Analysis of the film thickness of a root canal sealer following three obturation techniques

Gustavo André De Deus*
Fábio Martins**
Ana Carolina Machado Rocha Lima**
Eduardo Diogo Gurgel-Filho***
Claudio Ferreira Maniglia****
Tauby Coutinho-Filho*****

ABSTRACT: The aim of this study was to obtain a quantitative analysis of the film thickness of a root canal sealer formed after filling by three different techniques. Thirty human maxillary incisors were selected and access cavities were prepared using high-speed diamond stones and water spray. A size #15 K-Flexofile was introduced in the canal of each specimen until it was seen just at the apical foramen. The working length was determined to be 1 mm short of that position and the canals were prepared to an apical size of #45 K-Flexofile. Copious irrigation with 5.25% NaOCl (sodium hypochlorite) was used during and after instrumentation. The samples were divided into three groups and obturated as follows: G1 - lateral condensation, G2 - lateral condensation with an accessory cone, and G3 - continuous wave of condensation. The samples were evaluated in the cervical, middle and apical thirds. The film thickness of the root canal sealer was measured through a microscopic evaluation. Statistical analysis was obtained using the Wilcox test. Statistical analysis showed significant differences between G3 and G1, G3 and G2 (p < 0.05). In general, the lowest film thickness was observed in the continuous wave of condensation (G3). Lateral condensation with an accessory cone (G2) and lateral condensation (G1) demonstrated poorer results in this study, showing a higher film thickness. The small film thickness of the sealer obtained by the continuous wave of condensation technique may increase the clinical performance of this technique.

DESCRIPTORS: Dental cements; Endodontics; Root canal obturation; Root canal therapy.

INTRODUCTION

Although gutta-percha is not considered an ideal filling material, it still represents the first choice for a solid core filling for the root canal system, producing the best clinical performance when associated to a root canal sealer2,5. The excellent results, however, have not prevented the binomial gutta-percha/sealer from the constant questioning concerning the filling’s final quality, the capa-
city of lateral and apical sealing, leakage indexes and also its ability to promote a three dimensional filling.

Gutta-percha does not provide an apical seal to ink penetration when used without a root canal sealer. Upon this confirmation of the necessity of the presence of a root canal sealer, investigations about the performance of the sealer were conducted throughout the years. The physical properties of different canal sealers were analyzed and a strong tendency to increase their adhesiveness was observed during the 1970’s. It has also been confirmed that leakage may occur within the sealer or by its dissolution, either in the interface between sealer and dentine, or between sealer and the gutta-percha. Another aspect to consider is that areas filled by a sealer are more vulnerable. The presence of a root canal sealer, in any filling technique, reduces clinical leakage. Moreover, the root canal sealer is capable of filling imperfections and increasing the adaptation of the gutta-percha filling. Although many studies have indicated the undeniable necessity of a root canal sealer, its con-

firmation throughout the years. The physical properties of different canal sealers were analyzed and a strong tendency to increase their adhesiveness was observed during the 1970’s. It has also been confirmed that leakage may occur within the sealer or by its dissolution, either in the interface between sealer and dentine, or between sealer and the gutta-percha. Another aspect to consider is that areas filled by a sealer are more vulnerable. The presence of a root canal sealer, in any filling technique, reduces clinical leakage. Moreover, the root canal sealer is capable of filling imperfections and increasing the adaptation of the gutta-percha filling. Although many studies have indicated the undeniable necessity of a root canal sealer, its confirmed solubility implies the necessity to limit its presence to a thin film thickness. Sealer film thickness may be of particular relevance to conventional techniques that involve solid core fillings.

The aim of this study was to obtain a quantitative analysis of the film thickness of a root canal sealer formed after filling by three different techniques.

MATERIALS AND METHODS

For the present work, thirty maxillary central incisors were selected from the Tooth Bank of the Rio de Janeiro State University. Standard access cavities were made and the patency of each canal was confirmed by inserting a #20 file through the apical foramen before and after completion of the root canal preparation. The working length was determined at 1 mm short of the apex and the canals were shaped manually using a crown-down technique and stainless steel Flexofiles® (Dentsply-Maillefer, Ballaigues, Switzerland) and Gates Glidden burs (#6, #5, #4, #3).

The coronal and middle thirds of each canal were preflared using Gates Glidden drills (Dentsply-Maillefer, Ballaigues, Switzerland), #6, #5, #4 and #3. The middle and apical thirds were prepared with Flexofiles® (Dentsply-Maillefer, Ballai-
cone with a 0.6 taper (Diadent Group International, Chongchong Buk Do, Korea) was trimmed back until tug-back was achieved in the full working length. The trimmed gutta-percha cone was coated with a measured spoon of sealer (0.25 ml). At the level of the cementum-enamel junction the gutta-percha was scared off with the tip an activated heat carrier (Touch’n Heat model 5004, Analytic Technology, Redmond, WA, USA). After deactivating the heat carrier, the cooling instrument was removed from the canal, bringing out an increment of gutta-percha. Vertical force was applied with a size 11 plugger (1.1 mm diameter, Dentsply-Maillefer, Ballaigues, Switzerland) to compact the gutta-percha in the coronal third of the canal. This procedure was repeated twice, first to a level 3-4 mm deeper than the cementum-enamel junction and vertically condensing the gutta-percha in the middle third of the canal using a size 7 plugger (0.7 mm diameter, Dentsply-Maillefer, Ballaigues, Switzerland), and secondly to a level 4 mm short of the full working length and vertically condensing the gutta-percha in the apical portion of the canal using a size 5 plugger (0.5 mm diameter, Dentsply-Maillefer, Ballaigues, Switzerland). Back-filling of the rest of the canal space was achieved by injecting warm gutta-percha using the Obtura II System (Obtura Corp., Fenton, MO, USA), each time injecting a 4-5 mm segment and condensing the gutta-percha with a prefitted plugger.3,17,18,19

The samples were then stored in 100% humidity and at 37ºC for 2 weeks. After that, each sample was sectioned longitudinally using a low-speed saw (Isomet, Buhler Ltd., Lake Bluff, NY, USA) with a diamond disc (Ø 125 mm x 0.35 mm x 12,7 mm – model 330C) while constantly irrigating with water in order to prevent overheating. The cuts were made in different points: one located at the cervical third, the other two at the middle and apical thirds respectively. Subsequently, the samples were embedded in an epoxy resin cylinder (Arazyn 1.0, Ara Quimica, SP, Brazil) to facilitate their manipulation and improve the preparation result. The margins adjoining the epoxy resin and tooth were sealed with cyanoacrylate (Super Bonder gel, Loctite, Itapevi, SP, Brazil).

Specific sandpapering (NETOT 4050014, Struers, DK) for materialographic preparation was performed. The purpose of materialographic specimen preparation is to obtain a surface that is free from scratches and deformation. To achieve this result the samples were properly ground to remove damages or deformed surface material, while introducing as little new deformation as possible, thus preparing the sample surface for polishing. To remove deformations from fine grinding and obtain a surface that is highly reflective, the specimens were polished before they were examined under the microscope. Polishing was accomplished with diamond paste with 4-1 µm roughness (SAPUQ 40600235, Struers, DK).

The samples were examined under a microscope (Axiscope, Carl Zeiss Vision Gmbh, Hallbergmoos, Germany). For each sample, a sequence of photographs with increases of 50 X and 200 X was taken, the dentinal wall/filling material interface being always the observation focus. The negatives were scanned by a 35 mm/medium format film scanner (SprintScan 120, Polaroide, NY, USA) as tiff images (tagged image file format) with 1,200 dpi.

For image analysis and processing, the KS 400 Image System 4.0 (Carl Zeiss Vision Gmbh, Hallbergmoos, Germany) was used. Through a segmentation process on pixels shade of digitized image, the software allowed us, by a semi-automated process, to obtain measurements made in areas with higher film thickness of the root canal sealer. In order to rationalize and automate the work, a protocol (macro) was developed and used to analyze all images.

Through this digital image analysis and processing by the KS 400 Image System 4.0 (Carl Zeiss Vision Gmbh, Hallbergmoos, Germany), about 20 measurements for each observed field examined were obtained. A Wilcox test was used to determine whether there were significant differences between the groups.

RESULTS

With the aid of the digital analysis and processing imaging, numerical data were obtained from the measurements performed. The data obtained from the apical, middle and cervical cross-sections, and a general average for each technique, are displayed in Graphs 1 and 2. Statistical analysis was obtained using the Wilcox test (Table 1).

Cervical third

The evaluation of the cuts obtained from the cervical thirds in the samples demonstrated a gre-
at lack of homogeneity of the filling material in all techniques. Particularly in this area it was possible to observe smaller layers of root canal sealer (Figures 1 and 2). The results revealed film thickness varying from 15 to 101 μm, presenting an average post of 29 μm for Group 3, 53 μm for Group 2 and 97 μm for Group 1. The statistical analysis demonstrated significant differences between groups (p ≤ 0.05).

**Middle third**

In the same manner as for the cervical third, the analysis of the performed cuts of the middle third samples demonstrated a generalized lack of homogeneity of filling material in all techniques (Figure 3). Group 1 clearly confirmed a greater presence of root canal sealer. The measurements revealed layers of root canal sealer varying between 30 and 161 μm, presenting an average post of 47 μm for Group 3, 97 μm for Group 2 and 141 μm for Group 1. Statistical analysis established significant difference between the groups (p ≤ 0.05).

**Apical third**

The observation of samples obtained in this area demonstrated the greatest quantities of root canal sealers in all techniques (Figure 4). Measurements revealed sealer layers with thickness varying between 121 and 399 μm, obtaining an average post of 337 μm for Group 1, 352 μm for Group 2 and 187 μm for Group 3. There was no statistical difference between Group 1 and 2 (p > 0.05). However, statistically significant difference was observed for Group 3 in relation to the previous groups (p ≤ 0.05).

### DISCUSSION

A fundamental factor for this study is the fact that a thin film thickness sealer should be expected to wet the surface better than a thick film thickness sealer and thus provide a better seal. Grossman (1981) and other authors observed a diversity of characteristics, including solubility, flow, setting time, power of compression, radiopacity, and adhesion properties of the root canal sealers. With the introduction of warm gutta-percha techniques, authors have emphasized the necessity to reexamine the

---

**TABLE 1** - Wilcoxon test for significant differences for sealer film thickness in different thirds (ns: not significant, s: significant).

<table>
<thead>
<tr>
<th></th>
<th>Apical</th>
<th>Middle</th>
<th>Cervical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lateral condensation vs. lateral condensation with an accessory cone</td>
<td>ns (p &gt; 0.05)</td>
<td>s (p ≤ 0.05)</td>
<td>s (p ≤ 0.05)</td>
</tr>
<tr>
<td>Lateral condensation vs. continuous wave of condensation</td>
<td>s (p ≤ 0.05)</td>
<td>s (p ≤ 0.05)</td>
<td>s (p ≤ 0.05)</td>
</tr>
<tr>
<td>Lateral condensation with an accessory cone vs. continuous wave of condensation</td>
<td>s (p ≤ 0.05)</td>
<td>s (p ≤ 0.05)</td>
<td>s (p ≤ 0.05)</td>
</tr>
</tbody>
</table>
influence of the film thickness of the sealer towards the apical sealing produced by the filling material\cite{11,13,14,22}.

The analysis of the samples in this study showed that the thickness of the layer of the sealer in an interface between filling and the dentinal walls varied both according to the groups and to the analyzed cross-sections. As expected, results presented variation in the film thickness within the same sample, due to areas partially instrumented or areas with accumulation of debris.

The lack of mass uniformity, the compromised juxtaposition of the gutta-percha/sealer and dentinal walls unit and the greater extension of the root canal sealer interface were reflected in the analyses of samples in Group 1 and also Group 2, though in a smaller intensity. For the hydraulic compression and warm gutta-percha (Groups 2 and 3), a non-standardized medium cone with a 0.6 taper, which presents greater taper than the standardized cones, was used as the master cone\cite{3,4,14,17}. The smaller layer of the root canal sealer at the cervical and middle thirds can be used to explain superior adaptation of the medium large accessory cone to the conical pattern of the canal preparation\cite{4,14,17}.

Void areas were frequently observed in Group 1. This is evidence for a greater susceptibility of this group to leakage. This is also supported by studies that reaffirm the great importance of a
root canal sealer. In an experiment performed by Hata et al.\(^8\) (1992) for example, the authors indicated that the lack of sealer interface would result in a greater marginal leakage in their samples. Among such investigations, Bamiduro et al.\(^1\) (1992) tested the hypothesis that an apical sealing promoted by thermoplasticized gutta-percha techniques depends on the thickness of the layer of the root canal sealer. The degree of microleakage was based on the depth of ink penetration at the apical third.

In our study, the samples from Group 3 (warm gutta-percha condensation technique) presented a smaller interface of root canal sealer, and the presence of such unfulfilled spaces by the sealer was significantly smaller. Gutta-percha, after being heated, is plasticized from 3 to 5 mm from its heating locus. After heating, dynamic vertical condensation is performed, in a technique known as warm gutta-percha\(^3\). This dynamic process of heating and condensing must end 5 mm from the apex\(^17\).

The warm gutta-percha technique, when evaluated by scanning electron microscopy, demonstrated a very close adaptation between dentinal wall, sealer, and gutta-percha\(^8\). At the deepest point of penetration, 3 mm from the apex, a wall-to-wall adaptation was observed. The film thickness of sealer ranged from 40 to 100 \(\mu\)m. Our results presented a greater interval of 15 to 200 \(\mu\)m for the warm gutta-percha condensation technique, which nevertheless offered the best results in all three areas analyzed. It has been shown that deviations, undercuts, projections and resorptions many times disable the contact of the instrument to the dentinal walls, creating imperfections in the following filling procedure, especially in Group 1 and 2. On the other hand, considering the homogeneity factor, samples in Group 3 demonstrated a small incidence of voids, maybe because it promotes a higher degree of compaction of gutta-percha cones\(^1\).

**CONCLUSIONS**

The continuous wave of condensation promoted the lowest film thickness, which may increase the clinical performance of this technique.

**ACKNOWLEDGEMENTS**

The authors thank the Department of Science and Engineering of Materials (DCMM), Pontifical Catholic University of Rio de Janeiro (PUC-RJ), for the essential technical assistance in this study, especially in memorian to Eng. Maria de Fátima Lopes.