufacturer's instructions. Group I—root canal orifices were etched with 37% phosphoric acid for 15–20 seconds, followed by rinsing with water, and excess water was removed. Then Tetra N Bond adhesive was applied and light cured for 20 seconds. Finally, bulk fill composite restoration was done and cured for 40 seconds. Group II—specified amounts of powder and liquid were dispensed onto a paper pad in a ratio of 3:1, powder being divided into two equal parts. The first portion was mixed into a liquid with an agate spatula and the second portion was added into the remaining liquid. Mixed GIC was placed and compacted into canal orifices. Group III—according to the manufacturer's instructions the material was manipulated and condensed using a condenser and carved using Teflon coated instrument and cured for 20 seconds.

Microleakage Test

Later, the samples were subjected to thermocycling for 500 cycles at 5 and 55°C for a dwell time of 30 seconds. The samples were dried for 24 hours. Experimental groups were coated with two layers of nail varnish except at a 1 mm area around access restoration. All teeth were immersed in sealed glasses containing 2% methylene blue dye which was freshly prepared (according to the manufacturer's instruction) for 48 hours. After this, the excess dye was washed off in running water and air dried. These samples were sectioned longitudinally using a diamond disk and were observed under a stereomicroscope at 10× magnification. The measurements were made by assessing the distance from the coronal extent to the greatest depth of dye penetration.

Statistical Methods

Statistical analysis was done by descriptive statistics such as mean, SD, and percentage/proportions.

Comparisons were done by applying Student's unpaired *t*-test at 5 and 1% level of significance.

Also, one way ANOVA test with Tukey–Kramer multiple comparison test was applied to test the comparison of all three groups together at 5% (p-value = 0.05) and 1% (p-value = 0.01) level of significance.

Statistical analysis software namely SYSTAT version 12 (by Cranes software, Bengaluru) was used to analyze the data.

Results

The mean values of microleakage (in mm) for groups I, II, and III were 1.18, 0.81, and 0.74, respectively. By applying Tukey–Kramer multiple comparison test there was no significant difference between mean values when groups I, II, and III were compared together (Table 1 and Fig. 1).

One way ANOVA test (Table 2) was used to compare all groups together to check microleakage (in mm) (value of F = 2.411, p-value = 0.1069). No significant results were found.

A significant difference (p-value = 0.0722) between mean values of microleakage (in mm) was seen when group I was compared with group II using Student's unpaired *t*-test (Table 3 and Fig. 2). By applying Student's unpaired *t*-test there was a significant difference (p-value = 0.0725) in mean values of microleakage (in mm) between group I and group III (Table 4 and Fig. 3). When group II and group III were compared there was no significant difference (p-value = 0.7513) (Table 5 and Fig. 4).

Table 1: Comparison of mean values of microleakage (in mm) of sealing ability of three groups

Group I— packable bulk fill composite (Ivoclar Vivadent) (n = 11)	*Group II— Zirconomer (Shofu) (n = 11)*	*Group III— Cention N (Ivoclar Vivadent) (n = 11)*
Mean ± SD	*Mean ± SD*	*Mean ± SD*
1.18 ± 0.49	0.81 ± 0.41	0.74 ± 0.59

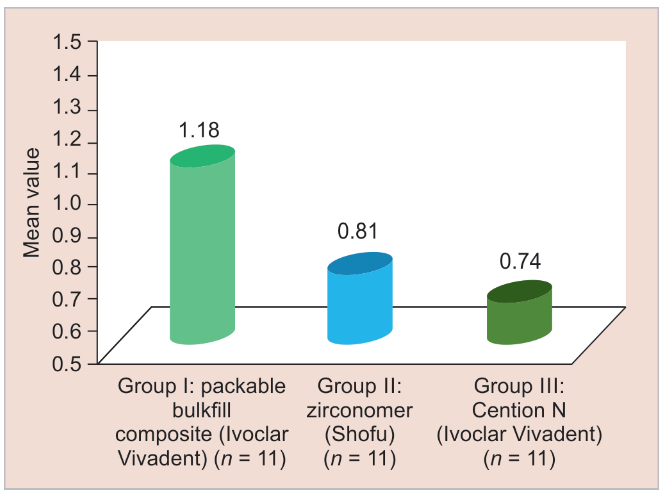

Fig. 1: Comparison of mean values of microleakage (in mm) of sealing ability of three groups under study

Discussion

Complete cleaning and shaping of the canal lead to total removal of microbes and necrotic tissue from the pulpal space. According to Dow and Ingle, improper seal at the apical end causes most of the failures.[16] But, recent studies have proved that maintaining a good quality of the coronal seal is equally significant.[17] Magura et al. reported that teeth with improper coronal seal failed twice in number than teeth which were sufficiently restored coronally.[18] The clinical performance of restorative filling material is assessed on the basis of microleakage caused.[19] Persistent efforts have been made to develop a newer generation restorative material to create a fluid-tight seal between the root canal and the oral cavity. Amid these recent techniques, placing an intra-orifice barrier before final restoration limits the cross-infection in root canal-treated teeth. Thus, various research papers have compared and evaluated different filling materials as intra-orifice barriers.[20] Ideal features of these materials should be such that,

Table 2: Comparison of groups for microleakage (in mm) using one-way ANOVA test

Source of variation	*d.f.*	*Sum of squares*	*Mean square*
Treatment (between columns)	2	1.235	0.6176
Residuals (within columns)	30	7.683	0.2561
Total	32	8.918	

Value of F = 2.411, *p*-value = 0.1069, not significant

Table 3: Comparison of mean values of microleakage (in mm) of sealing ability in group I—packable bulk fill composite and group II—Zirconomer

Group I— packable bulk fill composite (Ivoclar Vivadent) (n = 11)	*Group II— Zirconomer (Shofu) (n = 11)*	*Student's unpaired t-test value*	*p-value and significance*
Mean ± SD	*Mean ± SD*		
1.18 ± 0.49	0.81 ± 0.41	1.898	*p*-value = 0.0722, significant

Table 4: Comparison of mean values of microleakage (in mm) of sealing ability in group I—packable bulk fill composite and group III—Cention N

Group I—packable bulk fill composite (Ivoclar Vivadent) (n = 6)	*Group III— Cention N (Ivoclar Vivadent) (n = 6)*	*Student's unpaired t-test value*	*p-value and significance*
Mean ± SD	*Mean ± SD*		
1.18 ± 0.49	0.74 ± 0.59	1.896	*p*-value = 0.0725, significant

Table 5: Comparison of mean values of microleakage (in mm) of sealing ability in group II—Zirconomer and group III—Cention N

Group II— Zirconomer (Shofu) (n = 6)	*Group III—Cention N (Ivoclar Vivadent) (n = 6)*	*Student's unpaired t-test value*	*p-value and significance*
Mean ± SD	*Mean ± SD*		
0.81 ± 0.41	0.74 ± 0.59	0.3214	*p*-value = 0.7513, not significant

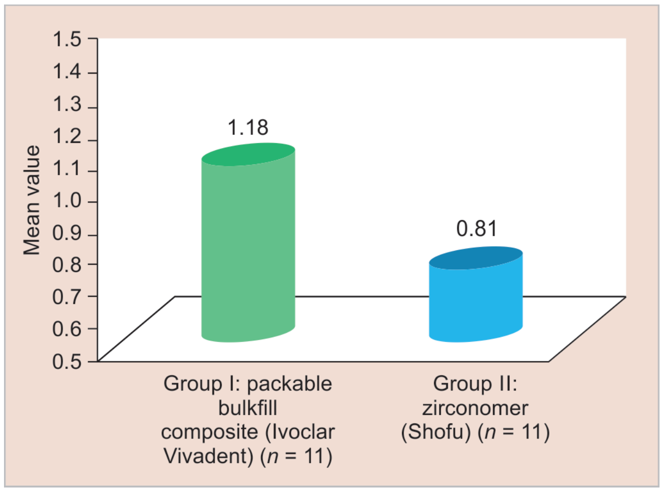

Fig. 2: Comparison of mean values of microleakage (in mm) of sealing ability in group I—packable bulk fill composite and group II—Zirconomer

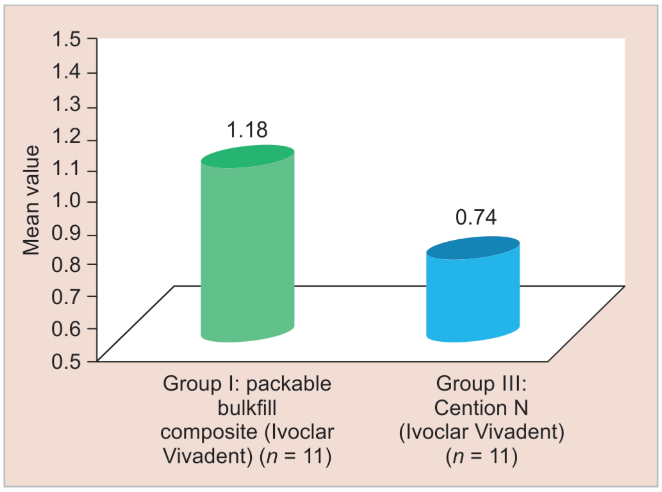

Fig. 3: Comparison of mean values of microleakage (in mm) of sealing ability in group I—packable bulk fill composite and group III—Cention N

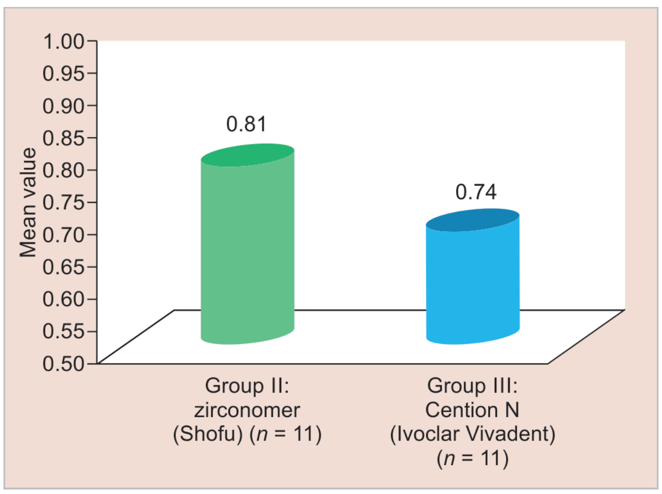

Fig. 4: Comparison of mean values of microleakage (in mm) of sealing ability in group II—Zirconomer and group III—Cention N

they should be leak-proof and permanent. The features that should be present in an intra-orifice barrier according to Wolcott et al. are (a) Strong bond to the tooth, (b) Easy placement, (c) Proper sealing ability, (d) No interference with final restoration, and (e) Easily differentiated from the natural tooth.

Placing an intra-orifice barrier up to 3 mm depth gives several benefits[13]:

- Coronally 3 mm of the canal can be easily accessed and sealed.
- No masticatory load in this area.
- Esthetic appearance is not necessary.[21]

In the current study, three different restorative materials (bulk fill composite, Zirconomer, and Cention N) were evaluated and the ability of each material was compared for intra-orifice sealing ability of endodontically treated teeth.

Bulk fill resin-based composite is a 4 mm dentine replacement material. It has good marginal quality. The photoinitiator present in it interacts with the polymerization modulator and reduces the elastic modulus, thus lowering the stress without affecting the rate of conversion.[19] Patel et al.[22] and Hariramani et al.[19] studied that bulk fill composite showed better sealing ability than nanohybrid composites.

Zirconomer, a newer modification of GIC, has strength and durability same as that of amalgam and fluoride releasing property along with chemical bonding feature is similar to that of GIC. Zirconomer has improved mechanical properties due to the inclusion of zirconia filler particles, thus, reinforcing the restored tooth under heavy occlusal load areas.[19,23] It bonds chemically to the tooth structure and has an equal coefficient of thermal expansion as that of the tooth, leading to low stresses.[23]

Cention N is available in powder and liquid forms and is a subgroup of the composite resin family. The alkaline ions present in the powder formula like calcium and fluoride neutralize the acidic ions, whereas the monomer present in the liquid part helps in increasing the flow and adaptation of the material to the cavity walls. The presence of 78.4% inorganic filler increases flexural and compressive strength, thus minimizing the shrinkage and stress within the restoration.[24,25]

For this study, single-rooted teeth with a single canal were selected so as to expose their intra-orifices which can be restored easily, and to reduce the anatomical variations, thus allowing standardization for the study.[16]

Thermocycling is a standardized method being used to simulate the aging process similar to that of *in vivo*. The samples are subjected to periodic exposures of cold and hot temperatures and the bonded materials are evaluated. When there is a difference in the coefficient of thermal expansion between the filling material and tooth structure, leakage occurs marginally. According to Korsali et al., the samples were thermocycled for 500 cycles at 50–550°C for 30 seconds in this present study.[13]

For *in vitro* studies, various methods are available for detection of microleakage namely dye penetration, fluid filtration,[26,27] electrical conductivity,[28] neutron activation method,[29] radioisotope method,[30] and many more.

In the present study, the dye penetration method was used because it is economical, easy to conduct, and has a greater depth of staining.[31] Low weight of the dye molecules penetrates into locations where microbial cells cannot. Therefore, in *in vitro* studies, microleakage is mostly investigated with low molecular-weight dyes.[32] The only limitation is that the amount of leakage is measured only in one plane, thus evaluation of the total amount of microleakage is quite impossible.[33,34] Matloff et al. stated that methylene blue is a superior tracer of micro spaces and is a more efficient indicator of microleakage.[34]

In this present study, the highest mean values of microleakage (in mm) were seen in group I (packable bulk fill composite) 1.18 ± 0.49, followed by group II (Zirconomer) 0.81 ± 0.41, and the least microleakage values were seen in group III (Cention N) 0.74 ± 0.59. By applying Student's unpaired *t*-test there was a significant difference between mean values of microleakage (in mm) when group I was compared with group II as well as between group I and group III.

The least microleakage values were seen with Cention N group (group III). This finding was in accordance to the study results by Sujith et al. He stated that Cention N has the lowest microleakage in comparison to GIC and hybrid composites. Meshram et al. reported that Cention N with a bonding agent showed lesser microleakage when compared with Cention N placed without adhesive and flowable composite. A lesser amount of microleakage was seen at the enamel restoration interface than the dentin restoration interface.[25] In contrast to our study, flowable composites proved to leak less according to Yazici et al. and Peutzfeldt and Asmussen. The reason behind this was they have high flowability and low viscosity.[35,36] Similar to our findings, Mazumdar et al. concluded least microleakage with Cention N when compared with amalgam and GIC.[24] George and Bhandary also stated lower microleakage with Cention N, when compared with GIC and composite.[37] Sahadev et al. concluded that Cention N showed lower microleakage when compared with Zirconomer.[38] Dodiya et al. found less amount of marginal adaptation with composite.[39] Hybrid composite showed higher leakage when compared with Cention N as resins undergo volumetric contractions ranging between 2.6 and 4.8%. Four different restorative materials were compared by Iftikhar et al. [conventional glass ionomer (Fuji IX), ClearFil AP-X, Filtex Z350-XT, and Cention N] and he concluded that the highest mechanical properties were with ClearFil AP-X, but the lowest scores were with Fuji IX.[40] Sahu et al. compared leakage among amalgam, bulk fill composite, and Cention N restorative material in class I cavities and concluded promising results with Cention N and reduced microleakage with amalgam than with resins.

The reasons supporting our finding are the high polymer network density of Cention N and its greater depth of polymerization along the complete thickness of the restoration. This is due to the presence of cross-linking methacrylate monomers in the formulation along with a stable and efficient self-cure initiator. The inclusion of filler (isofiller) acts as a shrinkage stress reliever and lowers down the volumetric shrinkage leading to the least amount of microleakage.[37]

Promising results were seen with Zirconomer group (group II). A certain amount of microleakage was observed after Zirconomer restorations by Patel et al.[14] This finding could be justified due to the chemistry of Zirconomer which includes ceramic particles (zirconia) as fillers. These zirconia fillers interfered in the chelating reaction between the calcium ions (Ca^{2+}) of tooth apatite and the carboxylic group (–COOH) of polyacrylic acid. This leads to the disruption of polyacrylate matrix in the cement. Asafarlal investigated the leakage of three different GICs—Zirconomer, Fuji IX Extra, and Ketac Molar in their study. The results of the dye penetration test showed that Zirconomer had the highest amount of microleakage than the other GICs. This was because of the large size of the fillers of zirconia which leads to weaker adaptation between the tooth and the restoration.

The highest amount of microleakage was seen in packable bulk fill composite group (group I). Leakage in composites can be explained on the basis of polymerization shrinkage which results in a poor bonding ability to tooth structures.

One of the limitations of this study was, due to its *in vitro* nature, specimens were standardized by decoronating at CEJ and conditions for use in the mechanical tests were restricted. Microleakage has multiple etiologies. Upgrade study models are required for clearing the link between the placement of intra-orifice barriers and coronal microleakage. Further research with higher and different study groups is required to search for more effective intra-orifice barrier in order to improve the success rate of root canal treatment. Moreover, there is a need for further *in vivo* and long-term research with a large sample size related to this topic to give better results clinically.

Conclusion

Within the limitations of this study, it can be concluded that the immediate placement of an intra-orifice barrier acts as a double seal and minimizes the amount of microleakage. Among all the groups checked, group III (Cention N) showed the highest sealing ability as an intra-orifice barrier.

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