Comparative evaluation of apical microleakage in immediate and delayed post space preparation using four different root canal sealers: An in vitro study

Prabeesh Padmanabhan, Joydeep Das, R. Veena Kumari, P. R. Pradeep, Ankur Kumar, Sneha Agarwal
Department of Conservative Dentistry and Endodontics, M R Ambedkar Dental College and Hospital, Bengaluru, Karnataka, India

Abstract

Background: Endodontically treated teeth often lack sufficient support for a permanent restoration. During post space preparation, it is important not to disturb the integrity of the apical seal.

Aim: This study compared the effect of immediate versus delayed post space preparation on the apical seal using four different sealers.

Materials and Methods: One hundred and thirty single rooted teeth were biomechanically prepared and obturated with single cone gutta-percha and 4 sealers: Endoflas FS, AH Plus, Gutta flow and MTA. Teeth were divided randomly into eight groups, post spaces were prepared using Gates Glidden drills immediately for group I, III, IV and VII. For groups II, IV, VI and VIII prepared after storage of the specimens in 100% humidity for one week. The samples were kept in methylene blue dye, centrifuged at 3000 rpm for 3 min sectioned and then measured under stereomicroscope for apical leakage.

Statistical Analysis: The data was analysed using one way ANOVA and post hoc Tukey test.

Results: All the specimens showed dye leakage, and a statistically significant difference was seen among all the groups (P > 0.05) except Gutta flow.

Conclusion: Less leakage is seen when post space is prepared immediately.

Keywords: AH Plus; Endoflas FS; GuttaFlow; microleakage; MTA Fillapex

INTRODUCTION

Endodontically treated teeth often lack sufficient support for a permanent restoration. Thus, these teeth often may require the use of an intracanal post for retention of the core.1,2

A hermetic apical seal is necessary to ensure a successful endodontic treatment; it is important not to disrupt the integrity of the same during post space preparation.3

Address for correspondence:
Dr. Joydeep Das, Department of Conservative Dentistry and Endodontics, M R Ambedkar Dental College and Hospital, Bengaluru, Karnataka, India.
E-mail: joydeepdas70@gmail.com

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used as the gold standard for comparisons with other endodontic sealers. GuttaFlow is a first sealer/gutta-percha combination which is flowable at room temperature that can be used as a sealer as well as obturating paste without a solid master cone.

Mineral trioxide aggregate (MTA) was developed by Torabinejad in the early 1990s. Holland et al. concluded that MTA induces closure of main canal foramen by new cementum formation with the absence of inflammatory cells after 6 months. However, the selection of sealer and timing of preparation for maintaining the hermetic seal during postspace preparation remain inconclusive.

Hence, the aim of this study was to compare the effect of zinc oxide-eugenol-based Endoflas FS (Sanlor Laboratories, Miami, FL, USA), resin-based AH Plus, silicone-based GuttaFlow (Coltene/Whaledent, Switzerland), and MTA Fillapex (Angelus, London Pr, Brazil) sealers effect on immediate and delayed postspace preparation.

**METHODOLOGY**

One hundred and thirty recently extracted human mandibular first premolar of approximately equal size with single root canals and mature apices were selected for this study. All teeth were stored in 0.9% saline and were immersed in 5.25% sodium hypochlorite (NaOCl) for 8 h to remove surface-adhered organic material. The teeth were decorated at the cementoenamel junction using water-cooled high-speed fissure bur (Prodottoda; Diamir Srl Loc., Resia, Italia).

The canal lengths were measured by placing a size 15 K-file (Kerr/Sybron, Romulus, MI, USA) into each root canal until the tip of the file was visible at the tip of the apical foramen. The working length was established 1 mm short of the apex. Root canals were instrumented at the working length with a size HyFlex CM #40, 0.04% files (Coltene/Whaledent, Switzerland) using a step-down technique. Then, root canals were prepared from crown to apex using sizes 1–4 Gates Glidden Drills (Maný, Inc. Takanezawa-machi, Shioya-gun, Tochigi-ken, Japan). The roots were irrigated with 10 mL of 5.25% NaOCl and then dried with Paper Points (Meta Dental Co. Ltd., Korea). One hundred and twenty roots were randomly assigned to eight experimental groups of 15 teeth each (n = 15) and the remaining ten roots were used as positive and negative controls of five specimens each. The canal sealers were mixed and handled according to the manufacturers’ instructions. Root canals obturation was done using single cone obturation technique by checking for resistance to displacement or “tug back.”

**Grouping**

- Group I: Obturated with gutta-percha cone and Endoflas FS (Sanlor Laboratories, Miami, FL, USA) sealer - immediate postspace preparation
- Group II: Obturated with gutta-percha cone and Endoflas FS (Sanlor Laboratories, Miami, FL, USA) sealer - postspace prepared 1 week after obturation
- Group III: Obturated with gutta-percha cone and AH Plus (Dentsply DeTrey, Konstanz, Germany) sealer - immediate postspace preparation
- Group IV: Obturated with gutta-percha cone and AH Plus (Dentsply DeTrey, Konstanz, Germany) sealer - postspace prepared 1 week after obturation
- Group V: Obturated with gutta-percha cone and GuttaFlow (Coltene/Whaledent, Switzerland) sealer - immediate postspace preparation
- Group VI: Obturated with gutta-percha cone and GuttaFlow (Coltene/Whaledent, Switzerland) sealer - postspace prepared 1 week after obturation
- Group VII: Obturated with gutta-percha cone and MTA Fillapex (Angelus, London Pr, Brazil) sealer - immediate postspace preparation
- Group VIII: Obturated with gutta-percha cone and MTA Fillapex (Angelus, London Pr, Brazil) sealer - postspace prepared 1 week after obturation

Control groups:
- Group IX: Obturation without sealer (positive control)
- Group X: No obturation and sealers (negative control).

The corresponding 0.04% Taper #40 gutta-percha cones were then inserted into the root canals of all the specimens of the groups with firm pressure. The excess gutta-percha extending from the coronal part of the canal was removed with a heated spoon excavator.

Radiographs were taken to confirm the quality of root canal. After filling and postpreparation were completed, the surfaces and coronal openings of all roots were coated with two layers of sticky wax (Cavex Set Up Regular Cavex Holland BV, RW Hearlem, The Netherlands), except for the apical 2 mm. Between phases of the experiment, the specimens were stored in 100% humidity.

The specimens used as positive and negative controls were instrumented, and the two positive control roots were filled with a loosely fitted gutta-percha cone without endodontic sealer and the two negative controls were not obturated. The apical foramen of the positive control was completely covered with two layers of sticky wax, except for the apical 2 mm, whereas that of the negative control was completely covered with two layers of sticky wax.

The postspaces were prepared immediately in Groups I, III, V, and VII with Peeso reamers from size 1 to 4 at 4000 rpm to a depth that left 5 mm of gutta-percha apically. In Groups II, IV, VI, and VIII, the samples were stored in 0.9% saline at 37°C for 1 week, and the postspaces were prepared with Peeso reamers from size 1 to 4 at 4000 rpm to a depth that left 5 mm of gutta-percha apically.
Dye penetration
The roots were then placed in 2% methylene blue dye and centrifuged at 3000 rpm for 3 min (REMI R-8C) all at room temperature. The teeth were then removed from the dye and were washed under running tap water for half an hour to remove dye on external root surface.

Method of microscopy
The teeth were then sectioned vertically along the long axis. To ensure that the sectioning process did not damage the inside of the canal, the sectioning was done with water-cooled microtome diamond saw (Struers ApS, Ballerup, Denmark). Samples were then evaluated under a stereomicroscope at ×20 magnification for visible coronal extent of dye penetration from the apical constriction, and the higher value among them was taken.

With the help of the photomicrographs obtained, the linear measurement of the dye penetration was noted from apical to coronal direction to nearest 0.1 mm at ×20 magnification with a calibrated ocular eyepiece. To remove any interobserver bias, the extent of dye penetration was evaluated by these independent observers, who were unaware of the materials and method used in the study but were instructed about the method of measuring and recording the extent of dye penetration.

RESULTS
The results of this study showed that apical microleakage was observed in all the groups [Graph 1 and Table 1]. All the specimens showed dye leakage, and there was statistically significant difference ($P < 0.001$) among all the groups using one-way ANOVA [Table 2]. Further on application of post hoc Tukey’s test. The specimen in Group III (AH Plus – immediate postspace preparation) showed minimal leakage and specimen in Group II (zinc oxide eugenol-delayed postspace preparation) showed a maximum leakage (3.613 mm). However, apical microleakage was less in immediate postspace preparation groups than when it was compared with delayed postspace preparation groups.

DISCUSSION
An adequate root canal-treated teeth often require intracanal post for the retention of postendodontic restotation. The restoration of endodontically treated teeth often requires intracanal postretention.\textsuperscript{[2,3]} To create space for post, some filling material is removed from the canal, and during the preparation of this space, the root filling material may be dislodged by creating voids in the obturation.\textsuperscript{[9]} Several studies have shown that the integrity of the remaining obturation after removal of root canal filling materials may depend on a number of factors, and some of these factors are techniques and instruments used for removal,\textsuperscript{[10]} the length of the remaining materials,\textsuperscript{[11]} endodontic obturation techniques,\textsuperscript{[3]} cements used, time of their setting, and time of removal of root filling\textsuperscript{[2]} which determines the durability of final restoration. Removal of the obturating material from the root canals for postspace can be done by thermal, chemical, or mechanical methods.\textsuperscript{[12]}

Several studies\textsuperscript{[10,13]} have reported that no statistical difference in apical leakage could be observed before or after postpreparation with various techniques. Furthermore, Hiltner et al.\textsuperscript{[10]} reported no significant difference in leakage when comparing gutta-percha removal using flame-heated endodontic plugger, Peeso reamer, GPX burs, and Touch’n Heat electrically heated spreader.

The integrity of apical seal is proportional to the amount of remaining filling material. It has been reported in studies

\begin{table}[h]
\centering
\begin{tabular}{|c|c|c|c|c|}
\hline
 & Minimum & Maximum & Mean & SD \\
\hline
Group I & 2.60 & 3.40 & 2.9933 & 0.23135 \\
Group II & 3.00 & 3.90 & 3.6133 & 0.25033 \\
Group III & 0.80 & 2.00 & 1.2133 & 0.32921 \\
Group IV & 0.90 & 2.20 & 1.5267 & 0.32616 \\
Group V & 0.70 & 2.40 & 1.2533 & 0.51805 \\
Group VI & 1.00 & 2.50 & 1.4800 & 0.45071 \\
Group VII & 2.20 & 3.00 & 2.5600 & 0.26939 \\
Group VIII & 2.40 & 3.10 & 2.8200 & 0.20071 \\
\hline
\end{tabular}
\caption{Representing mean (standard deviation) and minimum/maximum of microleakage in different experimental group}
\end{table}

\begin{table}[h]
\centering
\begin{tabular}{|c|c|c|c|c|}
\hline
 & Sum of squares & df & Mean square & $F$ & Significant \\
\hline
Between groups & 89.699 & 7 & 12.814 & 111.995 & 0.000 \\
Within groups & 12.815 & 112 & 0.114 & 0.45071 & \\
Total & 102.513 & 119 & & & \\
\hline
\end{tabular}
\caption{Comparison of experimental groups with respect to microleakage (mm) by one-way ANOVA and post hoc Turkey test}
\end{table}

Graph 1: Box plot comparing mean between the eight experimental groups
that 4–5 mm of apical gutta-percha should be retained apically which may provide adequate apical seal.\cite{14,16}

It is generally agreed that lateral condensation of gutta-percha cones with a sealer in the root canal is one of the most reliable methods for filling the root canal system.\cite{16,17} However, this technique produces many irregularities in the final mass of gutta-percha. There is also inadequate dispersion of sealer, leaving voids in and around the gutta-percha cones.\cite{17} Thus, a number of different obturating techniques have been introduced with the aim of securing better adaptation of the canal.

Gutta-percha has no adhesive qualities or adaptability to dentin of the root canal wall, so it must be used in combination with sealer. If leakage occurs, it can take place either at the gutta-percha/sealer interface or the sealer/dentin wall interface.\cite{18} Grossman\cite{19} studied the physical properties of sealers (e.g., flow, setting time, and shrinkage.) and postulated that sealing ability may be related to those physical properties, and that manipulation of the material during or after filling could affect the ability to produce a good seal. The ability of a sealer to bond to the tooth structure is of considerable importance.\cite{17} Adhesion to dentin and the lack of tensile strength of some of the sealers probably create gaps and voids caused by crumbling of the set material.\cite{19}

Torabinejad et al. have stated that if a root filling material does not allow penetration of small particles such as dye molecules, it is more likely to have the potential to prevent microleakage of bacteria and their by-products.\cite{20} As methylene blue has a low molecular weight and penetrates molecules, it is more likely to have the potential to prevent microleakage of bacteria and their by-products.\cite{20} Methylene blue dye presents promising physical, chemical, and biological properties. Although there are doubts regarding the filling capability of this filling material, which seems to be deficient because of the voids present in the filling mass,\cite{21} its adequate marginal sealing capacity can be explained by the expansion property (0.16% at 25°C and 0.76% at 37°C) of this polydimethylsiloxane-based sealer during polymerization.\cite{7}

Delayed postspace preparation done using AH Plus sealer showed dye penetration which was significantly more than immediate postspace preparation; this was in accordance with the results of Goodacre CJ et al.\cite{26} A study by Ørstavik et al.\cite{27} concluded that all epoxy-based materials show some expansion after setting. AH Plus expanded up to 0.4% after 4 weeks and depicted a slight but continuous expansion up to 1.2% during the next 4-week period. These dimensional changes of the material upon setting could be the possible reason for minimal apical leakage.

GuttaFlow, the new silicon-based sealer, presents promising physical, chemical, and biological properties. Although there are doubts regarding the filling capability of this filling material, which seems to be deficient because of the voids present in the filling mass,\cite{22} its adequate marginal sealing capacity can be explained by the expansion property (0.16% at 25°C and 0.76% at 37°C) of this polydimethylsiloxane-based sealer during polymerization.\cite{7}

Borges et al. evidenced that the solubility of MTA Fillapex was statistically higher than that of AH Plus even though both materials fulfill the ANSI/ADA,\cite{28} according to which a root canal sealer should not present solubility higher than 3%.

When the postspace is prepared at the time of obturation, the sealer does not form a lasting bond to the gutta-percha or root canal wall. When the heated instrument or rotary instrument is introduced into the canal to remove the gutta-percha, the sealer is still within its working time and allows the sealer to set without introducing microfractures where the sealer is in contact with the gutta-percha and root canal wall. When the sealer is set during delayed postspace preparation, it is possible that the rotational forces of the Gates Glidden Drill cause movement of the gutta-percha and thus break the bond at the sealer interface.
CONCLUSION

Within the limitations of this study, the following conclusions can be drawn:

- The quality of the root canal filling is important to maintain the integrity of the apical seal during postspace preparation. According to the results delayed postspace preparation causes more apical microleakage, and significant difference was found with zinc oxide-eugenol-based sealer.
- Immediate postspace preparation resulted in a relatively lower mean apical dye microleakage.
- Whereas there was no statistically significant difference in the apical dye microleakage between immediate and delayed postspace preparation in Groups V and VI (silicone-based GuttaFlow).

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Conflicts of interest
There are no conflicts of interest.

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