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ORIGINAL RESEARCH

Sealing Ability of Various Restorative Materials as Coronal Barriers between Endodontic Appointments

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ABSTRACT

Aim: To evaluate and compare the microleakage of various restorative materials used as coronal barriers between endodontic appointments.

Materials and methods: Eighty extracted human permanent posterior teeth were prepared for standardized access cavities with dimensions of 4 × 4 × 4 mm. The teeth were then randomly divided into four groups; Kalzinol, Caviton, GC Fuji IX and GC Fuji II LC. After incubation, the samples were immersed in 2% methylene blue for 7 days. The depth of penetration was measured using a digital macroscope after longitudinal sectioning of each tooth. Kruskal-Wallis ($p < 0.05$) and multiple Mann-Whitney test with Bonferroni correction ($p < 0.008$) were used for data analysis.

Results: The degree of microleakage varied at the material/tooth interface among the test materials, and the difference was statistically significant ($p < 0.05$). GC Fuji II LC group showed the least median microleakage value (0.8105 ± 0.305), followed by Caviton (1.1885 ± 0.396), GC Fuji IX (3.3985 ± 0.305) and Kalzinol (4.161 ± 0.853).

Conclusion: Within the limitations of this study, GC Fuji II LC exhibited the best marginal seal, and has the potential to be used as a suitable coronal barrier between endodontic appointments.

Clinical significance: Given the prime importance that dental practitioners should thoroughly restore any tooth with a suitable coronal barrier between endodontic appointments, this study shows that Fuji II LC has the ability to maintain a hermetic seal for 7 days.

Keywords: Coronal barrier, Endodontic appointments, Microleakage, Seal.

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INTRODUCTION

Complete elimination of microbial irritants from the root canal system, and maintaining the tooth in this disinfected state by preventing any ingress of oral microorganisms and/or their toxins during and after treatment are the principle goals of endodontic therapy.[1,2] If this can be achieved, indeed, this would pave the way for high levels of success of the endodontic and postendodontic treatment approaches, thus retaining the normal function and esthetics of the tooth.[2]

It is well known that endodontic treatment of uncomplicated cases with vital pulp can be performed in a single visit, which would eliminate the need for intracanal medicament and temporization.[3] However, many cases can be presented with complex root canal anatomy, persistent infection or iatrogenic procedural mishaps that warrant the completion of endodontic treatment in multiple appointments.[3] Therefore, it is essential that the prepared access cavity is adequately sealed with an appropriate intermediate coronal barrier that would prevent the recontamination of the pulp space, and avoid the seepage of intracanal medicament, which may be toxic, into the oral cavity.[3,4] In addition, this coronal barrier should be able to maintain dimension stability, withstand occlusal forces and abrasion, allow ease manipulation and provide acceptable esthetics.[3,5]

Many *in vitro* studies evaluated the sealing ability of intermediate coronal restorations between appointments at different endodontic steps: (a) Once the access cavity preparation is performed,[4,6] (b) After gaining access to the pulp chamber, and the root canals are initially instrumented,[7] (c) After the completion of endodontic treatment.[5,8] Coronal temporization following access cavity preparation is a usual emergency endodontic procedure. As such, this study aimed to assess and compare the sealing ability of Kalzinol, Caviton, GIC Fuji IX and GC Fuji II LC as intermediate restorative materials following access cavity preparation which, to the best of our knowledge, has not yet been carried out.

MATERIALS AND METHODS

Eighty extracted, caries-free, human permanent premolar and molar teeth were collected and stored in 0.9% isotonic saline at room temperature. After scaling the root surface, the access cavities were prepared using round and diamond fissure burs (Diatech Dental AG, Heerbrugg, Switzerland) in a high speed handpiece with water coolant to create a standardized access cavity volume with dimensions of 4 × 4 × 4 mm. The samples were then rinsed, dried and a cotton pellet was placed in each prepared cavity. A periodontal probe was used to measure the depth of each cavity, ensuring approximately 4 mm of cavity depth was attained before the restorative materials were placed into it.[9]

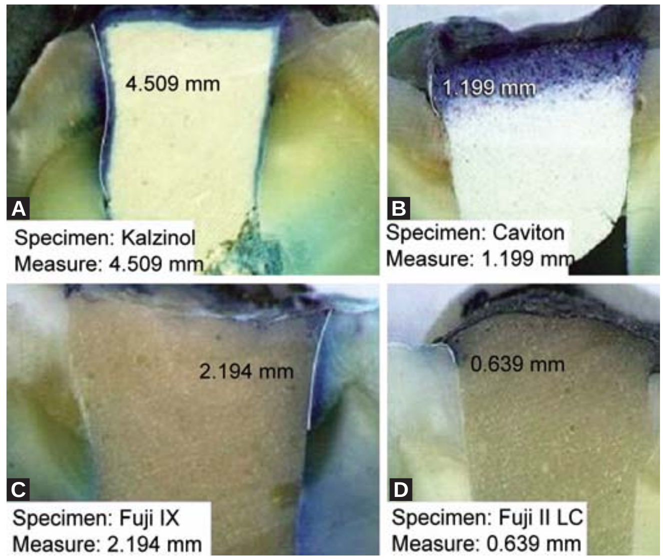
The teeth were divided at random into four groups of 20 teeth each. The tested materials, Kalzinol, Caviton, GC Fuji IX and GC Fuji II LC, were then mixed according to manufacturers' instructions, and introduced into the prepared cavities using a plastic instrument. For GC Fuji IX and Fuji II LC, the smear layer was removed using a polyacrylic acid dentin conditioner for 20 seconds as recommended by the manufacturer, and Fuji II LC was applied and cured at increments of 2 mm. After proper condensation against the cavity walls, the outer surface of only Kalzinol and Caviton was smoothened with a cotton pellet moistened with normal saline. The specimens were then incubated in normal saline at 37ºC for 2 hours.[10] After that, the specimens were double coated with nail varnish, except for 2 mm around the prepared cavities. Subsequently, the specimens were immersed in 2% methylene blue solution, and incubated at 37°C for 7 days.

After 7 days, the specimens were washed under running water, dried and then sectioned in a mesiodistal direction along their longitudinal axis using a slow speed diamond cutter (Exakt Hard Tissue Cutter, Germany). The sectioned specimens were viewed and photographed using a macroscope (Leica Microsystem Imaging Solution Ltd, England) at 5× magnification equipped with a digital camera. Finally, the measurements of dye penetration were recorded for analysis.

With the aid of statistical package for the social sciences (SPSS version 12) software, Kruskal-Wallis test was used for data analysis ($p < 0.05$). Then, the intergroup comparisons were performed using Mann-Whitney test with Bonferroni correction ($p < 0.008$).

RESULTS

The depth of microleakage differed distinctly among all the test groups (Fig. 1). GC Fuji II LC group showed the least median microleakage value (0.8105 ± 0.305), followed by



Figs 1A to D: Depth of dye penetration in (A) Kalzinol; (B) Caviton; (C) GC Fuji IX; (D) GC Fuji II LC

Caviton (1.1885 ± 0.396), GC Fuji IX (3.3985 ± 0.305) and Kalzinol (4.161 ± 0.853).

Analysis of results using Kruskal-Wallis test showed that the median depth of methylene blue dye penetration was statistically significant between all the test groups ($p < 0.05$) (Table 1). GC Fuji II LC group showed the least median microleakage value (0.8105 ± 0.305), followed by Caviton (1.1885 ± 0.396), GC Fuji IX (3.3985 ± 0.305) and Kalzinol (4.161 ± 0.853). The intergroup analysis, using multiple Mann-Whitney test with Bonferroni correction, also revealed significant differences among all groups ($p < 0.008$) (Table 2).

Table 1: Median of microleakage of the test groups

Material	*n*	Depth of penetration in mm median (IQR)	X^2 stat (*df*)[a]	*p*-value[a]
GC Fuji II LC	20	0.8105 (0.306)	67.57 (5)	<0.001
Caviton	20	1.1885 (0.396)	–	–
GC Fuji IX	20	3.3985 (1.190)	–	–
Kalzinol	20	4.1615 (0.853)	–	–

[a]Kruskal-Wallis test; mm: Millimeter

Table 2: Intergroup comparisons using Mann-Whitney test

Material	*Z-statistic*[a]	*p-value*[a]
A-B	–3.53	<0.001
A-C	–5.41	<0.001
A-D	–5.41	<0.001
B-C	–5.41	<0.001
B-D	–5.41	<0.001
C-D	–2.98	0.003

A: GC Fuji II LC; B: Caviton; C: GC Fuji IX; D: Kalzinol
[a]Mann-Whitney test

DISCUSSION

Coronal microleakage is an important etiological factor for failed root canal treated teeth, even if the endodontic treatment was performed adequately,[11] and it is one of the most frequent causes for continuing pain following endodontic treatment.[3] Owing to these undesirable consequences, many *in vitro* and *in vivo* investigations examined the ability of different restorative materials to serve as adequate coronal barriers either between endodontic appointments or prior the placement of a final restoration.[4-6]

For many decades, zinc oxide and eugenol cement, and its modified formulations, have widely been used for many dental applications including temporary coronal restorations.[3] Kalzinol is a zinc oxide eugenol-based cement reinforced with 2% by weight polystyrene polymer to double its compressive strength.[3] The sealing ability of Kalzinol has been investigated in previous studies.[12-14] Lim[12] compared the sealing ability of Kalzinol with Cavit-W and Ketac fil over 30 days, and found that both Kalzinol and Ketac fil exhibited better long-term seal than Cavit-W. On the contrary, Tamse et al[13] demonstrated the inferior sealing properties of Kalzinol, after 7 days, than other coronal barriers such as Cavidentin, Cavit and Cavit-G. This was in agreement with a study by Tewari and Tewari[14] who observed an extensive leakage from the fourth day with Kalzinol, and on the day 7, the dye was able to penetrate, in all samples, through the material/tooth interface to the cotton pellet in the pulp chamber. This marked microleakage also is consistent with the results of our study (Fig. 1A), which might be attributed to the dissolution or disintegration of the cement due to moisture contact,[14] besides the probability of voids formation during mixing, and the presence of unreacted particles after mixing. Despite the favorable results reported by Lim,[12] it seems that the removal of the smear layer, by ultrasonic cleaning for 1 hour with the teeth immersed in 1% sodium hypochlorite, played the major role in maintaining a hermetic seal of Kalzinol at the material/tooth interface.

Caviton is a ready made cement mainly composed of zinc oxide, Plaster of Paris and vinyl acetate.[9] The good sealing ability of Caviton has been reported in various *in vitro* and *in vivo* studies,[9,10,15] which is in agreement with our results. This desirable property is due to its ability to set on contact with moisture, and undergo hygroscopic expansion, thus maintaining a tight seal at the tooth/material interface.[9,10,15] This hygroscopic property explains the reason for dye penetration into the bulk of the material.[9,10] (Fig. 1B). Apart from this, being in a premixed application, this also may reduce the inconsistencies related to chairside manipulation, thus enhancing the sealing properties.[9,10]

Glass ionomer cement (GIC) is one of the most commonly used materials in clinical dentistry due to its biocompatibility, adhesion to hard tissue and antimicrobial activity.[16,17] In endodontics, it is usually indicated as root-end filling, root canal sealer, repair of perforation and resorption defects.[16] Owing to its adhesion and antibacterial properties, many studies examined the potential use of various glass ionomer cement formulations as coronal barriers[12,18-20] and it seems that there is a general agreement that conventional GICs have better sealing properties than other commonly used cements, such as zinc phosphate cement[18,19] and zinc oxide eugenol based cements,[18-20] which is consistent with our findings as Fuji IX exhibited lesser microleakage than Kalzinol. This is mainly attributed to the low initial solubility of Fuji IX,[21] besides its adhesion properties which may be enhanced by a previous application of a dentin conditioner,[22] though its sealing ability was lesser than some hygroscopic cements such as Caviton (Figs 1B and C).

Fuji II LC is a resin modified GIC (RMGIC) that shows a promising indication for coronal temporization, and its sealing ability has been found to compete that of mineral trioxide aggregate (MTA).[8] This superior performance may be explained by the hygroscopic expansion, and the inherent adhesion property to tooth structure through the acidic functional groups.[8] Interestingly, Tselnik et al[8] did not use a light cure for Fuji II LC as an attempt to prevent the excessive shrinkage on polymerization, and it was not clear whether the cavity was conditioned before its application or not. However in our study, the cavity was conditioned prior the application of Fuji II LC, which was light cured for 20 seconds of each 2 mm thickness of the material as recommended by the manufacturer. Although Fuji II LC set without light curing in 5 minutes,[23] it is recommended that RMGICs should always be cured for at least the manufacturers' recommended time to minimize the leaching of toxic components.[23,24] Apart from this, the suspected polymerization shrinkage following light curing of Fuji II LC would be compensated by its hygroscopic expansion, which explains the minimum microleakage identified with this material, which probably is enhanced by removing the smear layer. It is worth pointing out that excessive hygroscopic expansion is not always a desirable property for coronal barriers, as this may increase the likelihood for cusp deflection,[25] especially in badly decayed teeth.

In spite of the favorable results exhibited by RMGICs (Fig. 1D), further studies are required to investigate the short- and long-term sealing properties of RMGICs at different endodontic steps, under similar oral conditions including thermal fluctuations and occlusal loading in simple and more complicated access cavity configurations to ensure its ability to maintain this hermetic seal.

CONCLUSION

Within the limitations of this study, GC Fuji II LC exhibited the best marginal seal, and has the potential to be used as a suitable coronal barrier between endodontic appointments.

CLINICAL SIGNIFICANCE

Given the prime importance that dental practitioners should thoroughly restore any tooth with a suitable coronal barrier between endodontic appointments, this study shows that Fuji II LC has the ability to maintain a hermetic seal for 7 days.

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