Adaptation of Thermafil Components to Canal Walls

Jon J. Juhlin, DDS, MS, Richard E. Walton, DMD, MS, and Joseph S. Dovgan, DDS, MS

The desired result of the Thermafil system is described as a centered carrier encased by gutta-percha in apposition to the canal walls. This study examined, in curved canals, the intracanal relationships of: (a) the metal carrier; (b) the surrounding gutta-percha; and (c) the sealer. Following the manufacturer’s recommended techniques, 20 resin blocks that had canals prepared with conservative flaring were obturated. Cross-sections were made in the cervical, middle, and apical thirds and were evaluated with a stereomicroscope and scanning electron microscope to determine the location of the Thermafil components. In an additional 20 resin canal preparations obturated with the Thermafil system, the sealer was stained with dye to evaluate coating patterns. Then, these blocks were sectioned at the apex and examined under the stereomicroscope for adaptation at the apical extent of the preparation. In most preparations, the carrier abutted the canal wall in the cervical and middle sections but was usually surrounded by gutta-percha in the apical one third. The adaptation of components showed the most variability at the most apical extent of the preparation; complete encasement of the carrier did not occur in any specimen. Sealer distribution was variable throughout, usually being absent in the apical canal.

Gutta-percha is the most commonly used root canal filling material. Numerous techniques to place gutta-percha have been developed, e.g. cold compaction, heat plasticizing, and chemical softening. The objective of root canal obturation is to adapt the material to thoroughly fill and seal the root canal system in three dimensions (1-4). Johnson (5) described the obturation of canals with thermoplasticized alpha-phase gutta-percha encasing a stainless steel carrier as a special modification of materials and technique. Recently, an obturating system using the technique described by Johnson (Thermafil; Tulsa Dental Products, Tulsa, OK) has been introduced. The device consists of a stainless steel carrier surrounded by gutta-percha. This carrier is made to standardized sizes and is said to offer a method to totally obturate all canals with a single device. The manufacturer’s advertising diagrams show a centered metal carrier totally encased by gutta-percha that is closely adapted to the walls throughout the length of the canal. Advertising claims this to be a predictable occurrence, resulting in “The perfect apical seal.”

In the Thermafil obturation instruction brochure, there is a section of questions and answers regarding Thermafil (6). Three questions pertaining to the adaptation and characteristics of the material components within the canal are: (a) can Thermafil be used in curved canals? (b) the gutta-percha seems to be stripping off the carrier and gathering at the orifice, what is the situation here?, and (c) . . . on my X-rays, it appears that there is no gutta-percha around the carrier at the apical seat, is this so?

In the same brochure, the answers to the above questions could be generalized as: yes, Thermafil is the most effective method for obturating curved canals. There will be a buildup of excess gutta-percha at the orifice, but that is not indicative of stripping, just an accumulation of the excess. The carrier has flutes that remain filled with gutta-percha as the carrier encounters the wall of a curved canal. This thin layer of gutta-percha remains between the ridges of the flutes and the canal wall and is completely surrounding the carrier at the apical seat. It may not be obvious on an X-ray, but the carrier is always preceded by and completely encased in gutta-percha. Published data to support the above observations are not referenced in the brochure.

Some of these questions, as well as the sealability of Thermafil, were addressed in a recent study by Beatty et al. (7). They found Thermafil to have adequate sealability in straight canals. A concern of Beatty et al. (7) regarding obturation with Thermafil was whether the carrier would transport the gutta-percha uniformly through the canal to the level of the apical preparation to produce a three-dimensional obturation. Another concern was whether the gutta-percha would completely encase the central metal carrier in all situations.

However, Beatty et al. (7) did not investigate whether gutta-percha would completely encase the central carrier in various sizes and shapes of canals. Furthermore, curved canals may present additional problems as to control of the carrier, gutta-percha, and sealer. Intuitively, it would seem that the carrier would be relatively inflexible and penetrate to the outside curve through the soft gutta-percha. In addition, the placement of the sealer only in the region of the orifice (as suggested by manufacturer’s directions) may result in incomplete coverage at the gutta-percha/canal wall interface. The above factors have not been examined in controlled clinical studies.
The purpose of our study was to examine, in simulated curved canals, the relationship of Thermafil’s components and their adaptation to canal walls. The components are Thermafil’s metal carrier and gutta-percha. Also examined was the distribution throughout the canal of the associated sealer.

MATERIALS AND METHODS

Resin blocks with standardized, simulated, moderately curved canals were obtained from Tulsa Dental Products. The resin block system was used for ease of cross-sectioning as well as enabling visual inspection of canal preparation and obturation to desired working length. A standardized canal shape was selected to decrease the problem of the variability of canal morphology in extracted teeth. A moderate curvature was selected in order to test, under rigorous conditions, the carrier flexibility, centering capability, and gutta-percha relationship within the canal.

A #25 Thermafil device was selected for the obturator and was used for all obturations. This is a common apical canal preparation size in moderately curved canals of molars.

Roth’s 801 sealer (Roth’s Root Canal Co., Chicago, IL), one of the sealers suggested by Tulsa Dental Products to be used in conjunction with Thermafil, was mixed according to the instructions of the manufacturer. The thickness of mixture was such that 3 inches could be raised off the mixing slab with a spatula.

Canal patency was determined by passing a #15 K-Flex file (Kerr/Sybron, Romulus, MI) through the artificial apical foramen until it could be seen at the apex. One millimeter was subtracted to establish the working length for preparation and obturation. The technique used for canal preparation was according to the instructions from Tulsa Dental Products, which were somewhat nonspecific. The following cleaning and shaping approach was used to try to achieve minimal flaring, which was stressed in the instructions.

Apical preparation of the curved canal initially was to a #15 or #20 file. Straight line access was achieved with Gates Glidden burs #2 and #3 to give minimal flaring (approximately 6 to 7 mm from the orifice). The largest file to working length was a #25 master apical file. Canals were prepared by a step-back flare technique, usually to a size #60 file. After each file size and Gates Glidden bur, recapitulation was accomplished with a #15 file. Irrigation was with at least 1 ml of water between each file size and after recapitulation. After preparation, the canals were dried with paper points inserted to the working length. With the master apical file, the canals were apically cleared by spinning a #25 file to length to remove the apical resin debris. Lack of apical debris was readily confirmed by direct examination through the clear acrylic.

The first 20 canals were obturated with the Thermafil Endodontic Obturators according to the instructions of the manufacturer. A paper point was coated with Roth’s 801 sealer and inserted 2 to 3 mm into the canal to coat the walls. A #25 Thermafil obturator was selected because the apical preparations were enlarged to a #25 file. The rationale was that the diameter and shape of the central carrier should be similar to the diameter of the master apical file. The obturator was warmed over a flame, using a rotating motion, until it developed a surface sheen and began to expand. The obturator was then inserted into the canal to the working length without rotation, and the carrier was left in place. To avoid additional manipulation, the handle and coronal segment were not sectioned and separated from the carrier. An additional 20 prepared resin canals were obturated with Thermafil and Roth’s sealer, combined with a very small quantity of methylene blue dye as a marker to evaluate patterns of sealer distribution.

Sealer distribution was evaluated under the stereomicroscope through the clear acrylic block. The evaluators used the criterion of whether sealer reached and uniformly coated the canal walls in the apical one third. After this evaluation, all 40 blocks were sectioned.

The 40 obturated specimens were divided into two groups of 20 each in order to visualize cross-sections at various canal levels and at the apical extent (Fig. 1). All resin blocks were sectioned with a low-speed diamond saw (Buehler Isomet, Lake Bluff, IL) under water. In the first group of 20, the cross-sections were in the cervical, middle, and apical thirds and near the apex (Fig. 2). In the second 20, defined as the apex section, the sectioning was only through the reservoir (Fig. 2) and the cut was then polished back to the very apical extent of the carrier with a series of 60 to 600 grit discs on a grinder/polisher (Buehler Grinder EcoMet V Polisher, Lake Bluff, IL) under water.

After sectioning, all cross-sections were transilluminated and viewed at a magnification of x10 with a dissecting stereomicroscope (Nikon SMZ-10; Nikon, Tokyo, Japan) by three trained independent judges and evaluated by the following criteria: (a) carrier completely encased in gutta-percha; (b) carrier partially encased in gutta-percha; (c) carrier only (no gutta-percha); and (d) gutta-percha only (no carrier). All sections at each level of all specimens were evaluated as to position of carrier and appearance on the basis of the above criteria. Then, the number of sections in each category was

METHODS

40 Resin Blocks (simulated curved canals)

Canal Preparation (conservative flaring)

Obturation with Thermafil

Sectioning

Cross-sections @ cervical, middle, apical and near apex (n = 20)

Sections @ reservoir and polished back to apex (n = 20)

Evaluation

stereomicroscope and SEM

Fig 1. Flow diagram. SEM, scanning electron microscope.
TABLE 1. Evaluation of cross-sections*

<table>
<thead>
<tr>
<th>Cross-sections</th>
<th>Carrier Completely Encased in GP (%)</th>
<th>Carrier Partially Encased in GP (%)</th>
<th>Carrier Only (No GP) (%)</th>
<th>GP Only (No Carrier) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cervical (n = 40)</td>
<td>23</td>
<td>77</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Middle (n = 40)</td>
<td>17</td>
<td>83</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Apical (n = 60)</td>
<td>83</td>
<td>17</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Near apex (n = 20)</td>
<td>5</td>
<td>40</td>
<td>10</td>
<td>45</td>
</tr>
</tbody>
</table>

* GP, gutta-percha.

TABLE 2. Evaluation of sections polished at apex

<table>
<thead>
<tr>
<th>Sections at Apex (n = 20)</th>
</tr>
</thead>
<tbody>
<tr>
<td>70% carrier only (no gutta-percha)</td>
</tr>
<tr>
<td>30% carrier partially encased in gutta-percha</td>
</tr>
</tbody>
</table>

TABLE 3. Evaluation of sealer distribution

<table>
<thead>
<tr>
<th>Apical One Third of the Canal (n = 20)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50% totally absent</td>
</tr>
<tr>
<td>50% partial coating</td>
</tr>
<tr>
<td>0% total coating</td>
</tr>
</tbody>
</table>

RESULTS

The technique of sectioning the blocks and polishing to the apex proved to be effective in determining relationships of components. Both scanning electron microscope and stereomicroscope viewing were adequate. Most specimens were evaluated with the stereomicroscope because of less expense and ease of handling.

Overall, the Thermafil components (carrier, gutta-percha, sealer) were variable in adaptation to each other and to the canal walls. The data obtained are summarized in Tables 1 to 3. Examination of the cross-sectioned blocks (Table 1) showed that, in the cervical and middle sections, the carrier frequently abutted the canal wall (Figs. 3 and 4). In the 80 sections in the cervical and middle thirds, the carrier was only partially encased in gutta-percha, 77 and 83% respectively. In the apical one third, the carrier usually, but not always, was surrounded by gutta-percha (Figs. 5 and 6). The observation of 60 sections in the apical region (1 to 4 mm from the apex) showed a reversal of the above findings. The carrier was completely encased in gutta-percha in 83% of the samples; in only 17% combined and expressed as a percentage. Some sections were mounted, coated with 20 nm of gold-palladium, and examined and photographed with a JEOL 35C scanning electron microscope (JEOL Co., Peabody, MA).

Fig 2. Thermafil obturation of prepared canal. Solid lines indicate levels of cross-sectioning to and including the reservoir beyond the apex.

Fig 3. Cross-section through middle one third. Carrier (C) abutting the canal wall and partially encased in gutta-percha (GP).
Fig 4. Photomicrograph of Fig. 3. Carrier (C) contacting canal wall (CW) and partially surrounded by gutta-percha (GP). Remaining surface is resin (R) block (original magnification ×130).

Fig 5. Cross-section through apical one third. Carrier (C) completely encased in gutta-percha.

Fig 6. Apical one third showing carrier contacting canal wall and partially surrounded by gutta-percha.

Fig 7. Cross-section at apex. Carrier abutting canal wall with remaining space filled with resin (RS) shavings created during sectioning.

Fig 8. Apical section. Canal space occupied by carrier, some components of gutta-percha (GP), and methylene blue-stained sealer (S). Remaining space filled with resin (RS) shavings.

DISCUSSION

In this study of the Thermafil Endodontic Obturator, it was determined that in curved resin canals, a layer of both
gutta-percha and sealer was not often interposed between the ridges of the metal carrier and the canal wall. Furthermore, the carrier was not always preceded by, and completely encased in, gutta-percha. These findings are in contrast to the diagrams in Thermafil advertisements, in which the obturators are shown in straight canals and curved canals.

The differences from the manufacturer’s diagrams in our findings are not surprising, considering the physical properties of the three materials involved and how they would behave in straight versus curved canals. Logically, the stiffness of the stainless steel carrier could press through the relatively soft gutta-percha and lie against the outer curvature of the canal. The heated alpha-phase gutta-percha is sticky and would adhere to the walls; the carrier may push through and protrude beyond the end of the gutta-percha.

It might be supposed that a clinical situation in which the Thermafil technique would have an advantage over lateral condensation would be in a moderate to severely curved canal. The ease of a single-insertion motion with the Thermafil condensation would be in a moderate to severely curved canal. At the very apex, complete encasement of a central carrier was not observed in any specimen. Stripping off of the gutta-percha was occurring apically, as was evident in the sections polished to the apex, where carrier only was frequently observed (Fig. 7). Stripping may be due to both the characteristics of the alpha-phase gutta-percha and the constraints on the inflexible carrier due to the curvature of the canal. The physical properties (viscosity and flow) of the gutta-percha and sealer components determine the ability to flow to, around, and into the prepared canal and surround the carrier.

Sealer was also frequently absent in the apical canal. This lack of uniform coating possibly resulted from the limited amount of sealer placed only at the orifice (2 to 3 mm), as recommended by the instructions accompanying the Thermafil kit. Also, poor distribution would be likely because the gutta-percha would not necessarily pick up a sufficient amount of sealer, carry it apically, and spread the sealer evenly throughout the canal. This poor sealer distribution would likely be worse in a real canal in a real tooth because of the irregularities in internal anatomy. Further investigation may establish the correct sealer amount and placement technique to adequately coat the canal and avoid expressing sealer through the foramen during obturation. Furthermore, better distribution of sealer may lubricate and enhance the flow characteristics of the alpha-phase gutta-percha.

In heating the Thermafil devices, we found uniformity of softening to be a problem. Possibly, a properly controlled temperature heater would help in obtaining consistency. Also, further investigation may establish the desired temperature range of the alpha-phase gutta-percha to determine the optimal working time for better control.

Length control of obturation techniques has consistently been a problem for many semisolid obturation techniques (8–10). With Thermafil, which would be considered a semisolid technique, Batha et al. (7) did not observe overfills. In the study presented here, overfills were observed. Scott and Vire (11), using the Thermafil technique, demonstrated significantly greater problems with overextension of material than those that occur with other thermoplasticized gutta-percha techniques when foramen patency was maintained. However, a bench-top study may not correlate to usage in patients. Possibly, a real or simulated periodontal ligament may modify the prevalence or severity of overfills.

Regarding sealability, short-term results appear adequate under certain conditions as demonstrated by comparing Thermafil with lateral condensation in dye leakage studies. In one study (7), Thermafil was superior to lateral condensation; in another, McMurtrey et al. (12), showed Thermafil and lateral condensation to be equivalent in highly curved canals. In contrast to Beatty et al. (7), Lares and ElDeeb (13), using canines and molars obturated by the Thermafil technique, showed that more leakage occurred than when those obturated with lateral condensation were used. Long-term sealability studies of Thermafil have not yet been published. However, our findings might indicate eventual loss of integrity because of adaptability problems. These may not be manifest
until there has been longer exposure to tissue fluids or saliva with resultant dissolution of sealer (14).

An objective of obturation is to create a hermetic fluid seal the length of the root canal system. Although we did not study the hermetic seal phenomenon, the results obtained may be relevant. With an artificial model of a curved canal, the sections showed the carrier without gutta-percha or sealer at the apical end of the canal. This absence of gutta-percha and/or sealer may be a critical factor in the long-term success of root canal treatment. However, extrapolation of an in vitro model to an in vivo clinical situation is always questionable, considering other variables involved.

The authors acknowledge Dr. Kirk Baumgardner, a resident in the Dentist-Scientist program, affiliated with the Department of Endodontics, College of Dentistry, University of Iowa, for his technical assistance with the JEOL 35C.

Dr. Juhlin is a former endodontic resident, Department of Endodontics, College of Dentistry, University of Iowa. He is currently in private practice, Waterloo, IA. Dr. Walton is professor and chairman, Department of Endodontics, College of Dentistry, University of Iowa. Dr. Dovgan is a former endodontic resident, Department of Endodontics, College of Dentistry, University of Iowa. He is currently in private practice, Phoenix, AZ. Address requests for reprints to Dr. Jon J. Juhlin, 239 East San Maran Drive, Waterloo, IA 50702.

A Word for the Wise

The word “English” is derived from the Angles, one of the Germanic tribes who made up the Anglo-Saxons. The very earliest writing from these people, and therefore arguably the earliest known sentence written in English, is on a gold medallion from 450 A.D. found in England in 1982. The sentence is, “This she-wolf is a reward to my kinsman.” The circumstances and exact nature of the gift could be the basis for endless romantic speculation.

Harold Black