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Microleakage of different temporary luting agents used for cementing provisional restorations on custom cast posts and cores

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ABSTRACT

Background: This study aimed to compare the effect of four temporary luting agents on preventing the coronal microleakage of teeth restored with custom cast post and core.

Materials and Methods: In this *in vitro* original study, after removing 9 mm of gutta percha from root canals of 32 single-canaled premolars, the acrylic resin patterns of the post and core were fabricated. Patterns were cast with Ni-Cr metal alloy and then cemented with glass ionomer. Using self-curing acrylic resin, provisional restorations were made. Then, teeth were randomly allocated to four groups for each temporary cement including zinc oxide eugenol (Temp Bond), zinc oxide noneugenol (Temp Bond NE), noneugenol resin-based temporary luting agent (Temp Bond Clear), and noneugenol urethane methacrylate polymer-based temporary luting agent (Dento temp). Teeth were subjected to thermocycling, immersed in silver nitrate for 6 h and then sectioned. The amount of dye penetration in the margin of provisional crown and into the coronal part of the root canals was measured using a stereomicroscope. Data were analyzed using the Kruskal–Wallis and Dunn tests with significance level of 0.05.

Results: All the luting agents showed some degree of microleakage (Group 1 showed the most microleakage). According to the pair comparison between the groups, Group 1 revealed a significant difference with others ($P < 0.05$). Furthermore, Group 2 showed more microleakage as compared to Group 4 ($P = 0.037$).

Conclusion: Temp Bond showed the highest microleakage as compared to other luting agents. Furthermore, Temp Bond NE revealed a weaker sealability as compared to Dento temp.

Key Words: Dental cement, nonvital tooth, temporary dental restoration

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INTRODUCTION

Provisional restorations that resemble the form and function of the planned definitive restorations are the prerequisite for a biologically acceptable treatment.[1] Interim restorations not only play protection, functional, and stabilizing roles, but also are useful for diagnostic purposes, as long as the functional, occlusal, and esthetic parameters are finalized for optimum treatment outcome.[1] The materials used to fabricate provisional restorations can

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be classified into acrylic resins or composite resins.[2,3] Acrylic resin is the material of choice for provisional restorations; however, the main problem with most acrylic resins is their brittleness.[4,5] Therefore, when provisional treatment is planned for extended periods of time, heat-polymerized acrylic resin materials are recommended for additional strength. A heat-polymerized acrylic indirect provisional restoration is denser, more wear resistant, more color stable, and more resistant to fracture as compared to a self-curing acrylic direct provisional restoration.[6,7]

Along with the importance of material selection for provisional restorations, considering the suitable temporary luting agent is vital for protecting the restored teeth from coronal microleakage. Microleakage in the provisional state of treatment could endanger the success of treatment for both a vital and nonvital teeth.[8] The properties of temporary luting agent used to cement the provisional restoration could be critical for preventing tooth sensitivity or intracanal microleakage. In this regard, temporary luting agents should possess good mechanical properties, minimal film thickness, low solubility, and acceptable adhesion to resist bacterial and molecular penetration.[9] The most important function of these materials is to provide an adequate seal between the provisional restoration and the prepared tooth,[10] and also bonding them together through mechanical, micromechanical, chemical, or a combination of these mechanisms.[11] In general, temporary luting materials have poor mechanical properties as compared to permanent luting agents which despite providing easier removal for the provisional restoration, have a negative influence on the marginal microleakage.[9]

One of the most commonly used temporary luting agents is zinc oxide eugenol (ZOE).[1,9] This material provides sedative effects that reduces dentin hypersensitivity and also possess antibacterial properties.[9] However, free radical production necessary for polymerization of methacrylate materials can be significantly hampered by the presence of eugenol found in eugenol-containing temporary luting materials.[1,9] This can interfere with the polymerization of resin-based materials.[12] Although the softening effect of eugenol on the acrylic resin is dependent on the presence of the unreacted eugenol, which may be minimal in some luting agents such as ZOE luting agent.[13] Furthermore, eugenol-free temporary luting agents which contain polycarboxylic and polyacrylic acids are compatible with both resin-based provisional materials and luting agents.[14,15] However, both ZOE and noneugenol (ZONE) temporary luting agents have poor sealing abilities.[9,16,17]

Considering the clinical situations that nesseciate the extended provisionalization such as periodontic, orthodontic treatments, or diagnostic measures which potentially subject the vital teeth to pulpal necrosis and endodontically treated teeth to microleakage,[9,18,19] replacing the temporary luting agent on a regular basis,[9] or using a temporary luting agent with better mechanical properties, good adhesion, and lower solubility, is recommended.[16] On the other hand, more recently introduced resin-based temporary luting agents are claimed to exhibit high strength, excellent retention, better aesthetics, low solubility, and easy clean-up.[9,20] Moreover, due to the absence of eugenol in their composition, there is no interference with polymerization of resin-based materials and also no risk of eugenol sensitivity in patient.[9,20] However, there are very few studies evaluating the microleakage of provisional crowns cemented with these luting agents.

Therefore, the purpose of this study was to compare the coronal microleakage of four temporary luting agents with different chemical bases (ZOE, ZONE, resin, and acrylic/urethane polymer based) to determine the most suitable luting for cementing provisional restorations. The null hypothesis was that there is no difference between different temporary luting agents in terms of coronal microleakage of teeth restored with cast post and core.

MATERIALS AND METHODS

According to the power analysis (statistical power of 80% and an error probability of 5%), a minimum of eight samples was required for each group to examine the strength of the study hypothesis. In this *in vitro* original study, a total of 32 extracted noncarious single-rooted adult mandibular premolar teeth with single patent root canal of similar size and shape without cracks and root resorption were selected. All external debris was removed using a curette. The teeth were stored in 0.5% chloramine T solution for 1 week and then in distilled water at the room temperature up to 3 months until they were used. The root canals were straight in the 10-mm coronal portion of the root length. Teeth were decoronated from 2 mm above the cementoenamel junction using a round end tapered diamond bur in a high-speed hand piece under water spray.

Each tooth was endodontically treated with a working length 1 mm shorter than the length at which a K file #10 tip (MANI Inc., Kiohara Industrial Park, Tochigi, Japan) passed the apical foramen, using the flat surface of a coronal section as the reference point. Canals were prepared to a master file three size larger than the initial file, using the step-back technique and were flared at the middle and coronal thirds using Gate Gliddens drills #2 and #3 (Maillefer, Dentsply, Ballaigues, Switzerland), respectively. Files were replaced after use in four canals. Root canals were filled with gutta percha (Aria Dent, Tehran, Iran) and AH26 sealer (DeTrey Division, Dentsply Ltd., GmbH, Konstanz, Germany) using the lateral condensation technique. The access cavity was filled with a noneugenol provisional material (Cavit-G, 3M ESPE, St Paul, MN). The apical fourth was sealed externally with a glass-ionomer luting agent (Ionofill, Lot 1508251, VOCO, 3M ESPE) and stored in normal saline for 72 h before postspace preparation. Gutta percha was removed with #2 specified reamers of a DT light post (RTD, St. Egreve, France) to create a 9-mm long postspace. The root canals lengths were between 14 and 17 mm from the canal orifice. Drills were discarded after five postspace preparations.

A groove (1 mm deep and 2 mm long) was prepared as an anti-rotation using a diamond bur (#856-010, D-Z Co., Bern, Switzerland) to prevent postrotation during cementation. Passively fitting polycarbonate dowel *(*Pin-Jet*;* Angelus*,* Londrina*,* PR*,* Brazil*)* was adapted to the postspaces with auto-polymerizing acrylic resin (Pattern Resin, GC America Inc., Alsip, IL, USA). The occlusal surface was formed with two cusps of 15°. Patterns were cast in a base metal alloy (VeraBond, Fairfield, CA).Canals were cleaned with water and dried. Posts were cemented with glass ionomer luting agent (GC Co., Tokyo, Japan) according to the manufacturer instruction. In order to eliminate the procedural errors, the whole procedure was performed by one expert operator.

For a standard full cast crown tooth preparations, the occlusal and axial surfaces were reduced 1.2 and 1 mm, using round end-tapered diamond burs #012 and #010, respectively. Keeping the bur parallel to the tooth walls during preparation a 6^o taper was expected, as recommended. The cervical preparation margins were finished as circular chamfers using torpedo diamond burs (D&Z, Geneve, Switzerland) with water cooling. The occlusocervical height was kept 6 mm approximately. A new bur was used for every five preparations, and all preparation margins were entirely placed in dentin.

Following this, the provisional crowns were fabricated using the direct technique. The silicone mold was made to achieve the provisional crowns of approximately the same dimensions. The provisional crowns were fabricated using self-curing acrylic resin material (Tempron, GC Co., Tokyo, Japan), using the mold in which the prepared tooth was seated. The liquid and powder were mixed at a room temperature of 23°±1°C, according to the manufacturer's instructions. The mold was quickly filled with the acrylic resin and then manually pressed on the corresponding teeth. A constant pressure was maintained for 5 min with an axial load of 5 kg, which was applied with a wooden tablet that leaned on the mold flat tops. Once set, the prepared tooth with the provisional crown was retrieved, and excess flashes of resin was trimmed away. The provisional crowns were finished and polished.

The internal surfaces of provisional crowns were cleaned ultrasonically for 10 min. The teeth were also cleaned and randomly divided into four test groups (n = 8) for cementation procedures. The temporary luting agents used in this study were: (1) ZOE luting agent (Temp Bond, Kerr Europe AG, Basel, Switzerland); (2) ZONE luting agent (Temp Bond NE, Kerr Europe AG, Basel, Switzerland); (3) Resin-based temporary luting agent (Temp Bond Clear, Kerr Europe AG, Basel, Switzerland); and (4) NE acrylic urethane methacrylate polymer-based temporary luting agent (Dento temp, ITENA, Paris, France). All cementing procedures were used according to the corresponding manufacturers' instructions at the room temperature (23°C ± 1°C) and relative humidity (50% ± 5%). Cementation was performed by painting a thin layer of the luting agent into the interior surfaces of the provisional restorations and applying finger pressure for 10 s after seating them on the teeth. Then, a static load of 5 kg was applied axially on the restorations for 5 min, leaving the material to set. Finally, excess luting agent was removed by a scaler. After cementation, the specimens were kept in distilled water.[8]

After storing the specimens in distilled water at 37°C for 10 days, they were subjected to 3000 cycles of thermocycling in water baths between 5°C and 55°C (immersion time 20 s; transfer time 10 s). After thermocycling, the root apices were sealed with a light-cured resin composite, and the root surfaces were covered with two layers of nail varnish up to 2 mm below each crown margin. Then, the specimens were immersed into a 1M silver nitrate solution (Crystal, Merk, Germany) for 6 h, rinsed thoroughly, and then stored in a photochemical developer (D76, Eastman Kodak, Rochester, NY, USA) for 12 h followed by an exposure to a 150-W flood lamp for 6 h. The specimens were then embedded in a transparent self-curing acrylic resin (Rapid Repair, Meliodent, Heraeus Kulzer GmbH, Hanau, Germany). Each specimen was cut in a bucco-lingual direction through the center of the restoration using a slow-speed diamond saw (Isomet, Buehler, Lake Bluff, IL, USA) with water cooling.

The microleakage in the area of the tooth-cement interface was defined as the linear penetration of the silver nitrate starting from the restorative crown margins. Microleakage was determined with a stereomicroscope[21] (SZX12, Olympus, Tokyo, Japan) [Figure 1]. The images were taken at a resolution of 1024 × 768 pixels. The selected magnification was based on 2.44 µm equaling one pixel. The samples were examined by one expert operator twice. Data were collected and analyzed using the SPSS software version 21.0 (Microsoft Inc., Chicago, IL, USA). Due to the nonnormal distribution of the data according to Kolmogorov–Smirnov test, Kruskal–Wallis and Dunn tests were used for analyzing the data. The level of significance was considered 0.05.

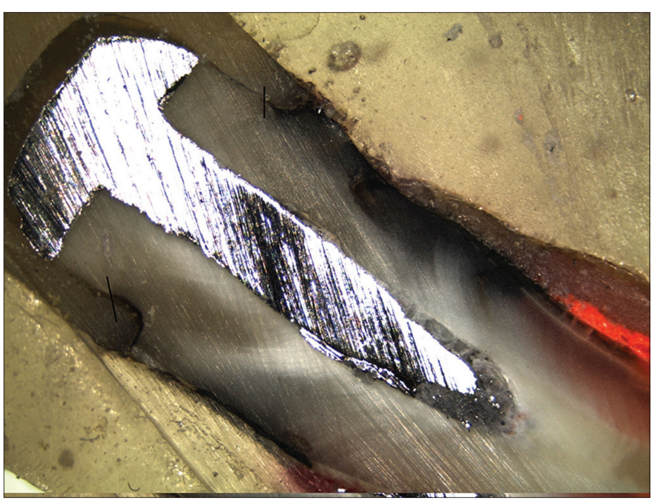

Figure 1: Stereomicroscope image of microleakage of temporary cements used for luting provisional crowns over custom cast post and core.

RESULTS

The comparison of data among groups obtained for the various luting agents is shown in Tables 1 and 2. The results of Kruskal–Wallis analysis revealed statistically significant differences in the microleakage values among groups ($P < 0.001$). According to the results, marginal leakage happened in all the specimens. The most and the least amount of microleakage were observed in Group 1 (ZOE) (273.50 µm) and Group 4 (NE acrylic urethane methacrylate polymer) (99.90 µm), respectively.

For pair comparison between the groups, Dunn's test was used which revealed significant differences between Group 1 (ZOE) and all the other groups ($P < 0.05$). Furthermore, pairwise comparison of microleakage between Groups 2 (ZONE) and 4 (NE acrylic urethane polymer) showed a significant difference, with more microleakage seen in Group 2 ($P = 0.037$).

DISCUSSION

In general, dental luting agents with desirable mechanical properties, dimensional stability, good adhesion to the tooth structure, low film thickness, low solubility in oral fluids, and also a similar coefficient of thermal expansion to the tooth structure possess good sealing abilities.[22-24] However, temporary luting agents do not have these properties.

Table 1: The mean, standard deviation, minimum and maximum of microleakage (µm) in different groups with a *P* value of<0.001

Group	Mean±SD	95% CI for mean	
		Lower bound	Upper bound
1	273.50±9.89	265.22	281.77
2	109.20±2.58	91.15	127.24
3	106.40±5.57	101.74	11.06
4	99.90±4.04	96.51	103.28

Group 1: ZOE luting agent (TempBond); Group 2: ZONE luting agent (TempBond NE); Group 3: Resin-based luting agent (TempBond Clear); Group 4: NE acrylic urethane methacrylate polymer-luting agent (Dento temp); CI: Confidence interval; SD: Standard deviation; ZOE: Zinc oxide eugenol; ZONE: Zinc oxide non-eugenol

Table 2: Pair comparison of microleakage in groups and their *P* values (in parentheses)

Group	1	2	3
2	2.67 (0.0038)	-	-
3	3.31 (0.0005)	0.64 (0.2606)	-
4	4.45 (0.0000)	1.78 (0.0371)	1.14 (0.1263)

Furthermore, the need for the easy removal of the provisional restoration (without damaging the restoration or the tooth)[9] makes it difficult to use cements with these characteristics. The purpose of this study was to compare the sealing ability of four commonly used temporary lutings for cementing provisional crowns on endodontically treated teeth. The tested null hypothesis was rejected because the type of temporary luting agent had a significant effect on the coronal microleakage. All the samples showed dye penetration along the root canal which indicated the weak sealability of the temporary luting agent for cementing provisional restorations.

ZOE luting agent exhibited the highest microleakage level of all the lutings examined in this study, which was consistent with previous reports.[9,25,26] The high solubility, hydrolytic breakdown, and low mechanical properties are the major drawbacks that leads to the poor sealing ability of this temporary luting agent.[27] However, this material has antibacterial properties due to the presence of eugenol, which could provide an inhibitory effect against the plaque accumulation in the areas affected by microleakage. The possible explanation for this finding is that eugenol-containing temporary luting agents have high film thickness. This could lead to a higher microleakage due to the higher chance for restoration marginal gap, cement water absorption, hydrolytic degradation (solubility), and decreasing of the mechanical properties.[8,28] Therefore, it could be concluded that when ZOE-luting agent is used for cementing long-term provisional restorations, the probability of canal contamination, and even coronal caries might rise.

The resin-containing luting agents (Groups 3 and 4) were the most effective at preventing microleakage regardless of their volumetric shrinkage and higher linear coefficient of thermal expansion.[29,30] The factors that have a role in their good sealing properties include water uptake to compensate the volumetric shrinkage, low solubility, and higher flexural strength (40 vs. 7 MPa as compared to other temporary cements).[24] Furthermore, since the microleakage in the Group 2 (ZONE) was significantly more than in the Group 4 (NE acrylic urethane polymer), it could be concluded that the presence or absence of eugenol is not a determining factor for sealing ability properties. Regarding the less microleakage seen in resin containing temporary luting agents, it could be concluded that if relatively long-term provisionalization is indicated, using noneugenol resin-based temporary luting agents are a wider choice.

Since *in vitro* microleakage tests using dyes are more strict than the *in vivo* tests,[9] the clinical acceptance of these results requires careful interpretation. Furthermore, *in vitro* bacterial microleakage investigation is recommended for further conclusion. One of the limitations of this study was not using cyclic loading which could create microfracture in the cements and accelerate the microleakage process. Further investigations and clinical studies with a larger sample size are necessary to gain more insights into the clinical performance (retention, flexural strength, etc.,) of these temporary cements.

CONCLUSION

Based on the findings of this *in vitro* study, the following statements can be made:

1. ZOE-luting agent lead to a significant coronal microleakage for teeth restored with a cast post and core and a provisional crown
2. The sealibility of noneugenol resin-based temporary luting agent was better than the zinc oxide noneugenol luting agent.

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Conflicts of interest

The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or non-financial in this article.

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