Original Article

Comparative Evaluation of Coronal Sealing Ability of Seven Different Temporary Restorative Materials used in Endodontic Therapy: An *In vitro* Stereomicroscope Study

G. P. V. Srikumar*, Akansha D. Wasule, Tejaswini Kalaskar, Aarushi Gajpal, Akshay Phafat, Saurabh P. Vairagade

Department of Conservative Dentistry and Endodontics, Triveni Institute of Dental Sciences, Hospital and Research Centre, Bilaspur, Chhattisgarh, India.

Abstract

Background: Bacterial infection of teeth is the most common cause of pulpal and periradicular diseases. Infected root canals require dressing with antibacterial medicaments in a multi-visit root canal treatment in which temporization of endodontic access cavities becomes mandatory. Lack of satisfactory coronal temporary restorations can lead to failure of endodontic therapy. The aim of our study was *in vitro* comparative evaluation of coronal sealing ability of various temporary restorative materials in endodontic therapy using stereomicroscope analysis. **Materials and Methods:** Eighty extracted human permanent maxillary first and second premolar teeth were selected. Standardized endodontic access cavity preparations with dimensions of 5 × 5 mm were done, and root canal orifices were located. All the specimens were then randomly divided into nine groups; seven experimental and two control groups. Experimental groups; Group 1: Orafil-LC (n = 10), Group 2: Cavit-G (n = 10), Group 3: Coltosol-F (n = 10), Group 4: MD TempPlus (n = 10), Group 5: Zinc Oxide Eugenol (n = 10), Group 6: Orafil-G (n = 10), Group 7: TMP RS (n = 10) used as coronal temporary restorative materials. Control group: Positive control (n = 5), negative control (n = 5). Temporary restorative materials were placed in all specimens over the cotton pellets except in the control group. All specimens were incubated at 37°C for 48 h; thermocycling of all specimens was done and were then placed in Indian ink dye at room temperature for 7 days. All specimens were then sectioned mesio-distally, examined under stereomicroscope at ×10 magnification. Degree of dye penetration was evaluated using 4-point scale grading criteria and obtained data was tabulated. **Results**: Tabulated data were statistically analyzed using one-way analysis of variance test, student "t" test, and Fisher Exact test, $P \leq 0.05$ was considered statistically significant. Group1 showed the least dye penetration with superior coronal sealing ability, followed by Group 2 and Group 3. Group 5 and Group 7 showed maximum dye penetration with poor coronal sealing ability. **Conclusion:** Premixed Orafil-LC and Cavit-G as coronal temporary restorative materials in endodontic access cavities exhibited the least dye penetration with superior coronal sealing ability among the seven restorative materials tested.

Keywords: Dye penetration, Microleakage, Sealing ability, Temporary restorative.

Introduction

Endodontic treatment fundamentally aims to eradicate infected pulpal tissue and prevent microbial invasion from oral environments. The sealing ability of coronal temporary restorative materials plays a critical role in the success of root canal treatment. These interim filling materials temporarily replace lost tooth structure, until permanent restoration can be completed.[1] The primary function of an endodontic coronal temporary restoration is to provide a protective barrier that prevents oral bacterial infiltration into the root canal system between the dental appointments. Inadequate sealing of coronal temporary restorations results in bacterial penetration of the root canal filling, potentially compromising root canal treatment effectiveness and treatment outcome.[2] Multiple clinical scenarios; the presence of periapical pathology, persistent infections, procedural complications, patient-related challenges needing multi-visit endodontic treatment, the endodontic access cavity requires interim coronal sealing using temporary restorative materials to maintain treatment integrity.[3]

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Address for correspondence: Dr. G. P. V. Srikumar.
Department of Conservative Dentistry and Endodontics,
Triveni Institute of Dental Sciences, Hospital and Research Centre,
Bilaspur-495220, Chhattisgarh, India.
Email: drsrikumar2611@gmail.com

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An ideal temporary restorative material can be an important factor which determines the success or failure of root canal therapy. It should effectively seal the tooth, blocking salivary fluids, microorganisms, and extraneous debris from entering the root canal space.[4] Moreover, they also serve to prevent contamination of intracanal medicaments placed from oral fluids.[5] The coronal temporary restorative materials should be easy to place and manipulate, not soluble in saliva, non-toxic, impermeable to oral fluids and microorganisms, ease of removal from the access cavity when required, excellent marginal sealing ability, minimal porosity, dimensionally stable under intra-oral temperature variations, non-irritant to the oral tissues and optimal esthetics.[6]

Kidd[7] defined microleakage as the clinically undetectable passage of bacteria and its products, fluids, molecules, or ions from the oral cavity along the tooth surface-restoration interface. The quality of the coronal seal is also of a paramount importance to the health of periapical tissues during root canal treatment, matching with the clinical significance of the apical seal in root canal therapy.[8] However, temporary restorative materials inherently present certain challenges due to their poor adhesion to the tooth structure creating microscopic spaces at the interface with dentinal walls of endodontic access cavity; facilitating microleakage, enabling undetectable passage of microorganisms and oral fluids leading to failure of root canal therapy. Various coronal temporary restorative materials were routinely used in endodontic practice and they are characterized with diverse setting time, composition, properties, and sealing ability.[9]

Orafil LC (light-cure) is a recently introduced pre-mixed Urethane di-methacrylate-based temporary restorative material whose setting is initiated when exposed to visible dental curing light to a depth of 4 mm, providing a tight seal with the tooth structure, it is ready to use, easy to manipulate and can be removed easily in a single entity without causing any damage to walls of the prepared tooth.[10]

Cavit-G (Grey) is a pre-mixed, eugenol-free self-setting hygroscopic temporary restorative material based on zinc oxide/zinc sulfate cement. Its unique characteristic is its high linear expansion coefficient resulting from water sorption or saliva and has better dentin wall adaptation, which can be removed in one piece without any residues whenever required.[11]

Coltosol-F (Fluoride) is a pre-mixed non-eugenol, zinc oxide/zinc sulfate-based, self-setting cement designed for temporary restorations. It chemically hardens and is radio-opaque in nature. It hardens through water absorption, accompanied with 17–20% hygroscopic setting expansion, providing a good marginal seal.[11]

Zinc oxide eugenol (ZOE) cement is available in powder and liquid form. It is a temporary restorative material used traditionally since 50 years in endodontic practice. Powder is composed of zinc oxide powder (100%) and liquid is composed of eugenol (100%) are mixed together in 10:1 ratio to obtain the cement in desired consistency for its use as a temporary restorative material. ZOE cement is well known for its sedative, analgesic, and antibacterial properties. The reversible chemical reaction of ZO-E starts with a chelation reaction, producing zinc eugenolate when zinc oxide powder is mixed with eugenol liquid in the presence of water.[12]

MD-temp plus is a pre-mixed hydraulic temporary restorative material containing calcium sulfate and resin. It is based on zinc oxide/calcium sulfate preparations, sets on contact with saliva or moisture. During its setting, it chemically reacts and adhere to tooth dentin and undergo linear hygroscopic expansion, thus providing good adaptation with prepared cavity walls eventually providing a tight seal in endodontic access cavities preventing microleakage.[13]

Orafil G (Grey) is a pre-mixed, available in thick paste-like consistency, radiopaque, non-eugenol, zinc sulfate-based temporary restorative material with resin additives that sets in the presence of moisture. It shows slight hygroscopic setting expansion providing excellent sealing and with the addition of resin adhesives, it shows good adherence with the dentin walls of the endodontic access cavity.[14]

TMP-RS is a premixed, non-eugenol-based, self-curing temporary restorative material that sets under humid conditions. The cement sets within 2 h of placement, so exposure to chewing pressure should be avoided 2 h after its application as a coronal temporary restorative material in endodontic practice.[15]

In endodontic practice, the coronal sealing ability of temporary restorative materials remains critically important. The emergence of light-cured temporary restorative material Orafil LC has not been extensively researched regarding its coronal sealing effectiveness. Consequently, this *in vitro* study aims to comparatively assess the coronal sealing ability of Coltosol F, ZOE, Cavit-G, Orafil LC, MD-temp plus, TMP-RS and Orafill G temporary restorative materials with dye penetration test using stereomicroscope analysis.

Materials and Methods

An *in vitro* study was conducted in the Department of Conservative Dentistry and Endodontics after obtaining the Institutional Ethical Committee clearance; TIDSHRC/IEC/2024/D0021 of the Triveni Institute of Dental Sciences, Hospital and Research Center, Bilaspur, Chhattisgarh, India. Our study sample consisted of 80 human permanent maxillary first and second premolar teeth, extracted either for orthodontic reasons or periodontally compromised. All teeth were examined under a stereomicroscope (Olympus SZ61, Olympus Optical Co., Tokyo, Japan) at ×10 magnification to ensure that they were intact and without any caries or non-caries lesions, devoid of restorations, clinically detectable fractures, cracks, or enamel hypoplasia, following strict inclusion criteria. All specimens utilized in our study were within 1 month of extraction. Preliminary preparation involved meticulous cleaning of extracted teeth using ultrasonic instruments to remove superficial debris, calculus, and residual tissue tags from all collected specimens. Occupational Safety and Health Administration and Center for Disease Control and Prevention guidelines were followed throughout specimen collection, sterilization, and handling process. All specimens were stored in 0.5% thymol at room temperature until use. This methodical approach ensured a standardized and scientific preparation of all specimens, laying a robust foundation for subsequent investigative analysis.

All the specimens (n = 80) were then individually embedded in self-cure acrylic resin (DPI-RR Cold Cure, Mumbai, India) blocks up to the level of the cementoenamel junction, exposing only the crown portion of the teeth to facilitate ease of handling of specimens. Standardized endodontic access cavities in dimensions of 5 × 5 mm were prepared in all the specimens except in 5 specimens, using Endo Access Bur No. 2 (Dentsply Sirona, Switzerland) and refined with Endo Z bur (Dentsply Sirona, Switzerland) attached to contra-angled high-speed airotor handpiece (NSK, Japan) and the contents of the pulp chamber was removed using spoon excavator (GDC, Dental Pvt. Ltd. India).

All the specimens (n = 80) were randomly divided into 9 distinct Groups: Seven experimental groups (n = 70); with each group consisting of 10 specimens. Two control groups (n = 10); positive control (Group 8, n = 5): Access cavities were packed with only cotton pellets, negative control (Group 9, n = 5): Intact specimens with no endodontic access cavity preparation. In all experimental group specimens, dry cotton pellets were placed in the pulp chambers of all endodontic access cavity preparations, such that at least 4 mm standard depth was maintained in all the specimens to accommodate the coronal temporary restorative materials to be tested. A Williams graduated periodontal probe (GDC, Dental Pvt. Ltd. India) and a Metallic scale (Kokuyo Camlin, India) were used to measure and standardize the depth.

Seven experimental groups: Group 1: Orafil-LC (Prevest DenPro Limited, Jammu, India), Group 2: Cavit-G (3M ESPE, Minnesota, USA) Group 3: Coltosol-F (Coltene, Altstatten, Switzerland), Group 4: MD-TempPlus (Meta Biomed Co. Limited, South Korea), Group 5: ZOE (Prevest DenPro Limited, Jammu, India), Group 6: Orafil-G (Prevest DenPro Limited, Jammu, India), Group 7: TMP-RS (Prime Dental Products Pvt. Ltd.) (Figure 1).

All temporary restorative materials were manipulated according to the manufacturer's instructions, placed, and properly condensed into the prepared endodontic access cavities over cotton pellets using plastic filling instrument (GDC Dental Pvt. Ltd. India). To ensure the complete setting of all temporary restorative materials used, all the specimens were incubated at 100% relative humidity at 37°C for 48 h. To simulate to clinical situations of cyclic thermal fluctuations in oral cavity, all specimens were then subjected to thermocycling

Figure 1: Seven temporary restorative materials used

of 500, 2-min cycles at 4° ± 2°C and 56° ± 2°C with a transfer time of 5 s and a dwell time of 30 s as per the International Organization for Standardization 11405[16] in a thermocycler device (Holmarc, Opto-Mechatronics Ltd, India).

All the specimens were then air-dried and coated with two layers of nail varnish (Lakme Lever Pvt. Ltd. India) except over the coronal temporary restorations and 1 mm along their circumference, allowed to dry for 15 min after each layer of application. To prevent any dye leakage from the root apex, the apical foramen of all specimens was sealed with Sticky wax (Pyrax polymers. Pvt Ltd. India). All the specimens were then immersed in 10% Indian Ink dye (Black color dye) (HiMedia Laboratories Pvt. Ltd Thane, India) and placed at room temperature for 7 days. All the specimens were then removed from the dye, washed under running tap water, and air-dried. Nail varnish and Sticky wax were completely removed using Bard Parker blade (Kehr Surgical Private Limited, Kanpur, India). Subsequently, all the specimens were sectioned longitudinally in mesio-distal direction (or) plane using a Diamond disc (D and Z, Munchen, Germany) attached to a micromotor straight handpiece (NSK, Japan) at low speed of 20,000 RPM (Revolutions per minute) into 2 equal halves. The most representative halve of each specimen was chosen, the other halve been discarded. Thus, 80 samples were selected. The extent of the Dye penetration of each sample was viewed under Stereomicroscope (Olympus SZ, 9-ILL B200-Chiyoda KU, Japan) at ×10 magnification, Linear dye penetration was assessed and Scoring was done in 4-point scale, as suggested by Lee *et al*.[17] and the obtained data were tabulated.

- 0: No dye penetration into the temporary restorative material or along the restoration-tooth interface.
- 1: Dye penetration into the temporary restorative material or along the restoration-tooth interface up to the enamel-dentin junction.
- 2: Dye penetration into the temporary restorative material or along the restoration-tooth interface up to the edge of the restoration.

3: Dye penetration into the temporary restorative material or along the restoration-tooth interface up to the full depth of endodontic access cavity (Cotton pellet got discolored with the penetration of Indian ink dye).

Results

The tabulated data were statistically analyzed with Computer software; Statistical Package for the Social Sciences Version 24, using analysis of variance (ANOVA) (One Way ANOVA test), Student "*t*" test and Fisher Exact test. One-way ANOVA test showed a statistically significant difference among all the groups, $P \leq 0.05$ was considered as statistically significant (Table 1). Student "*t*" test was used for inter-group pair-wise comparison of the dye penetration (Table 2). Fisher Exact test was used to gauge the statistically significant difference between the proportions in the extent of dye penetration among the samples of all groups, to assess the effectiveness in the coronal sealing ability of the seven temporary restorative materials tested (Table 3).

It was found that Group 1; Orafil LC as temporary restorative material in endodontic access cavities showed the least dye penetration (Black color dye) with superior coronal sealing ability followed by Group 2; Cavit G and Group 3; Coltosol F, however, there was no statistically significant difference between them. Group 4; MD TempPlus and Group 6; Orafill G showed moderate dye penetration. Whereas, Group 5; ZOE followed by Group 7; TMP-RS as coronal temporary restorative materials exhibited maximum dye penetration (Black color dye) with poor coronal sealing ability among all the tested materials.

Table 1: One-way ANOVA test for comparison of dye penetration among the groups

Groups	No. of specimens	*P*-value (Mean±SD) (μm-μicrometers)
Group 1 (Orafil-LC)	10	0.2±0.42
Group 2 (Cavit-G)	10	0.4±0.7
Group 3 (Coltosol-F)	10	0.7±1.06
Group 4 (MD TempPlus)	10	1.7±1.34
Group 5 (Zinc oxide eugenol)	10	2.4±0.84
Group 6 (Orafil-G)	10	1.8±1.23
Group 7 (TMP RS)	10	2.3±0.82
Group 8 (Positive control)	5	4.5±0.34
Group 9 (Negative control)	5	0

P: Probability, SD: Standard deviation, ANOVA: Analysis of variance

Table 2: Pair-wise inter-group comparison using student "*t*" test

Pair-wise comparison of dye penetration among all 9 groups	*P*-value
Group 1 versus Group 2	0.67 NS
Group 1 versus Group 3	0.55 NS
Group 2 versus Group 3	0.78 NS
Group 5 versus Group 7	0.45 NS
Group 4 versus Group 5	0.07 S
Group 4 versus Group 6	0.39 NS
Group 4 versus Group 7	0.03 S
Group 1 versus Group 4	0.020 HS
Group 1 versus Group 5	0.0003 HS
Group 1 versus Group 6	0.007 HS
Group 1 versus Group 7	<0.001 HS
Group 2 versus Group 4	0.04 S
Group 2 versus Group 5	<0.001 HS
Group 2 versus Group 6	0.017 S
Group 2 versus Group 7	<0.001 HS
Group 3 versus Group 4	0.04 S
Group 3 versus Group 5	0.007 HS
Group 3 versus Group 6	0.017 S
Group 3 versus Group 7	<0.001 HS
Group 1 versus Group 8	<0.001 HS
Group 5 versus Group 6	0.016 S
Group 5 versus Group 8	0.23 NS
Group 6 versus Group 7	0.013 S
Group 1 versus Group 9	0.56 NS
Group 5 versus Group 9	0.030 HS

NS: Non-significant, S: Significant, HS: Highly significant

Discussion

Coronal temporary restorative materials in endodontic access cavities should provide optimum fluid-tight seal until endodontic treatment is completed and permanent restoration is done. Failure of coronal temporary restorative material is mainly due to the use of insufficient thickness of material and its improper placement.[3] A commonly suggested cause of endodontic treatment failure is apical leakage due to inadequate apical seal, but lack of satisfactory coronal temporary seal during endodontic therapy is also an important cause for endodontic treatment failure.[18] Coronal microleakage appears to be of equal or greater clinical relevance as a factor in endodontic failure than apical leakage due to the risk of recontamination. Sealing of access cavity during endodontic treatment visits is essential in achieving endodontic success. Factors including coefficient of thermal expansion, modulus of elasticity, and handling property affect the success of temporary filling materials.[14] Swanson and Madison[3] reported that microleakage of saliva and oral fluids through coronal restorative materials can reach up to 85% of root canal length.

In the present study, after endodontic access cavity preparation in the experimental group specimens, dry cotton pellets were placed in the pulp chamber, and care was exercised such that no cotton fibers were left attached to the cavity walls, as they tend to serve as a wick upon its contact with the India Ink dye. Webber *et al*.[4] suggested that a minimum thickness of 3.5 mm–4 mm of temporary restorative materials should be placed to provide superior coronal seal during endodontic therapy. Hence, in the present study, we standardized the thickness of all coronal temporary restorative materials to 4 mm.

Microleakage between the temporary restorative materials and tooth surface can be evaluated by several methods and they include dye penetration tests, fluid filtration

Table 3: Proportions in the extent of dye penetration among the samples of all groups using Fisher Exact test

Dye penetration scoring Criteria	Group 1 (*n*=10) Orafil-LC (%)	Group 2 (*n*=10) Cavit-G (%)	Group 3 (*n*=10) Coltosol-F (%)	Group 4 (*n*=10) MD-TempPlus (%)	Group 5 (*n*=10) Zinc oxide Eugenol (%)	Group 6 (*n*=10) Orafil-G (%)	Group 7 (*n*=10) TMP RS (%)	Group 8 (*n*=5) Positive control (%)	Group 9 (*n*=5) Negative control (%)
Grade 0	8 (80)	7 (70)	6 (60)	3 (30)	0 (0)	2 (20)	0 (0)	0 (0)	5 (50)
Grade 1	2 (20)	2 (20)	2 (20)	1 (10)	2 (20)	2 (20)	2 (20)	0 (0)	0 (0)
Grade 2	0 (0)	1 (10)	1 (10)	2 (20)	2 (20)	2 (20)	3 (30)	0 (0)	0 (0)
Grade 3	0 (0)	0 (0)	1 (10)	4 (40)	6 (60)	4 (40)	5 (50)	5 (50)	0 (0)

methods, radioisotopes, electrochemical methods, fluorescent microscopy, resin infiltration methods, and chemical tracers. Of these, dye penetration method was the most widely used as it is simple, easy, and reproducible. Various dyes were used in dye penetration tests, among them Indian ink and Methylene blue dyes are common. Hence, in the present study, linear dye penetration method was used and the dye utilized was 10% Indian ink for evaluation of microleakage and assess the coronal sealing ability of seven temporary restorative materials. Indian ink is a black color dye, has a small particle size that can easily penetrate by simple diffusion through the restorative material and also along the tooth-restoration interface. It is not absorbed by the hydroxyapatite crystals of tooth structure and is frequently used in dye penetration studies.[19]

In our study, all specimens were subjected to thermocycling to simulate cyclic thermal fluctuations of the oral cavity. Cruz *et al*.[20] stated that thermocycling affected the sealing ability of certain temporary restorative materials. Thermocycling tests the effect of temperature fluctuations on the dimensional stability of temporary restorative materials. Normal temperature in the oral cavity is believed to be around 35°C and it changes upon the intake of food and drinks ranging between 1°C and 58.5°C.[19] Deveaux *et al*.[21] reported that thermocycling aggravated percolation of dye and decreased the tightness of temporary restorative materials used in endodontic access preparations. Bobotis *et al*.[22] stated that temperature fluctuations can adversely affect the marginal sealing ability of coronal temporary restorative materials used in endodontics.

In our study, Orafil LC showed the least dye penetration with superior coronal sealing ability, followed by Cavit and Coltosol. Orafil LC is a light cure temporary restorative material whose setting is initiated when exposed to visible dental curing light, up to the depth of 4 mm with tight margins. The findings of our study corroborate with Chadgal *et al*.[1] reported Orafil LC showed significantly lower dye leakage with superior coronal sealing ability compared to all other temporary restorative materials used. Our findings are also in line with Joseph *et al*.[23] concluded that Orafil LC showed superior sealing ability with least microleakage compared to other traditional temporary restorative materials used. However, the only disadvantage in the use of Orafil LC as coronal temporary restorative material in endodontic access cavities, the material is not tooth-colored and instead it is blue in color and can have esthetic concerns to the patient.

In our study, Cavit-G also showed superior sealing ability with least dye penetration. Shah *et al*.[24] concluded Cavit G showed lower microleakage and good coronal sealing ability. Cavit-G is a hygroscopic material that expands when it comes in contact with moisture and presumably this expansion permits the material to adapt more tightly to dentin walls, thus providing a good seal under various conditions, including thermocycling. In our study, ZOE cement showed the highest dye penetration with the least coronal sealing ability among the tested materials. Our findings are in agreement with Joseph *et al*.[23] and Aledrissy *et al*.[25] reported that ZOE-based temporary restorative materials showed the least coronal sealing ability with severe dye penetration, as the material showed less homogeneity during manipulation of its powder and liquid components with each other. ZOE cement also showed poor sealing ability on exposure to thermal stress, attributed to the instability of zinc oxide, and inconsistencies in the mixing process, and concluded that ZOE-based temporary restorative materials to be less leak-proof among many coronal temporary restorative materials used in endodontic access cavities.

Marosky *et al*.[26] found a correlation between the ease of handling and coronal sealing ability of temporary restorative materials used in endodontic access cavities. They concluded that the premixed cements allowed less marginal leakage and showed better sealing ability, as fewer chances for manipulative errors with premixed cements than those cements that depend upon the clinician skills in mixing powder-liquid components of the cements. *In vitro* studies definitely cannot duplicate the environment that exists *in vivo*. However, these *in vitro* evaluations aid the clinicians to choose the best coronal temporary restorative material in endodontic access cavities.

Conclusion

Within the limitations of our study, it can be concluded that choosing an appropriate temporary restorative material in endodontic access cavities, gives an excellent coronal seal and thereby preventing microleakage, root canal contamination and thus contributing in the success of endodontic therapy. Hence, the importance of coronal temporary restorative materials should not be neglected and undervalued. Orofil LC and

Cavit-G as coronal temporary restorative materials showed the least dye penetration with superior coronal sealing ability compared to other temporary restorative materials used and they offer tremendous scope for their use in routine endodontic therapy.

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Conflicts of Interest

Nil.

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