

Comparative analysis of three different filling techniques and the effects of experimental internal resorptive cavities on apical microleakage

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ABSTRACT

Objectives: The aim of this study was to evaluate the sealing abilities of three different gutta-percha techniques in experimentally defective roots (EDR) and non-defective roots (NR). **Materials and Methods:** Sixty canine teeth were divided into six groups of ten; Group 1, NR + cold lateral condensation (CLC); Group 2, EDR + LC; Group 3, NR + BeeFill; Group 4, EDR + BeeFill; Group 5, NR + Thermafil; and Group 6, EDR + Thermafil. Apical leakage was measured using a computerized fluid filtration meter with a laser system. **Results:** Statistical analysis revealed that the CLC demonstrated more microleakage in the EDR than in the NR ($P < 0.01$). Thermafil demonstrated more microleakage in the NR than in the EDR ($P < 0.01$). No statistically significant differences were found between the BeeFill groups ($P > 0.05$). **Conclusions:** The results of this study indicate that internal resorptive cavities can affect the apical sealing properties of different root canal filling techniques, with Thermafil ensuring the lowest apical microleakage.

Key words: Internal resorption, microleakage, root canal filling techniques

INTRODUCTION

A complete and hermetic obturation of the root canal system is an important objective in root canal treatment in addition to proper cleaning and shaping of the root canal.^[1] Root canal anatomy may display complex irregularities in shape as a result of pathological processes, such as internal resorption.^[2] By their very nature, internal root resorption defects can be difficult to obturate adequately.^[3-5]

Cold lateral condensation (CLC) technique is one of the widely accepted root canal obturation technique in most dental schools.^[5] The Thermafil technique contains the obturation of the root canal with heated

gutta-percha with a plastic carrier.^[6] BeeFill is a warm vertical compaction system, which contains down-pack and backfilling equipment's each other.^[7]

Many *in vitro* studies have evaluated different techniques of filling internal defects.^[2,8-11] Voids, obturation masses, and different amounts of gutta-percha or sealer in the defect areas have been evaluated in these studies, which showed differences among obturation techniques with respect to their capacity to fill defects.^[2,8-10] Such differences between obturation techniques may alter the quality of the filled apical canals beyond defects, as well as the quality of the obturated resorptive defects. Obturation of the apical canal could be a challenge, while differences

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in the sealing ability of various filling techniques might appear with the presence of internal resorptive cavities.

This current study focused on the sealing abilities of three different gutta-percha techniques, Thermafil, BeeFill, and CLC, in experimentally defective and non-defective roots by measuring apical leakage levels using a computerized fluid filtration meter. The null-hypothesis of this work was that internal resorptive defects have important effects on filling technique's apical sealing capability.

MATERIALS AND METHODS

After ethics committee approval (protocol #93/2012), 60 extracted human maxillary canine teeth that were approximately of the same dimension were selected. All teeth were examined with a microscope ($\times 25$ magnification) to detect any pre-existing fractures; only intact teeth were included. The external surfaces of the teeth were cleaned and stored in distilled water until required.

The coronal part of each tooth was removed. A # 10 K-file was inserted into the canal until its tip was visible at the apical foramen, and the working length was determined to be 1.0 mm shorter. The roots were instrumented with a master apical file of size 45 using the step-back technique combined with 5% sodium hypochlorite and 15% EDTA irrigation. Subsequently, 60 roots were randomly assigned to six groups ($n = 10$ per group).

Artificial internal resorptive cavities were created as previously described.^[2,12] To create artificial internal resorptive cavities, the roots were sectioned horizontally with a fine diamond disc 7 mm from the apex. Semi-circular cavities were created using a low-speed No. 6 round diamond bur around the periphery of the opening of the root canal of each section. The sections were then luted together using Panavia F resin cement (Kuraray Medical, Osaka, Japan) on the dentin surface around the cavities. Artificial internal resorptive cavities were created in 30 roots. Six additional roots were used as controls (3 each as negative and positive controls). For the negative controls, 3 roots were completely covered (including the apical foramina) with 2 layers of nail varnish to establish the reliability of the isolation method. Positive controls were left unfilled, while 2 layers of nail varnish were applied to the external root surfaces except at the apical foramina.

Group 1: The roots were obturated with CLC using AH Plus (Dentsply De Trey GmbH, Konstanz, Germany) and gutta-percha (Aceone-Endo, Aceonedent Co. Gyeonggi-Do, Korea). AH Plus was mixed according to the manufacturer's instructions and placed into the root canal with a lentulo spiral filler (Dentsply Maillefer, Ballaigues, Switzerland). A #45 master gutta-percha cone was fit to the working length. Then, the gap for the accessory cones was created consecutively using number 35, 30, 25, 20, and 15 finger spreaders (Dentsply Maillefer, Ballaigues, Switzerland). Excess gutta-percha was removed.

Group 2: The experimentally defective roots were obturated using CLC, as in Group 1.

Group 3: The roots were filled using BeeFill (VDW, Munich, Germany). AH Plus was applied to the canal walls with a lentulo spiral filler. A #45 master gutta-percha was fitted 0.5 mm short of the working length with a tug-back. The BeeFill down-packing device was used for the obturation of the apical part of the root canal system. A plugger (Dentsply Maillefer, Ballaigues, Switzerland) was introduced, searing the points off approximately 3 to 4 mm from the apex. The coronal part of the root canal was filled with a backfilling device. The heated gutta-percha was vertically compacted with pluggers until the gutta-percha hardened.

Group 4: The experimentally defective roots were filled using BeeFill, as in Group 3.

Group 5: The roots were obturated using the Thermafil technique with a plastic carrier. AH Plus was placed into the root canal with a lentulo spiral filler. A #45 Thermafil obturator with a plastic carrier was heated in the Thermaprep® Plus Oven (Dentsply, Maillefer, Ballaigues, Switzerland). The heated obturator was slowly inserted into the canal to the previously determined working length. A plugger was used to condense the coronal gutta-percha around the carrier until the gutta-percha hardened.

Group 6: The experimentally defective roots were obturated using Thermafil, as was done in Group 5.

All obturation procedures were carried out by the same clinician. Radiographic documentation was performed to ensure the quality of the root canal filling [Figure 1]. The filled root segments were stored for 2 weeks at 37°C and 100% relative humidity to allow the sealer to set completely before the leakage test.

Determination of microleakage

In this *in vitro* study, apical leakage was measured using a computerized fluid filtration meter as previously described.^[13]

Statistical analyses

Two-way ANOVA analysis was performed to assess the statistical significance of interactions between the factors. Independent samples T-test was performed to compare leakage between the defective and non-defective roots obturated with same technique. In addition, one-way ANOVA and post-hoc Duncan tests were used to compare techniques in the defective and non-defective groups. All statistical analyses were performed at the 95% confidence level.

RESULTS

The positive control group showed significantly more apical microleakage than all other experimental groups, whereas the negative control group showed no evidence of apical microleakage.

Both the obturation technique and the presence or absence of defects significantly affected the extension of fluid conductance ($P < 0.05$).

Two-way ANOVA revealed that more microleakage occurred in the defective group than in the non-defective group, which was statistically significant ($P < 0.05$) [Figure 2].

In the non-defective groups, CLC demonstrated the least amount of microleakage, resulting in $2.05 \pm 0.5 \times 10^{-4} \mu\text{L.cmH}_2\text{O}^{-1}.\text{min}^{-1}.$ at 1.2 atm. BeeFill proved to have the second lowest amount of microleakage among the tested techniques, exhibiting

$4.43 \pm 0.8 \times 10^{-4} \mu\text{L.cmH}_2\text{O}^{-1}.\text{min}^{-1}.$ at 1.2 atm. In the non-defective groups, Thermafil samples demonstrated the greatest amount of microleakage, $5.36 \pm 0.9 \times 10^{-4} \mu\text{L.cmH}_2\text{O}^{-1}.\text{min}^{-1}.$ at 1.2 atm ($P < 0.05$). The mean microleakage values and standard deviations for this group are shown in Table 1.

In the experimentally defective groups, Thermafil demonstrated the least amount of microleakage among the tested techniques, resulting in $3.11 \pm 0.6 \times 10^{-4} \mu\text{L.cmH}_2\text{O}^{-1}.\text{min}^{-1}.$ at 1.2 atm. BeeFill proved to have the second lowest amount of microleakage among the tested techniques, exhibiting $4.56 \pm 1.1 \times 10^{-4} \mu\text{L.cmH}_2\text{O}^{-1}.\text{min}^{-1}.$ at 1.2 atm. In the experimentally defective groups, CLC samples demonstrated the greatest amount of microleakage, at $6.60 \pm 0.6 \times 10^{-4} \mu\text{L.cmH}_2\text{O}^{-1}.\text{min}^{-1}.$ at 1.2 atm ($P < 0.05$). The mean microleakage values and standard deviations for this group are shown in Table 2.

The microleakage values of the experimentally defective and non-defective groups are presented in Figure 3 as mean values. Statistical analysis revealed that the CLC samples demonstrated more microleakage in the experimentally defective roots than in the non-defective roots ($P < 0.01$). Thermafil samples demonstrated more microleakage in the non-defective roots than in the defective roots ($P < 0.01$). No statistically significant differences were found between the BeeFill samples ($P > 0.05$).

DISCUSSION

The objective of filling a root canal is to provide an environment that prevents the growth of residual

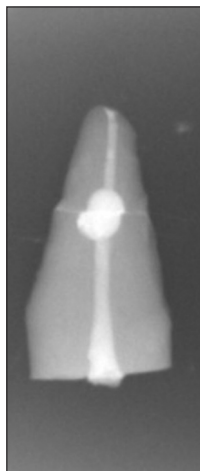


Figure 1: Radiographs of root filling specimens

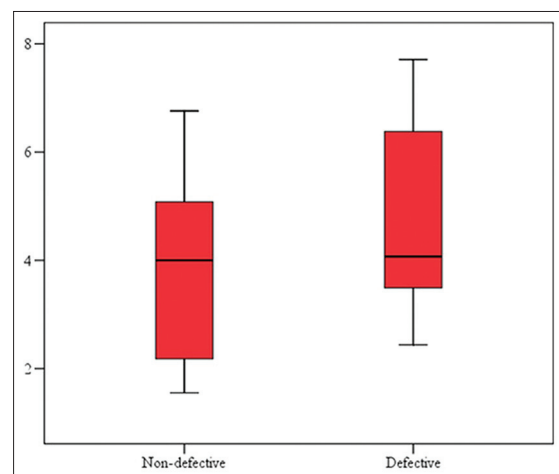


Figure 2: Changes in the fluid conductance values ($\mu\text{L.cmH}_2\text{O}^{-1}.\text{min}^{-1}.$ at 1.2 atm) between the non-defective and defective groups

Table 1: Mean microleakage ($\mu\text{L.cmH}_2\text{O}^{-1}.\text{min}^{-1}.\text{10}^{-4}$ at 1.2 atm) levels and standard deviation for the non-defective group

Technique	Mean \pm SD
CLC	2.05 ^a \pm 0.5
BeeFill	4.43 ^b \pm 0.8
Thermafil	5.36 ^c \pm 0.9

SD: Standard deviation, CLC: Cold lateral condensation, Means with different superscript symbols indicate significant differences ($P < 0.05$)

Table 2: Mean microleakage ($\mu\text{L.cmH}_2\text{O}^{-1}.\text{min}^{-1}.\text{10}^{-4}$ at 1.2 atm) levels and standard deviation for the defective group

Technique	Mean \pm SD
Thermafil	3.11 ^a \pm 0.6
BeeFill	4.56 ^b \pm 1.1
CLC	6.6 ^c \pm 0.6

SD: Standard deviation, CLC: Cold lateral condensation, Means with different superscript symbols indicate significant differences ($P < 0.05$)

bacteria while inhibiting the introduction of new bacteria. However, little data are available regarding particular techniques that are superior in filling canals with resorptive defects.^[2]

In previous studies, radiographic and micro-computed tomographic methods,^[8,12] image analysis programs,^[2] or split-tooth models^[9,10] were used to evaluate the obturation quality of the filled resorptive areas. These studies revealed significant differences among the filling techniques with respect to their capacity to obturate resorptive defects. The results of this study revealed both insufficient obturation of a defect and apical root canals affected by the defect.

To date, this is the first investigation to evaluate and statistically compare the ability of the filling techniques to obturate apical root canals with experimentally defective roots. The quality of obturation was evaluated using an apical leakage test. The computerized fluid filtration meter used in this study has some advantages over conventional methods, such as computerized control and a digital air pressure arrangement.^[13]

In the present study, the null-hypothesis was accepted. Both experimentally defective and non-defective roots were obturated with three different filling techniques. Thus, the ability of the filling techniques to seal the apical parts of root canals was compared between experimentally defective and non-defective roots. Previous studies have already compared these techniques, though with inconsistent results.^[14-21] Endodontic leakage tests may be difficult

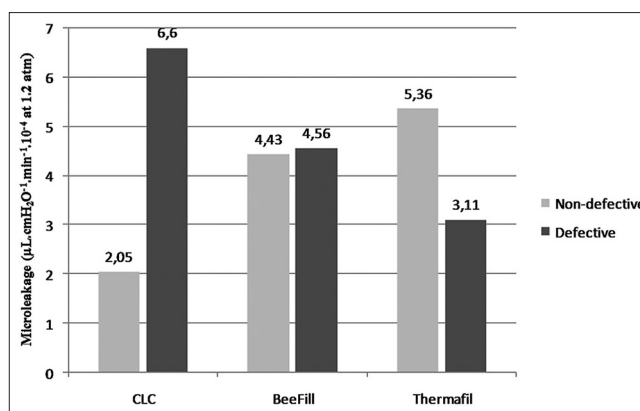


Figure 3: Microleakage levels of different filling techniques in both defective and non-defective groups. Statistical analysis revealed that CLC samples demonstrated more microleakage in the experimentally defective roots than in the non-defective roots ($P < 0.01$). Thermafil samples demonstrated more microleakage in the defective roots than in the non-defective roots ($P < 0.01$). No statistically significant differences were found between the BeeFill samples ($P > 0.05$)

to standardize, leading to results that are difficult to reproduce and compare.^[22]

In this study, all of the controllable factors apart from the filling technique were standardized as much as possible. All roots were instrumented using the same technique. The age of the patient, the type of gutta-percha, and dentinal sclerosis were not taken into account. The good clinical performance associated with Panavia F has already been described in the literature. In this study, Panavia F was used to stick the root pieces because of its suitable properties, such as low microleakage,^[23] higher shear-bond values,^[24,25] and good marginal adaptation,^[23] Fixed root fragments did not separate or collapse during the experiment.

Microleakage values were higher in the artificially defective group than in the non-defective group in this study. Three factors might have played an important role in this result. First, the quality of apical obturation of the root filling techniques can influence the artificial defects. Second, microleakage levels increased as evidenced by the leakage of test liquids from the apical canal through the artificial resorption cavity and third, there may have been leakage from the artificial cavity between Panavia F and dentin, but when the BeeFill technique was evaluated in the sub-groups, the presence of an artificial cavity did not affect the microleakage level while it decreased for the Thermafil technique. Result of BeeFill and Thermafil sub-groups cannot be associated with the presence of artificial cavity.

The results of this study showed that experimental internal resorptive cavities did not alter the apical seal quality of BeeFill. On the other hand, the apical seal quality of other filling techniques was affected by experimental internal resorptive cavities. While the CLC technique demonstrated the least amount of microleakage in the non-defective roots, it also demonstrated the greatest amount of microleakage in the experimentally defective roots ($P < 0.05$). This result may have occurred when the tip of the spreader touched the defect floor before enough compaction was achieved in the apical root canal. Moreover, the tip of the gutta-percha could have touched the defect floor before enough compaction was achieved by a spreader to create a path for the gutta-percha point, which could have caused the gutta-percha to inadequately fill the spreader tract.^[8] Thus, such defects may have adversely affected the CLC technique, preventing an effective seal.

The results of this study indicate that Thermafil can achieve the best apical seal in the experimentally defective roots. Moreover, the apical seal properties of the Thermafil technique observed in the experimentally defective roots were better than those in the non-defective roots. Previous studies have reported that Thermafil is associated with stripping of the gutta-percha from its carrier surface, incomplete extension of gutta-percha within the working length,^[26] and the lowest levels of homogeneity and adaptation versus other obturation techniques.^[27] The incomplete extension of gutta-percha within the working length may have resulted from the corruption of integrity between the carrier and gutta-percha caused by the scraping of the softened gutta-percha when pushing Thermafil further into the root canal, as well as the incomplete transportation of Thermafil to the apex. In the experimentally defective roots, softened gutta-percha might not touch the wall of the defect when Thermafil is pushed toward the apex of the root canal. Thus, more gutta-percha mass could be transported to the apex with the aid of less scraping, which may explain the superior apical seal of Thermafil in the experimentally defective roots.

CONCLUSION

The results of this study indicate that internal resorptive cavities can affect the apical sealing properties of different root canal filling techniques, with Thermafil ensuring the lowest apical microleakage.

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