ORIGINAL RESEARCH

Coronal sealing ability of three sectional obturation techniques – SimpliFill, Thermafil and warm vertical compaction – compared with cold lateral condensation and post space preparation

Velayutham Gopikrishna, MDS and Anantanarayanan Parameswaren, MDS

Department of Conservative Dentistry and Endodontics, Meenakshi Ammal Dental College, Chennai, Tamil Nadu, India

Keywords
coronal seal, sectional obturations, SimpliFill, Thermafil.

Correspondence
Dr Velayutham Gopikrishna, Department of Conservative Dentistry and Endodontics, Meenakshi Ammal Dental College, Maduravoyal, Chennai – 600095, Tamil Nadu, India. Email: hi_gopikrishna@hotmail.com

doi: 10.1111/j.1747-4477.2006.00030.x

Abstract

The purpose of this study was to evaluate the effect post space preparation has on the coronal seal of root canals obturated with cold lateral condensation of gutta-percha compared with the corsonal sealing ability of three sectional obturation techniques not requiring post space preparation. Sixty-eight human maxillary central incisors were divided equally into four groups: cold lateral condensation (Group I), SimpliFill (Group II), Thermafil (Group III) and warm vertical compaction (Group IV). After coronal flaring, all four groups were cleaned and shaped with Lightspeed rotary instruments to a size 60 master apical rotary. After obturation Peeso Reamers were used to create a post space for Group I, while Groups 2, 3 and 4 incorporated the post space in the obturation (sectional technique) and did not require making a post space after obturation. The teeth were then stored in 100% humidity for 1 week and then kept in rhodamine B fluorescent dye for 3 weeks. The teeth were then split open, and the linear dye penetration from a coronal to apical direction (coronal seal) was evaluated with a fluorescent light microscope. Statistical analysis showed that Group I (cold lateral condensation followed by post space made with Peeso Reamers) leaked significantly more ($P < 0.05$) than the remaining three sectional obturation groups. It was concluded that stresses generated during post space preparation might be detrimental to the seal obtained by the obturation. Sectional obturations with their superior sealing ability offer a viable alternative.

Introduction

Endodontically treated teeth require crown restorations for prevention of root canal recontamination, protection of remaining tooth structure and aesthetics. Often such teeth are restored with a post and core followed by a crown. Various depths and techniques are recommended for the preparation of a post space (1). It is widely accepted that 5 mm of root canal filling should be left in the apical section of the canal to avoid disruption of the apical seal (2). However, Abramovitz *et al.* (3) found that 3–6 mm fillings after post space preparation provided a seal inferior to that of intact root canal fillings. This could be attributed to the stresses created during post space preparation, which might be detrimental to the seal previously obtained by the obturation.

Traditionally, while assessing the apical seal after post space preparation, emphasis has been placed on apical to coronal microleakage of the remaining gutta-percha filling (4). However, materials used to cement posts and fabricated crown build-ups are soluble and might allow leakage of irritants through the filling material apically. The exposure of coronal segments of filled root canals to oral flora can result in total recontamination of the root canals in a short period of time (5). Hence, the purpose of this study was to evaluate the effect that post space preparation has on the coronal seal of root canals obturated with cold lateral condensation of gutta-percha. This was compared with the coronal sealing ability of three sectional obturation techniques, namely, SimpliFill, Thermafil and warm vertical compaction, using a rhodamine B fluorescent dye penetration method.

Materials and methods

Sixty-eight human maxillary central incisors were collected and stored in deionised water with thymol. Before the experiment, the teeth were placed in 5.25% sodium hypochlorite for 8 h to remove any organic debris. Soft periodontal tissue was removed by hand curettes. Using a diamond saw with air-water spray coolant, the crown of each tooth was removed, leaving a root length of 12 mm. After the pulp tissue was removed with a barbed broach, a No. 010 K-file ISO was introduced into the root canal until it could be seen at the apical foramen. One millimetre was subtracted from this length to determine the working length. The coronal one-third of the root canal was then enlarged with No. 3 and 4 Gates Glidden drills.

Biomechanical preparation was initiated in each canal using Lightspeed rotary files (Lightspeed Inc, San Antonio, TX, USA) in a 10:1 gear reduction handpiece at 1500 rpm. Biomechanical preparation was completed with sequentially larger Lightspeed rotary instruments until a final apical preparation (master apical rotary – MAR) of ISO size 60 was achieved. Solutions of 5.25% sodium hypochlorite and 17% EDTA were used sequentially as irrigants. After each instrument change, the canals were irrigated with a 2-mL flush of each of the irrigants. The irrigating solutions were delivered through a 25-gauge needle, which was placed as far as possible into the canal without allowing the needle to touch the canal walls.

The teeth were randomly divided into four test groups of 15 specimens each (Table 1). In Group I (cold lateral condensation followed by post space preparation), Group III (ThermaFill, Dentsply-Maillefer, Tulsa, OK, USA) and Group IV (warm vertical compaction), after completing instrumentation using the MAR (No. 60), a uniform taper was produced by stepping back 1.0 mm with each subsequent instrument until the apical extent of the pre-flared portion of the canal was reached. Recapitulation to the working length with the MAR file was then carried out.

Table 1 Mean and standard deviation of dye leakage

Group	*n*	Mean	Standard deviation
I	15	2.80	1.02
II	15	1.76	0.74
III	15	1.66	0.57
IV	15	1.83	0.88

Group I: cold lateral condensation followed by post space preparation; Group II: SimpliFill sectional obturation technique; Group III: Thermafil sectional obturation technique; Group IV: warm vertical compaction sectional obturation technique.

In Group II (SimpliFill), after the completion of the MAR instrumentation, the procedure was modified by advancing the next larger Lightspeed rotary instrument to a depth of 4 mm short of the working length. This created an apical 4-mm canal section with minimal, if any, taper. Further instrumentation was continued by stepping back 1 mm with each subsequent instrument until the apical extent of the pre-flared portion of the canal was reached. Recapitulation to working length with the MAR (No. 60) was then carried out as in Groups 1, 3 and 4. The smear layer in all the specimens was removed with a final flush of 10 mL of EDTA, followed by 10 mL of NaOCl. The canals were then dried with paper points.

Group I: cold lateral condensation followed by post space preparation

The canals in Group I were obturated with cold laterally condensed gutta-percha. A standardised ISO No. 60 master cone gutta-percha was trial-fitted up to the working length. Topseal epoxy resin sealant (Dentsply-Maillefer, Konstanz Germany) was then mixed according to the manufacturer's instructions, and, using a paper point, the sealer was introduced along the entire length of the canal. The apical part of the master gutta-percha cone was coated with the sealer and placed into the canal. The master cone was laterally condensed by inserting a finger spreader between it and the root canal wall. The spreader was inserted to a point 1 mm short of the working length. The spreader was rotated through 180° several times before disengaging it from the canal. The void created by the spreader was filled by condensing an auxiliary gutta-percha point. The procedure was repeated until gutta-percha points could not be introduced more than 3 mm into the root canal. The excess gutta-percha was removed with a hot plastic instrument and the remainder was condensed vertically with a finger plugger.

A post space preparation was carried out using Peeso Reamers No. 2 and 3 in a contra-angled handpiece running at 4000 rpm. After removal of the coronal gutta-percha, a 5 mm apical segment of gutta-percha remained in all canals. The remaining root canal filling was then vertically condensed using a cold plugger.

Group II: SimpliFill sectional obturation group

The SimpliFill gutta-percha carrier consists of a thin stainless steel shaft with a 2-mm Hedstrom-like tip that engages a 5-mm section of 0.02 tapered gutta-percha. The technique advocates the use of the stainless steel carrier to place and condense a 5-mm section of gutta-percha into the apical portion of the canal after Lightspeed instrumentation. A slight apical force seats the 0.02 tapered 5-mm plug into an almost 'parallel apical preparation' created in during the Lightspeed instrumentation. This is achieved by advancing the next Lightspeed instrument after the MAR file to a depth 4 mm short of the original working length. Once placed, the carrier is turned and removed, leaving a gutta-percha 'plug'. The second phase consists of backfilling the remainder of the canal with a sealant and gutta-percha cones. However, this technique can be modified as a sectional obturation technique for a post, wherein after the completion of the apical obturation, the second 'backfill' phase is omitted.

In the present study, the SimpliFill gutta-percha plug was used according to the manufacturer's instructions in the Group II specimens. A plug the same size as the MAR (No. 60) was prefitted into the canal. The plug was properly sized if it began to bind 1–2 mm short of the working length. The rubber stopper was set to the working length. The Topseal sealant was carried into the canal with a paper point. The gutta-percha plug, also coated with a sealant, was inserted into the canal and vertically condensed to working length by using moderate apical pressure. Once the gutta-percha plug was in place, the carrier was removed by turning its handle counterclockwise until the plug was released and the carrier could be removed without unseating the gutta-percha (Fig. 1).

Group III: Thermafil sectional obturation group

When the metal Thermafil obturator is used and post space is required, the manufacturer recommends that the carrier be notched at the desired level before obturation. After the obturator is inserted, it is twisted in order to separate and remove the coronal portion and leave the apical segment intact. When the post space is required with a plastic Thermafil obturator, the use of a high-speed Prepi bur (Dentsply-Maillefer, USA) is recommended. However, in the present study, the 15 specimens in Group III were sectionally obturated with the Thermafil plastic obturators using the technique recommended by the manufacturer for the metal Thermafil obturators.

After completion of Lightspeed instrumentation, a Thermafil size verification carrier was used to check whether the carrier reached the working length without any resistance. Any tooth in which the carrier appeared to be shorter than the working length was prepared further using the Lightspeed instrumentation, and a verification carrier was re-tried. Once the fit was verified, each canal was coated with a thin layer of Topseal sealant with the help of a paper point. Each canal was then obturated using a No. 60 plastic Thermafil obturator in which gutta-percha was removed from the carrier to a level 5-mm coronal to the apex. Then, with the help of a fissure bur, the plastic carrier was notched at this same level. This notched carrier containing 5 mm of apical gutta-percha was placed in the Thermaprep Plus oven (Dentsply-Maillefer, Ballaigues, Switzerland) and heated as per the manufacturer's directions. At the appropriate time, as indicated by the oven's timer, the thermoplasticised carrier was then placed into the root canal in a clockwise rotation and seated to the working length. Now, by twisting the handle of the carrier in a counterclockwise direction, the apical portion of each root canal was obturated with 5 mm of Thermafil. This sectional root canal filling was then vertically condensed using a cold plugger (Fig. 2).

Group IV: warm vertical compaction sectional obturation group

Before the obturation, appropriate finger pluggers were selected for each root canal and level of plugger penetration. The various levels of plugger penetration were 5, 7

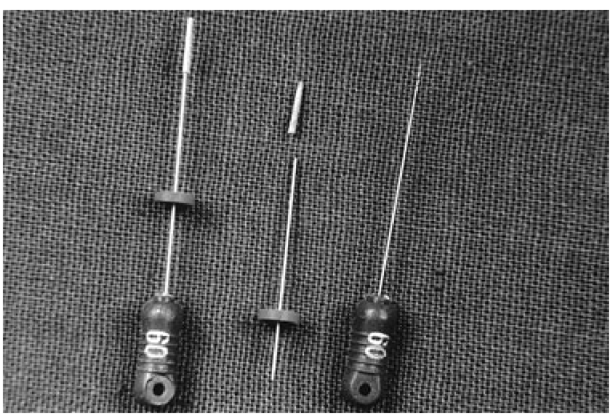

Figure 1 SimpliFill stainless steel carrier with 5-mm sectional gutta-percha filling.

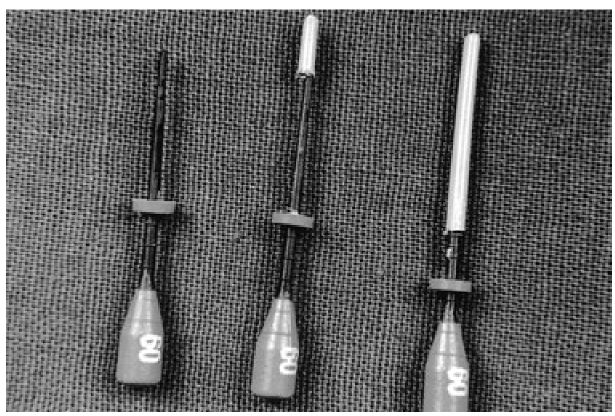

Figure 2 Thermafil plastic carrier before and after sectional filling.

and 9 mm short of the working length. The prepared canal walls were first coated with the Topseal sealant. The apical 1 mm of the selected master cone (ISO No. 60) was cut off to achieve apical tug-back at about 1 mm from the working length. The master cone was coated with the sealant and was placed into the canal. Gutta-percha protruding from the canal orifice was then removed with a hot plastic instrument. The preselected plugger was used to compact the gutta-percha into the canal using 2–3 mm vertical strokes. The heat-transfer instrument, once heated to cherry-red, was plunged into the gutta-percha and was quickly withdrawn. The appropriate plugger was then used as described earlier. This procedure was continued until only 5 mm of apical gutta-percha filling was left behind.

The canals of all the obturated teeth were coronally sealed with a sterile cotton pellet and an intermediate restorative material. All the teeth were wrapped in wet pieces of gauze and stored in 100% humidity for a period of 1 week to allow the complete setting of the sealant. In each group, there were two controls. One tooth was instrumented but not filled, and another tooth was instrumented and filled in the same manner, but sticky wax sealed the coronal opening below the cotton pellet and intermediate restorative material filling. After 24 h the temporary filling was removed and rhodamine B fluorescent dye was placed in the root canal space coronal to the 5-mm sectional fillings.

The teeth with the dye were kept in an upright position for a period of 3 weeks. The roots were then longitudinally split in a buccolingual direction with a mallet and chisel. The sectioned roots were then analysed under a fluorescent light microscope (Olympus Bx40F4, Olympus, Japan) under 10× magnification for evaluation of dye leakage. Rhodamine B dye gives a red-orange fluorescence when excited with green light of 546-nm wavelength. The length of dye penetration was measured in millimetres using a JVC digital colour video camera with micrometer (TK – C1380E, JVC, Yokohama, Japan). Two dye leakage scores were recorded for each sample, one for each of the two split root sections. The highest score was taken as the extent of dye leakage in each tooth.

Mean and standard deviation of dye leakage in the four groups was assessed. The Kruskal–Wallis one-way analysis of variance and the Mann–Whitney *U*-test determined the statistical difference of dye leakage among the groups. The statistical package SPSS – PC+ (Statistical Package for Social Science, version 4.01) was used for the statistical analysis.

Results

Table 1 gives the dye leakage distances for the four groups. As there were four independent groups of observations, the Kruskal–Wallis test was used first. In this test the *P*-value of <0.05 indicated that there was a significant difference among at least two groups. The Mann–Whitney *U*-test was used to identify the differences, making due allowances for multiple comparisons by the Bonferroni method. $P < 0.05$ was considered as the level of significance.

Data indicated that there were no significant differences among Groups 2, 3 and 4. However, Group I had a significantly greater linear dye penetration ($P < 0.05$) than the other three groups. The unfilled controls leaked the entire length of the canal, whereas the negative controls did not leak.

Discussion

Although dye penetration is a popular and convenient technique to determine leakage, the results obtained from this and other dye penetration studies are still suggestive only and might not represent *in vivo* microbial leakage. However, this dye technique was chosen as it offers several advantages over other conventional tracers that have been used. These advantages include a more accurate evaluation of the microleakage, higher resolution imaging and the ability to avoid specimen dessication (6).

Five-millimetre gutta-percha fillings were placed apically using four different obturation techniques. The greatest linear dye penetration occurred in the cold lateral condensation group. Peeso reamers were chosen for post space preparation after obturation because they are commonly used and have minimal influence on the apical seal (7). Lateral condensation is widely accepted for its excellent long-term results, predictability, controlled placement and relative ease of use. However, this technique produces many irregularities in the final mass of gutta-percha, and it might not fill canal fins, cul-de-sacs and isthmuses. There is also inadequate dispersion of sealer, leaving voids in and around the gutta-percha points (8). These shortcomings, in conjunction with the stresses created during the post space preparation, may have contributed to the significantly higher coronal leakage.

Santos *et al.* (9) compared the sealing ability of SimpliFill with cold lateral condensation in an apical to coronal direction and found no statistical difference between the two techniques. In this study, assessing coronal to apical leakage, the SimpliFill group leaked significantly less than cold lateral condensation. The SimpliFill technique relies on an almost parallel apical preparation, the tapered gutta-percha plug and the sealer to obtain the superior seal exhibited in this group.

Thermafil obturators with plastic carriers were used in this study. Chohayeb (10) and Clark and Eldeeb (11) found no statistical difference in leakage between the

Thermafil plastic and metal obturators before post space preparation. When post space is required with a plastic Thermafil obturator, the manufacturer recommends a high-speed Prepi bur. However, in a study conducted by Ricci and Kessler (12) on the effect of post space preparation on teeth obturated with plastic and metal Thermafil carriers, the plastic obturators leaked more. The poor results of the plastic obturators after post space preparation may be explained by the subsequent cooling of the Prepi bur, causing it to stick to the plastic obturator and dislodging it (12). Also, some of the plastic could remain on the bur, causing it to rotate eccentrically and vibrate excessively, thereby disturbing the apical seal. Ricci and Kessler (12) inferred that the method of post space preparation probably caused the loss of the apical integrity of the plastic Thermafil obturator group. They suggested that notching the plastic obturator the same way as for the metal obturator might leave the apical seal undisturbed. For this reason, we used the method recommended for metal Thermafil obturators with the plastic Thermafil obturators.

Beatty *et al.* (13) found that the Thermafil technique leaked the least among the test groups and that it provided a better seal than lateral condensation. However, the results of a dye study by Ravanshad and Torabinejad (14) showed that the Thermafil group leaked more than cold lateral condensation and warm vertical compaction. Roth's sealer, a ZnO–eugenol-based sealer was used in that study.

Dalat and Spångberg (15) found that Thermafil provides a superior seal with an epoxy resin sealer. Hence, Topseal (Dentsply-Maillefer), an epoxy resin, was used in the present study. Topseal (also marketed as AH Plus) is a successor to AH 26 epoxy resin cement. The epoxide amine chemistry of AH 26 has been retained. Topseal consists of a paste–paste system (epoxide paste–amine paste), which is delivered in two tubes. In addition to diepoxide, the epoxide paste contains radiopaque fillers and aerosol. The amine paste consists of three different types of amines. As a result, Topseal retains the advantageous properties of AH 26, including good mechanical properties, high radiopacity, low solubility, little shrinkage and good tissue compatibility, while losing certain disadvantageous properties, such as tendency to discolouration and the release of formaldehyde. Its use could have been a reason for Thermafil's superior seal. The irrigants used in Ravanshad and Torabinejad's study were not mentioned. The irrigants used in our study were NaOCl and EDTA, with EDTA having the ability to remove smear layer. The absence of smear layer could have improved the seal. It has been shown that Thermafil seals better when the smear layer is removed (16).

The results of this study do not agree with that of Fan *et al.* (17), who compared the leakage of warm vertical compaction and Thermafil obturations in curved canals. They found that the Thermafil group leaked more. In their study, they made the post space with a Prepi bur after obturating with plastic obturators. This could have compromised the seal obtained before the post space preparation (12). To prevent this possibility, we did not use the Prepi bur. Instead, we notched the carrier as is done when metal obturators are used.

In this study, warm vertical compaction was comparable to SimpliFill and Thermafil. Shrinkage of thermoplasticised gutta-percha occurs when cooling to body temperature (18). This setting contraction has to be compensated for by the sealer (19). The potential for shrinkage of the thermoplasticised gutta-percha, as used in Thermafil, should be minimal as the majority of the canal space is filled with the plastic core, thereby reducing the volume of setting contraction of gutta-percha.

This study therefore reinforces the belief that the stresses created making a post space after obturating the canal with the lateral condensation technique might be detrimental to the seal previously obtained (20). All three sectional obturation techniques leaked less than the lateral condensation group. As there was no need for a post space preparation, the original seal was undisturbed.

Conclusion

The results of this *in vitro* study indicate that the sectional obturation techniques of SimpliFill, Thermafil and warm vertical compaction are superior to lateral condensation when a tooth requires a post space after obturation.

Acknowledgements

The authors would like to thank Dr B. Sivapathasundharam, Professor and Head, Department of Oral Pathology, Meenakshi Ammal Dental College, Chennai for evaluation of dye penetration; Mr A. K. Mathai, research assistant, National Institute of Epidemiology, Indian Council of Medical Research, Chennai for statistical analysis; and Lightspeed Inc and Dentsply-Maillefer for material support.

References

1. De Cleen MJH. The relationship between the root canal filling and post space preparation. Int Endod J 1993; 26: 53–8.
2. Goodacre CJ, Spolnik KJ. The prosthodontic management of endodontically treated teeth: a literature review. Part II. Maintaining the apical seal. J Prosthodont 1995; 4: 51–3.
3. Abramovitz I, Lev R, Fuss Z, Metzger Z. The unpredictability of seal after post space preparation: a fluid transport study. J Endod 2001; 27: 292–5.

4. Wu MK, Wesselink PR. Endodontic leakage studies reconsidered. Part I. Methodology, application and relevance. Int Endod J 1993; 26: 37–43.
5. Siqueira JF Jr, Rocas IN, Favieri A, Abad EC, Castro AJR, Gahyva SM. Bacterial leakage in coronally unsealed root canals obturated with three different techniques. Oral Surg Oral Med Oral Pathol 2000; 90: 647–50.
6. Torabinejad M, Watson TF, Pitt Ford TR. Sealing ability of a mineral trioxide aggregate when used as a root end filling material. J Endod 1993; 19: 591–5.
7. Camp LR, Todd MJ. The effect of dowel preparation on the apical seal of three common obturation techniques. J Prosthet Dent 1983; 50: 664–6.
8. Kersten H, Fransman R, Velzen TVS. Thermomechanical compaction of gutta-percha. A comparison with lateral condensation in curved root canals. Int Endod J 1986; 19: 134–40.
9. Santos MD, Walker WA, Carnes DL. Evaluation of apical seal in straight canals after obturation using the Lightspeed sectional method. J Endod 1999; 25: 609–12.
10. Chohayeb A. Microleakage comparison of apical seal of plastic versus metal Thermafil root canal obturators. J Endod 1992; 18: 613–15.
11. Clark DS, Eldeeb ME. Apical sealing ability of metal versus plastic Thermafil obturators. J Endod 1993; 19: 4–9.
12. Ricci ER, Kessler JR. Apical seal of teeth obturated by the laterally condensed gutta-percha, the Thermafil plastic and Thermafil metal obturator techniques after post space preparation. J Endod 1994; 20: 123–6.
13. Beatty RG, Baler PS, Haddix J. The efficacy of root canal obturation techniques in preventing apical dye penetration. J Am Dent Assoc 1989; 119: 633–7.
14. Ravanshad S, Torabinejad M. Coronal dye penetration of the apical filling materials after post space preparation. Oral Surg Oral Med Oral Pathol 1992; 74: 644–7.
15. Dalat DM, Spångberg LSW. Comparison of apical leakage in root canals obturated with various gutta percha techniques using a dye vacuum tracing method. J Endod 1994; 20: 315–19.
16. Gencoglu N, Samani S, Gunday M. Dentinal wall adaptation of thermoplasticized gutta percha in the absence or presence of smear layer: a scanning electron microscopic study. J Endod 1993; 19: 558–61.
17. Fan B, Wu MK, Wesselink PR. Leakage along warm gutta percha fillings in the apical canals of curved roots. Endod Dent Traumatol 2000; 16: 29–33.
18. Schilder H, Goodman A, Aldrich H. The thermomechanical properties of gutta-percha. Part V. Volume changes in bulk gutta-percha as a function of temperature and its relationship to molecular phase transformation. Oral Surg Oral Med Oral Pathol 1985; 59: 285–96.
19. Yared GM, Dagher FB. Sealing ability of the vertical condensation with different root canal sealers. J Endod 1996; 22: 6–8.
20. Abramovitz I, Tagger M, Tamse A, Metzger Z. The effect of immediate versus delayed post space preparation on the apical seal of a root canal filling: a study in an increased sensitivity pressure driven system. J Endod 2000; 26: 435–9.