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ORIGINAL ARTICLE

The effect of immediate and delayed post-space preparation using extended working time root canal sealers on apical leakage

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zinc oxide—eugenol sealer

Abstract *Background/purpose:* The purpose of this study was to compare the effect of different post-space preparation time intervals on the apical sealing ability of filling material using two different extended setting time root canal sealers.
Materials and methods: A total of 100 single-canal teeth were incrementally cleaned with crown-down instrumentation using K3 rotary nickel—titanium instruments and randomly divided into four groups. There were 30 teeth in the experimental groups (Groups 1—3) and 10 teeth in the control group (Group 4). We obturated the teeth using a warm gutta-percha vertical compaction technique with pulp canal sealer (Group 1), Tubli-Seal EWT (Group 2), and pulp canal sealer EWT (Group 3). We then stored all the specimens in 100% humidity at 37°C for 1 week. We used heated pluggers to create post space at three different intervals postobturation (i.e., immediately after obturation, on Day 3, and on Day 7), leaving 5-mm gutta-percha filling at the apices. We then immersed the teeth in 2% methylene blue solution for 72 hours, and finally sectioned them longitudinally into two halves. The amount of apical dye leakage was measured under a stereomicroscope.
Results: The results showed no significant difference ($P > 0.05$) in dye leakage between the standard and extended working time root canal sealers. Apical leakage tended to increase more severely in Group 1 at the three different intervals was considered.
Conclusion: Extended working time root canal sealers do not affect microleakage results using a warm gutta-percha vertical compaction technique. The sealing ability of extended working

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time root canal sealers on high heat conditions is as good as the standard working time root canal sealer during post-space preparation of different intervals.

Introduction

Long-term success of root canal therapy depends on maintaining the hermetic seal of three-dimensional fillings. With the goal of rehabilitating phonetic and mastication functions, post and core restorations are frequently needed when the coronal tooth structure is inadequate to retain a crown. Intracanal posts are often necessary before crown fabrication. It is important not to disrupt the integrity of the remaining filling material that is providing the apical seal during the post-space creation.

Post-space preparation methods associated with gutta-percha removal technique, the amount of root canal filling that should remain, the type and setting time of root canal sealer, and the time interval of root canal filling removal have been extensively studied.[1] While Hiltner *et al*. are skeptical that different methods of gutta-percha removal significantly contribute to apical leakage, the thermal method is generally accepted as the safest, most controlled, and effective way of removing the specific length or amount of gutta-percha required.[2–4] Metzger *et al*. demonstrated that the sealing is proportional to the length of the remaining filling.[5] Authors of most previous studies agree that keeping 5 mm of the obturating material in the apical region constitutes a safe margin.[6–8] In addition, McComb and Smith compared two commonly used root canal sealers to evaluate whether post placement before or after the sealer setting shows a difference in post stability, and concluded that there is no significant difference[9]; however, Fan et al and Karapanou et al suggested that delayed post-space preparation resulted in greater leakage using zinc oxide—eugenol (ZOE) sealers.[10,11] They explained that the leakage was due to the disintegration of thin layer sealers upon removal of gutta-percha, which affected the apical seal and resulted in canal reinfection.[11,12] Therefore, the result was the same irrespective of the type of root canal sealer used with gutta-percha.

Recently, a vertical compaction obturation technique combined with extended working time ZOE sealers (pulp canal sealer EWT) has been recommended to enhance the sealing ability of root canal obturation.[13] Wiener and Schilder, Yared and Bou Dagher evaluated the dimensional changes and sealing ability of the Kerr Pulp Canal Sealer (Kerr, Sybron, Romulus, MI, USA).[14,15] The composition and setting conditions of the regular and extended working time root canal sealers are described in Table 1. Although a number of detailed researches and discussions regarding dimensional changes have been carried out, there is little consensus on the time interval of root canal filling removal using extended working time root canal sealers for root canal obturation.

The objective of this study was to assess the effects of different time intervals before post-space preparation and two different extended working time ZOE root canal sealers, Tubli-Seal EWT and pulp canal sealer EWT, on maintaining the apical seal after root canal treatment. The results from our study should clarify the optimum timing and root canal sealer for post-space preparation, which will help in reducing endodontic failure and improving the success rate of prosthodontic procedures.

Materials and methods

We extracted a total of 100 single-canal teeth with a mature, intact apex for reasons such as advanced periodontitis or orthodontic treatment. They were collected and preserved in 10% buffered formalin solution at 37°C until use. Before performing experimental procedures, all the samples were soaked in 5.25% NaOCl solution for 8 hours to remove all surface organic debris, then rinsed with water and stored in physiological saline.

Root canal preparation

The crowns of the teeth were first cut at the cement—enamel junction using a lower-speed carborundum disk under water cooling. The working length was established by gradually

Table 1 The compositions of three different root canal sealers.

	Pulp canal sealer	Tubli-Seal EWT	Pulp canal sealer EWT
Powder	Zinc oxide 40—50% Rosin (oligomers) Dimeric acid resin Silver powder Thymol iodide Metallic	Base: Zinc oxide Barium sulfate Lecithin Cornstarch Mineral oil	Zinc oxide: 50—60% Rosin (oligomers) Silver powder Metallic
Liquid	4-Allyl-2-methoxyphenol Balsam resin	Accelerator: 4-Allyl-2-methoxyphenol Dimeric acid resin	4-Allyl-2-methoxyphenol Balsam resin Water
Setting time (h)	1—2	6—8	6—8

introducing a #10 K file (apical diameter: 0.10 mm; Kerr, Romulus, MI, USA) extending through the apex until it was visible at the apical foramen and by deducting 1 mm from the actual tooth length. We cleaned and shaped the root canals using K3 rotary nickel–titanium following incremental crown-down preparation sequences of 0.12/25, 0.10/25, 0.08/25, 0.06/25, and we continued enlargement up to apical size #35 (0.06/35 diameter of 0.35 mm). The root canals were irrigated with 5 mL of 5.25% NaOCl solution for every file change. When the preparation was complete, the root canal was irrigated with 10 mL of 5.25% NaOCl and 3 mL of 17% trisodium ethylenediaminetetraacetic acid solution. A #10 file was finally inserted into the canal to verify the integrity of apical constriction.

Root canal obturation

After completing the root canal preparation, the root canals were dried with sterile absorbent paper points and randomly divided into three experimental groups of 10 each ($n = 30$) and one control group ($n = 10$). All the teeth including the experimental and control groups were then obturated using warm gutta-percha vertical compaction technique with pulp canal sealer (Group 1), Tubli-Seal EWT (Group 2), and pulp canal sealer EWT (Group 3) (Fig. 1).

Group 1 (30 teeth)
All the samples were dried with aspiration and absorbent paper points, and tried a size #35 gutta-percha master cone, verifying the correct size by frictional fit or tug-back sensation. We coated the canal walls with an even layer of ZOE pulp canal sealer (Kerr, Romulus, MI, USA) and obturated the canal with a warm vertical compaction technique (System B and Obtura II combination technique). After completing root canal obturation, we randomly divided the 30 samples into three subgroups ($n = 10$). Post spaces were prepared at the following time intervals: immediately, on Day 3, and on Day 7. We removed the root canal fillings at the coronal area using a heated plugger, leaving 5-mm gutta-percha filling at the apices. Once adequate amounts of gutta-percha had been removed, we corked the canal orifices with dry cotton pellets and the access cavity was sealed with ZOE cement (IRM; Caulk/DENTSPLY, Milford, DE, USA).

Group 2 (30 teeth)
The samples were treated similar to Group 1, except that obturating the root canals was carried out using Tubli-Seal EWT sealer (Kerr, Romulus, MI, USA).

Group 3 (30 teeth)
The samples were treated similar to Group 1, except that obturating the root canals was carried out using pulp canal sealer EWT (Kerr, Romulus, MI, USA).

Group 4 (10 teeth)
A total of five teeth were treated similar to Group 1, except that root canal fillings were not removed. The other five teeth were left without root canal fillings.

Apical dye penetration

As soon as we had obturated all the specimens and prepared post spaces, the coronal portion of the root was sealed with IRM temporary filling material. We coated the roots with two layers of fast-acting cyanoacrylate ester adhesive (SuperBonder, Loctite, Louisville, KT, USA) and nail polish, covering the whole specimens including the access restoration, but leaving 2 mm at the apical area of the root. We then soaked them in a water bath at 37°C for 72 hours. Subsequently, all the samples were thermal cycled in a water bath at 55°C and then immersed in 2% methylene blue dye for 72 hours. Finally, the samples were washed in running tap water to remove any excess dye material.

Final assessment and statistical analysis

We longitudinally sectioned all the specimens using a sharp chisel along the buccolingual direction after grooving them with a fissure diamond bur. We then examined all the sections (selecting any one intact section from each tooth) and photographed them at a 20× magnification next to a millimeter ruler using a Nikon automatic camera fixed to the stereomicroscope (Fig. 2). Dye leakage was measured as the linear penetration of the stain. The resulting data were considered as mean values. All the sections were examined and recorded by two experienced endodontists.

Figure 1 Three different root canal sealers: (A) pulp canal sealer (regular set); (B) Tubli-Seal EWT; (C) pulp canal sealer EWT.

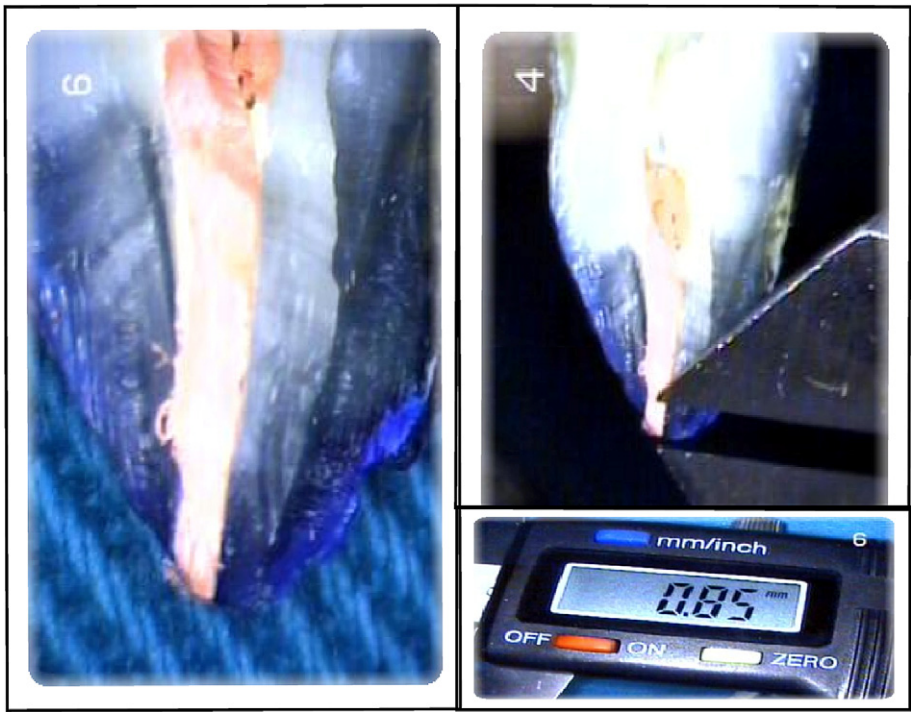

Figure 2 Tooth sections were examined under a stereomicroscope and dye leakage was measured using a micrometer.

In the analyses, leakage was considered as the dependent variable. We used the SPSS one-way analysis of variance test to assess the three root canal compaction techniques, the different time intervals for post-space preparation, and their statistical significance in terms of beneficial or adverse outcomes. A P value of 0.05 was taken to be statistically significant.

Results

After we completed procedures for all the tooth specimens, including root canal enlargement, obturation, gutta-percha filling removal for post-space preparation, the dye penetration test, and vertical splitting, we scrutinized them under a stereomicroscope to assess the depth of dye penetration. The means and standard deviations of dye leakage after post-space preparation following the three different techniques of root canal obturation are listed in Table 2. Results of statistical analysis indicated that irrespective of the type of root canal sealers chosen—i.e., standard or extended working time—there was no significant difference in leakage based on the timing of post-space preparation when comparing those prepared immediately after obturation, on Day 3, and on Day 7, with the one exception of Group 1, where the dye leakage measurements indicated a trend toward increased leakage over time. Selecting and comparing only extended working time root canal sealers, the effect of gutta-percha removal at three different time intervals (immediately after obturation, Day 3, and Day 7), no significant differences were noted between the Tubli-Seal EWT and pulp canal sealer EWT. We found that extended working time root canal sealers produced less leakage than the standard working time root canal sealer, but no statistically significant differences were apparent. We thus present two observations: (1) at any given post-space

Table 2 One-way analysis of variance, mean and standard deviation of the dye penetration observed on the canal walls.

	Group	Mean	SD	No.	P
Pulp canal sealer (zinc oxide—eugenol)	Immediate	1.98	0.061	10	>0.05
	Day 3	1.96	0.053	10	>0.05
	Day 7	1.92	0.068	10	>0.05
Tubli-Seal EWT (zinc oxide—eugenol)	Immediate	1.96	0.073	10	>0.05
	Day 3	1.90	0.080	10	>0.05
	Day 7	1.90	0.078	10	>0.05
Pulp canal sealer EWT (zinc oxide—eugenol)	Immediate	1.92	0.065	10	>0.05
	Day 3	1.90	0.072	10	>0.05
	Day 7	1.92	0.076	10	>0.05

Leakage values are measured in millimeters ($P < 0.05$).

preparation time interval, the apical sealing ability of the standard working time ZOE root canal sealer seems slightly inferior to the integrity of apical fillings using the warm gutta-percha vertical-compacted obturation technique, and (2) there was no statistically significant difference between the two different extended working time root canal sealers in terms of dye penetration.

Discussion

Complete canal disinfection and the integrity of canal fillings are essential for successful root canal therapy. In order to prevent root canal contamination during post fabrication and installation, which may indirectly affect the stability or retention of subsequent prosthetic crowns, adequate amounts of root canal filling material must be removed for post-space preparation. The integration or sealability of the remaining obturation material is associated with many factors such as the method of removing filling material, the amount of root canal filling remaining, the type and setting time of the root canal sealer, and the timing of filling material removal. The procedures for preparing the post space are therefore critical, and proper care is required to maintain the root canal seal and the aseptic conditions achieved with endodontics.[1]

The technique for removing filling material does not appear to be as clinically significant as the amount of remaining gutta-percha. Using heated pluggers for gutta-percha removal, Schnell reported no significant difference in leakage of the apical seal,[16] but Hiltner et al reported that the thermal method is generally the safest, most controlled, and effective way of removing the specific length or amount of gutta-percha required.[2–4]

In many clinical situations, a minimum of 3—5 mm of gutta-percha must be left in order to improve post retention.[17] Results of the study by Zmener specify that at least 4 mm of the filling material should be left so as not to compromise the apical seal,[18] but many previous studies have recommended 5 mm of obturating material as a safer margin.[3,8,17] There is a general consensus that the length of remaining filling is inversely proportional to the probability of apical leakage, and it is best to retain at least 5 mm of the filling material in the canal. For this reason, we left 5 mm of the filling material as the baseline.

Microleakage studies have used methods such as dye penetration, fluid transport, pressurized fluid filtration, radioactive isotope, and bacterial leakage. Matloff et al found that aqueous solution of dye penetrated deeper than other methods and concluded that dye penetration was the most sensitive method for studying leakage.[19] Several studies using the dye penetration method reported minimal differences in apical leakage with immediate or delayed post-space preparation using different methods for removing the filling material.[10,20–22] Meanwhile, the most widely used methodology for assessing dye leakage is the longitudinal sectioning of samples, expressing the measurement in linear millimeters. The advantage of this technique for our study was that we were able to measure the dye, and the total leakage of a sample could be counted from a single section.[23,24]

Yared et al evaluated the dimensional stability and sealing ability of the vertical compaction of gutta-percha with standard and extended working time ZOE root canal sealers and found no significant difference in outcomes.[25] Meanwhile, Chen and Chang reported that vertical compaction obturation technique is superior to the lateral compaction method in terms of less dye leakage during post-space preparation.[26] There is no consensus on the time interval for post-space preparation with commonly used root canal sealers, but studies on the effect of the time interval for post-space preparation and the extended working time ZOE root canal sealers have produced ambiguous results. Our study found a tendency to leakage in the standard working time root canal sealer (Group 1). Recorded data showed that extended working time root canal sealers produced less dye leakage when gutta-percha was removed at three different time intervals, but no statistically significant differences were observed ($P > 0.05$) (Table 2). This fact could be attributed to different physical properties of extended working time root canal sealers such as pulp canal sealer EWT. Moreover, the adhesion between gutta-percha and dentinal wall does not depend primarily on the root canal sealer, particularly when using the vertical compaction technique. The amount of root canal sealer used for the vertical compaction technique is not sufficient to disturb post-space preparation, whether it is completely set or not. According to Yared and Bou Dagher, the extended working time of ZOE root canal sealer and its suitability for high heat conditions (e.g., vertical compaction technique) did not affect microleakage results using warmed gutta-percha obturation. We have therefore verified that the standard and extended working time root canal sealers will not affect the apical sealability of the obturation.[27]

We suggest that it is better to allow sufficient time for the root canal sealer to set in order to minimize disturbance of the apical seal before post-space preparation. Despite the insistence of scholars such as Mattison et al that simultaneous post-space preparation and root canal obturation are advantageous and produce no noteworthy discrepancy in outcomes, experimental results suggest that when there is ample time, it is optimal to wait for the complete reaction and setting of filling materials before other preparations.[6] In addition, whether or not ZOE root canal sealers are preferable to other materials such as epoxy resin root canal sealer requires further research.[27–29]

In conclusion, according to our results (Table 2), extended working time root canal sealers used in the vertical compaction obturation technique are evidently as effective as the standard working time root canal sealer in terms of greater dye leakage when root canal filling materials are removed using heated instruments for post-space preparation. This approach produced the least amount of dye leakage, although the difference was not statistically significant ($P > 0.05$). We, therefore, suggest waiting for the sealer to set completely before preparing post spaces if there are no esthetic considerations.[23,29] In order to sustain the integrity of fillings and a proper apical seal, we recommend that post spaces should be prepared only when crown fabrications are ready to be installed. New root canal sealers such as the methacrylate resin-based obturation system (Resilon) are now available for root canal therapy. Whether or not these differences of

filling materials will affect the effectiveness of apical seals or post-space preparation requires further investigation.

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