A comparative study of lateral condensation, heat-softened gutta-percha, and a modified master cone heat-softened backfilling technique

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Abstract

Aim The aim of the study was to compare the quality of root fillings completed by lateral condensation (LC), Thermafil (TF), and a new technique using Thermafil for backfilling (BF), with special emphasis on control of overfilling.

Methodology Sixty curved canals in plastic blocks were prepared with the ProFile system to size 40/04 taper in the apical half and to 06 taper in the coronal half. The canals were divided into three groups of 20. Apical patency was verified with a size 15 K-file. The canals were then filled using three different techniques: LC (20 canals), TF (20 canals), and BF, where a size 40 master point with sealer was seated prior to the introduction of a size 30 Thermafil point (20 canals). The same resin-based sealer was used on each occasion. The root fillings were assessed using stereomicroscopy for material extrusion, digital radiography for occurrence of voids, and microscopy of sections for voids and thickness of sealer layer.

Results Extrusion of both gutta-percha and sealer occurred in all 20 canals filled with the TF technique, but only three and five cases of sealer extrusion were detected with LC and BF techniques, respectively. No voids were detected in the TF group, whereas small voids were present in most fillings in the LC and BF groups. The average total length of the voids was less than 1 mm per canal. The thickness of the sealer layer in the middle and apical parts was greater in the LC and BF groups than in the TF group.

Conclusions LC and BF techniques resulted in fewer overfills than TF. Voids were absent in TF fillings, whilst small voids were found in the LC and BF groups.

Keywords: backfilling, lateral condensation, overfilling, root filling, warm gutta-percha.

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Introduction
Root filling, particularly of curved canals, is often regarded as technically demanding and difficult. This is reflected by the high number of existing root-filling techniques and by the frequency of new techniques being developed. Heat-softened gutta-percha on a solid carrier is a method that has rapidly gained popularity. It is an easy and rapid technique. The quality of root fillings produced in this way, including apical and coronal leakage, has been evaluated in a number of studies during the last 15 years (Lares et al. 1990, Gencoglu et al. 1993a, Gutmann et al. 1993a,b, Bhambhani & Sprechman 1994, Dalat & Spangberg 1994, Dummer et al. 1994, Hata et al. 1995, Weller et al. 1995, Taylor et al. 1997, Gulabivala et al. 1998, Lee et al. 1998, Cohen et al. 1999, Kytridou et al. 1999). Although the methods used as well as the design of the carriers has varied between the different studies, there seems to be agreement that the method is simple to use and produces root fillings of good quality.
(Dummer et al. 1993, Gencoglu et al. 1993b, Gutmann et al. 1993b, Dummer et al. 1994, Leung & Gulabivala 1994, Gulabivala et al. 1998). However, the majority of studies where overfilling has been addressed, indicate that the possibility of extrusion of gutta-percha/sealer is higher than with several other methods, including lateral condensation (Clark & ElDeeb 1993, Dummer et al. 1993, Gutmann et al. 1993b, Kytridou et al. 1999). Combining the speed and ease of the softened gutta-percha method with the apical precision of a master cone would seem advantageous. Therefore, the aim of the present study was to evaluate a backfilling technique with Thermafil in comparison with lateral condensation and Thermafil, with special emphasis on the occurrence and control of overfilling and voids.

**Materials and methods**

**Preparation**

Sixty plastic blocks (Endo-training-block 015_035, Maillefer, Ballaigues, Switzerland) with curved canals 17 mm in length were prepared with the ProFile system (Maillefer) to size 04/40 in the apical canal. The largest instrument, ProFile 06/40, was used to 14 mm (3 mm short of preparation length). The taper of the prepared canals was 0.4 between D0 (0.40 mm) and D9 (0.76 mm), and 0.6 between D9 and D17 (1.24 mm). The following ProFile instruments were used in order: 06/40 (OS3), 06/30 (OS2), 06/25, 04/25, 06/20, 04/30, 04/35, 06/40, 04/40. The same instrument set was used to prepare five canals. A micromotor (Tecnica, ATR srl, Pistoia, Italy) was used at 300 r.p.m. with pre-programmed settings for the various instrument sizes, as recommended by the manufacturer. Apical patency after ProFile preparation was ensured with a size 15 hand K-file (Maillefer).

**Root filling**

The canals were examined under a stereomicroscope (Olympus SZ40, Olympus Optical, Tokyo, Japan) at a magnification of 10× for the quality of the preparations. The criteria for acceptable preparations were: absence of steps, transportation of the canal and overinstrumentation that would result in a poorer apical stop. The canals were then divided into three groups of 20 each and coded randomly. The canals were then filled using one of the three different techniques: Thermafil (TF group, 20 canals) (Maillefer), backfilling with Thermafil (BF group, 20 canals), and lateral condensation (LC group, 20 canals). An oven (Thermaprep Plus, Maillefer) was used to soften the gutta-percha on the Thermafil points as recommended by the manufacturer. In the TF group, a thin layer of sealer (AH Plus, Dentsply, Tulsa, USA) was applied to the canal walls with a size 35 paper point (taper .02, Maillefer), before filling with a size 40 TF point (taper .04) following the manufacturers instructions. Excess coronal gutta-percha and the plastic handle were removed with a round bur (ISO 016, Maillefer) at 2000 r.p.m. without water cooling, and the gutta-percha was vertically condensed with pluggers (model LM 41–42 XSi, LM-Dental, Naantali, Finland).

In the BF group, a gutta-percha master point (ISO size 40, taper .02, Maillefer), coated with sealer (AH Plus, Dentsply) was first introduced into the canal. The master point was condensed with a size C finger spreader (Maillefer), and a Thermafil point size 04/30 was used for backfilling of the canal. Excess coronal gutta-percha and the plastic handle were removed with a round bur and the root filling was vertically condensed as with TF. In the LC group, a master point size 02/40 (Maillefer), coated with sealer (AH Plus, Dentsply) was introduced into the canal, condensed with finger spreader C (Maillefer, Dentsply) followed by three accessory gutta-percha points of size C (Maillefer) with sealer. Excess gutta-percha was removed using a warm excavator, and the filling was vertically compacted as above.

**Assessment of the root fillings**

The presence or absence of extruded sealer/gutta-percha through the apical opening was assessed through a stereo microscope at a magnification of 10× (Olympus SZ40, Olympus Optical). The quality of the root fillings was assessed on digital radiographs (CCD sensor, 0.04 s, 70 kV) (RVGui, Trex-Trophy Radiology Inc., Marne-la-Vallée, France) studied on a computer screen. Two projections with a 90° difference were used for each filling. The occurrence of voids in the apical, middle and coronal third of the root filling was registered and the total length (±SD) of the voids per canal was measured to the nearest 0.5 mm.

The blocks were cut into four sections under water cooling (Accutom, Struers, Denmark) that allowed the cross-section of six surfaces in each root filling to be evaluated. The sectioning levels are indicated in Fig. 1. A light microscope (Leitz Aristoplan, Leitz Wetzlar, Oberkochen, Germany) was used at a magnification of 25× under reflected light. The sections were studied for the presence of voids and sealer.
Statistical analysis

Fisher’s exact tests (two-sided) were used to assess the probability of a hypothesis of no difference between the backfilling with Thermafil versus the Thermafil and versus the lateral condensation technique.

Results

Extrusion of root-filling material

Overfilling with both gutta-percha and sealer was detected in all 20 canals in the TF group (Tables 1 and 2; Fig. 2). Overfilling with gutta-percha was not found in any of the specimens in the LC and BF groups; however, extrusion of sealer was detected in five canals in the BF group and three in the LC group (Table 1; Figs 3–5). The risk for overfilling with either gutta-percha or sealer was statistically significantly ($P = 0.000$) higher in the Thermafil group than in the two other groups (Table 2). No differences could be detected between the LC and BF groups (Table 2).

Voids

Radiographic evaluation by digital radiography of the fillings revealed no voids in the TF group, whereas small voids were present in 18 and 19 of the 20 fillings in the LC and BF groups, respectively (Tables 1 and 2; Figs 4 and 5). The average total length of the voids ($\pm SD$) per canal was 0.9 $\pm 0.6$ mm for the LC group and 0.6 $\pm 0.6$ mm for the BF group.

Table 1 The occurrence of overfilling and voids with the three techniques

<table>
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<tr>
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<th>Overfilling with gutta-percha</th>
<th>Overfilling with sealer</th>
<th>Voids</th>
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<tbody>
<tr>
<td>Thermafil</td>
<td>20/20</td>
<td>20/20</td>
<td>0/20</td>
</tr>
<tr>
<td>Backfill Thermafil</td>
<td>0/20</td>
<td>5/20</td>
<td>19/20</td>
</tr>
<tr>
<td>Lateral condensation</td>
<td>0/20</td>
<td>3/20</td>
<td>18/20</td>
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Table 2 Statistical evaluation of the hypothesis of no difference between the filling techniques (Fisher’s exact tests, two-sided)

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<thead>
<tr>
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<th>Overfilling with gutta-percha</th>
<th>Overfilling with sealer</th>
<th>Voids</th>
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<tr>
<td>Backfill with Thermafil vs. Thermafil</td>
<td>$P = 0.000$</td>
<td>$P = 0.000$</td>
<td>$P = 0.000$</td>
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<tr>
<td>Backfill with Thermafil vs. lateral condensation</td>
<td>$P = 1$</td>
<td>$P = 0.69$</td>
<td>$P = 1$</td>
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0.3 mm for the BF group. The majority of the voids (71%) were in the middle part of the root filling, whilst 12% were in the apical filling and 17% in the coronal filling.

The risk of voids was statistically significantly lower ($P = 0.000$) in the TF group than in the LC and BF groups. No differences could be detected between the LC and BF groups (Table 2).

In the BF technique, sections studied with the microscope revealed no gaps between the master cone and the Thermafil plastic core or the Thermafil gutta-percha (Fig. 6).

**Sealer**

Sections studied under the microscope showed no gaps between the root fillings/sealer and the canal wall in any of the three groups. In TF fillings, no sealer could be seen under the microscope. In the LC and BF groups, the sealer layer was thickest in the lower middle third of the canal, usually between 10 and 100 μm. Voids demonstrated in the radiographs were also verified in

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**Figure 3** Minor apical extrusion of sealer was detected in some canals filled with the BF and LC techniques.

**Figure 4** (A, B) A radiograph showing two plastic canals filled with the BF technique. Despite apical patency, no extrusion of the root-filling material can be seen. Small voids can be seen in the root filling (arrows).

**Figure 5** (A, B) A radiograph showing plastic canals filled with the LC technique. Small voids can be seen in the root filling (arrows).
the sections studied with the microscope when the sectioning had occurred through such an area. The voids were typically located between the canal wall and the gutta-percha; however, a thin but continuous layer of sealer was seen covering the canal wall (Figs 7 and 8).

Discussion

A modification of the lateral condensation method with a Thermafil backfilling technique was presented and evaluated in this study. The new technique can be regarded as a combination of the lateral condensation and the Thermafil techniques with the goal being to add the ease of use of the TF technique to the successful control of the length of the root filling in the master cone/LC technique.

Extrusion of gutta-percha and/or sealer is frequently seen in vivo in connection with TF. In the present study, all TF fillings produced overfilling with both sealer and gutta-percha. However, these in vitro observations in the plastic canals cannot be regarded as directly representative of the clinical situation. Apical patency with size 15 K-file was established after the canal preparation, whereas in the clinical situation, apical patency cannot always be obtained. Moreover, resistance by the periapical tissues and tissue pressure in the in vivo situation may reduce the occurrence/extent of overfilling, although the exact effect of these variables is difficult to determine. In preliminary experiments with extracted teeth, less overfilling with the Thermafil technique was observed than in the present study with standardized simulated canals (data not shown). Similarly, pilot experiments to the present study, where apical patency was not established with the small K-files, showed that

Figure 6  A cross-section of a BF filling. Master point (MP), Thermafil plastic core (TF-core), gutta-percha from the Thermafil point (TF-GP) and sealer are seen in the section, level 2a (see Fig. 1).

Figure 7  Avoid (shown in Fig. 5A, right arrow) between the sealer and the gutta-percha in a LC filling (section level 3b, see Fig. 1).
overfilling with TF seldom occurred. This can be explained through the packing of plastic chips at the apical foramen during preparation. Packing of dentine chips has been suggested in vivo for better control of overfilling when using the TF technique (Scott & Vire 1992). However, dentine chips may contain infectious or antigenic material, and therefore, apical packing of dentine chips should be considered only in vital cases.

The present study showed clearly that under the experimental conditions employed, the possibility of overfilling was greatly reduced with the backfilling technique and was similar to lateral condensation. Although the warm gutta-percha from the TF points seamlessly united with the gutta-percha of the master point as seen in the sections studied under the microscope, the heat capacity of the intruding warm gutta-percha was not high enough to cause melting of the master cone in the apical portion, which could have resulted in extrusion of the filling material. Moreover, no sealer was extruded from the canal during filling.

Radiographic analysis of the root fillings demonstrated good adaptation of the TF fillings to the canal walls in all parts of the canal. However, visual observations made during filling emphasized the importance of vertical compaction. Vertical condensation had a clear effect on the root filling down to the apical part of the canal, but did not, in any case, cause more extrusion of the root filling.

Small voids were detected in both LC and BF fillings. The total number of voids was 42 in 40 canals, 0–2 voids per canal. However, the size of the voids was small, and their average total length per canal was less than 1 mm. It seems that voids were created as a result of air being trapped in the filling after the apical opening was sealed with the master cone in the LC and BF techniques. The voids in the sealer were typically trapped between the gutta-percha and the canal wall. However, also in such areas, a thin and continuous layer of sealer was seen covering the canal wall resin.

In order to measure the volume of the voids, pilot experiments were completed using a micro CT-scan technique. However, the resolution and sensitivity of the method was not sufficient to detect the voids that were seen on radiographs and verified by stereo microscopy of thin sections.

The BF technique was easy to use and the filling was completed quickly. In the TF technique, the sealer was introduced into the canal with a paper point, whereas in the BF technique, the master gutta-percha point was used. The only additional step in the BF technique compared to TF alone was the condensation of the master gutta-percha point with the spreader before introducing
the Thermafil point. In the model used in the present study, BF gave full control of overfilling and was an acceptable alternative to TF technique. The present study was completed in standardized plastic canals with round cross-sections; further studies are required to determine the suitability of the BF technique in natural root canals.

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References


