Analysis of gutta-percha’s root canal filling capacity through three different obturation techniques

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Abstract

Introduction and objective: The aim of this study was to determine gutta-percha’s root canal filling capacity through three different filling techniques. Material and methods: Sixty single-rooted human teeth were cleaned, shaped and randomly divided according to the filling technique: Group I: Lateral condensation; Group II: Hydraulic compression; Group III: Tagger’s hybrid. All procedures were performed by two previously calibrated operators. The teeth were transversely sectioned into four cuts, starting from the root apex (at 3 mm, 6 mm, 9 mm, and 12 mm), by using an Isomet diamond blade (wafering blade, series 15 high concentration, 5 inch blade, Buehler Ltd., Lake Bluff, IL, USA), mounted in an IsoMet Low Speed Saw (Buehler Ltd., Lake Bluff, IL, USA), and water as a cooling medium. Each group's cut was embedded in acrylic resin and polished. Root canal images were captured and then analysed by Image Tool 3.0 software (Department of Dental Diagnostic Science, University of Texas, Health Science Center, San Antonio, Texas). Measurements of root canal overall area and gutta-percha-filled area were executed, therefore, obtaining the percentage of gutta-percha’s root canal filling capacity for each slice. Results: Data were analyzed by GMC software 10.0 and Kruskal-Wallis test. Tagger’s hybrid technique (95.1%) was superior to the other two techniques, followed by Hydraulic compression (89.1%) and lateral condensation (70.6%).
The results were statistically different among the three techniques, for all cuts (p<0.01). Intra-group analyses showed statistically significant differences only in Group I (p<0.01). However, slices obtained at 6 mm and 9 mm were statistically equal (p>0.05). **Conclusion:** These results suggest that Tagger’s hybrid technique may yield better root canal filling capacity than Hydraulic compression and lateral condensation technique, which showed the worst filling capacity of all the three techniques employed.

**Introduction**

Endodontic therapy goals are cleaning, shaping, antisepsis, and tridimensional filling of the root canal system [30]. These have been reached through inter-dependent steps that have the same importance, beginning with a proper access and ending with a flawless filling [6, 7]. Some studies demonstrated that failures in the quality of root canal system fillings may affect endodontic treatment success [2, 31, 33].

Gutta-percha is the main root canal filling material for over 100 years [19, 36] due to its characteristics, such as: biocompatibility, dimensional stability, passivity to be condensed and adapted to dentinal walls, plasticity after heating, besides being easily removed whenever necessary [30, 38].

Several studies have been reporting the different chemical compositions of gutta-percha points available in the market [16, 21], as well as their advantages and disadvantages, and the results of this material utilization through different obturation techniques of the root canal system [4, 15, 36].

According to Leonardo and Leal (1998) [20], to fill a root canal means to occupy its entire extension with inert or antiseptic materials that permanently, in the most possible hermetic way, seal it. This must not interfere at, and must preferably stimulate, the apical and periapical repair that must occur after radical endodontic treatment.

Another root canal system obturation purpose is to prevent reinfection by microorganisms still within root canal after the cleaning and shaping procedures. This is obtained by using endodontic cements associated with gutta-percha points. Gutta-percha points with endodontic cements based on zinc oxide and eugenol is the association most employed by the clinicians [3], because provides good obturation quality, besides eliminating empty spaces and the antimicrobial activity [25].

When the root canal is empty, it becomes a proper site for bacterial cultures developing due to environmental conditions of temperature [34], gas concentrations [14], and lack of specific and unspecific defenses [35]. An infection becomes a source of products toxic and irritant to the surrounding tissues [27].

Countless techniques have been employed to fill the root canal. Some use cold gutta-percha; others use heated gutta-percha that is adapted to root canal walls. Lateral condensation, proposed by Callahan, in 1914 [6], is the root canal obturation technique most used worldwide, representing the cold method. It has the advantage of controlling the apical overflow of the filling material; however, it shows the disadvantage of an excessive time amount for execution [22], lack of homogeneity of the filling material [26], inadequate adaptation to root canal walls [38], very thick cementation line [10], and presence of cement blisters [24].

Described by De Deus (1992) [6] and also a cold technique, hydraulic compression consists in vertically condense only one gutta-percha point tapered between 0.04 mm/mm and 0.08 mm/mm, aided by condensers that passively penetrate into root canal. After the cut of gutta-percha point at the root canal entrance, the point is vertically condense toward the apex, promoting the shaping and adaptation of the filling to the dentinal walls [6]. However, such technique requires a greater caution by the clinician. It is important the correct root canal shaping and apical tapering where the gutta-percha point will be supported and tugged fit. When the main gutta-percha point is vertically condensed, it will shift toward the apical direction, reaching the exact working length determined by odontometry [17].

Several heat techniques have been also proposed [4, 30, 36], indicating the possibility of apical overflow of filling material. On the other hand, these techniques have shown obturation’s homogeneity and perfect adaptation to root canal walls, sulcus, fissures, and system, promoting optimum apical and coronal sealing when compared to lateral condensation [19].

There is a lack of studies on the capacity of gutta-percha’s root canal filling through lateral condensation, hydraulic compression, and Tagger’s hybrid technique. Since these three techniques have
been used in the Dentistry course of the University of Fortaleza, an investigation was performed by using transversal cuts of teeth endodontically treated and filled with the three aforementioned techniques.

Material and methods

Obtainment and selection of the specimens

The study was performed with 60 human, single-rooted, extracted teeth kept in saline until the moment of their usage.

All teeth were referred to extraction due to either aggressive periodontal disease therapeutics, showing great loss of clinical insertion; or due to orthodontic or prosthetic reasons. Their treatment history is described in patient’s files, according to the content present in the donation form’s attachment. The project was judged and approved by the Ethical Committee in Research of the University of Fortaleza under number 017/2004, and record 03-524.

Specimen preparation

Cleaning and shaping procedures were based on the principles of the crowndown technique, described by De Deus (1992) [6]. Cervical and medium thirds were prepared by Gates-Glidden burs (GG #6, GG#5, GG#4, GG#3, and GG#2), in descending order, respecting the teeth’s length. Before the use of Gates-Glidden burs, all specimens were negotiated and had their patency determined by #15 Kerr file (Dentsply-Maillefer, Ballaigues, Switzerland).

Working length was determined 1 mm short of the apex, at patency, when the apex was surpassed. Therefore, the length was shortened until the file was completely inside root canal.

Apical preparation was performed by Flexofile and K type files 2nd series (Dentsply-Maillefer, Ballaigues, Switzerland). All specimens had their apical preparation standardized at #45 apical file.

Irrigation was standardized with 5 ml of 1% sodium hypochlorite (Biodinamica, Sao Paulo, Brazil), at every instrument change. Irrigation was performed with aid of disposable syringe (5 ml) and BD needle (20 x 0.55 mm). Root canals was also submitted to auxiliary chemical action with 1 ml of EDTA (Biodinamica, Sao Paulo, Brazil), which occupied all root canal, for 4 minutes, prior to final irrigation with sodium hypochlorite and drying with absorbent paper points (Dentsply, Petropolis, Brazil).

Study groups

After the shaping procedures, teeth were randomly divided into three groups of 20 specimens each. Obturation was performed by specific technique, according to table I. Endofill (Dentsply-Maillefer, Petropolis, Brazil) was used as endodontic filling cement.

Gutta-percha points were calibrated, tested, and adapted for all specimens’ root canals, within all working length. This step’s proof was carried out through radiographic shots.

Table I – Study groups according to the technique type and employed obturation

<table>
<thead>
<tr>
<th>Groups</th>
<th>Specimens</th>
<th>Obturation technique</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group I</td>
<td>20</td>
<td>Lateral condensation</td>
</tr>
<tr>
<td>Group II</td>
<td>20</td>
<td>Hydraulic compression</td>
</tr>
<tr>
<td>Group III</td>
<td>20</td>
<td>Tagger’s hybrid</td>
</tr>
</tbody>
</table>

In group I, teeth were filled with standard, size #45, 0.02 mm/mm tapered gutta-percha points, associated with size #R1 accessory gutta-percha points, adapted into root canals with the aid of digital condensers (Dentsply-Maillefer, Ballaigues, Switzerland). Gutta-percha points were placed up to root canal was full along its extension. A hot instrument (Paiva’s condenser) was used to remove, at once, the excess of gutta-percha points from pulp chamber at enamel-cement junction. Following, a gentle vertical compression was executed by using a cold condenser.

Concerning to group II, the sequence aforementioned described for group I was performed, except that the selected master point was a medium-type, 0.06 mm/mm tapered, accessory gutta-percha point calibrated to size #45 through a calibrator rule (Dentsply-Maillefer, Ballaigues, Switzerland). This technique used a single gutta-percha point (single cone). Prior to the beginning of the procedures, a condenser which diameter passively access root canal’s medium third was
selected. This was performed because the active condensation, after the cut of the gutta-percha point at the cervical third, should be executed avoiding the interference of root canals wall. Such condensation (compression) occurs towards the apex, for 10 seconds.

In group III, a medium, 0.06 mm/mm tapered point was associated with three size R1 accessory gutta-percha points, and performed as the same as in group I. Next, a gutta-percha condenser (size #55) (Guta-Condensor, Dentsply-Maillefer, Balaigues, Switzerland), mounted in a micromotor, in clockwise direction, was inserted into root canal towards the apex, up to 4 mm short of the working length, for 10 seconds, which is the amount of time necessary for gutta-percha thermoplastification. The filling was then vertically condensed by using a cold Paiva’s condenser, previously selected. All procedures were performed by two calibrated operators, who repeated the shape and filling of root canals up to present acceptable and similar levels of the endodontic treatment. The operators were measured through 0-10 scores by the professor responsible for the Endodontics discipline of the University of Fortaleza.

Specimens cut and images obtainment

After obturation, the teeth were cross-sectioned with aid of an Isomet diamond blade (Ø125 mm x 0.35 mm x 12.7 mm – 330C), mounted in an IsoMet® Low Speed Saw (Buehler Ltd., Lake Bluff, IL, USA), and water as a cooling medium. Three cuts, at every 3 mm were executed from apical vertex, totalizing four cuts (3, 6, 9, 12 mm). These cuts were embedded in acrylic resin (Centrofibra, Fortaleza, Ceará, Brazil) in order to facilitate the handling and polishing (800 and 1,200 grit sandpapers) of the cuts for posterior analysis through stereoscopic magnifying glass (Lambda Let, Hong Kong, China) (x40).

Images assessment

The obtained images were evaluated through Image Tool 3.0 software (University of Texas, Texas, USA), for observing the gutta-percha area in relation to root canal area. This software enables the operator to delimit on the section, the root canal lumen (RCL), gutta-percha (GP), and the endodontic cement (EC). Based on that, the software scores a gross value for each one of the measurements, where the value for root canal lumen corresponds to the total percentage (100%). Therefore, it is possible to find the gross value percentage of both the gutta-percha and the endodontic cement. The sum of the percentages of the gutta-percha and endodontic cement is subtracted from root canal lumen percentage (100%), totaling the percentage of empty space (ES) (ES = 100 – [GP+EC]). The obtained data were tabulated and compared.

Statistic analysis

The results were statistically analysed through GMC 10.0 software (Forp-USP, Ribeirao Preto, Brazil) (Kruskal-Wallis test).

Results

The results were shown in table II. The techniques were statistically different among each other (p<0.01). Tagger’s hybrid technique was superior to the other techniques regarding gutta-percha’s root canal filling capacity, followed by hydraulic compression and lateral condensation.

The analysis evidenced that the specimens obturated by Tagger’s hybrid technique presented a mean area of gutta-percha filling of 95.1%. Hydraulic compression and lateral condensation techniques showed mean areas of 89.1% and 70.6%, respectively. This divergence of results was repeated for all cuts.

Table II - Percentage means of gutta-percha filling of root canals, for different cuts and techniques

<table>
<thead>
<tr>
<th>Techniques \ Cuts</th>
<th>3 mm (%)</th>
<th>6 mm (%)</th>
<th>9 mm (%)</th>
<th>12 mm (%)</th>
<th>Mean (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lateral condensation (G I)</td>
<td>60.4A1</td>
<td>66.4A2</td>
<td>69.5A3</td>
<td>86.2A4</td>
<td>70.6A5</td>
</tr>
<tr>
<td>Hydraulic compression (G II)</td>
<td>90.2B1</td>
<td>88.7B2</td>
<td>82.3A3</td>
<td>87.4A4</td>
<td>89.1B5</td>
</tr>
<tr>
<td>Tagger’s hybrid (G III)</td>
<td>98.5B1</td>
<td>95.2B2</td>
<td>93.9A3</td>
<td>92.8A4</td>
<td>95.1B5</td>
</tr>
</tbody>
</table>

Intragroup analysis showed statistically significant differences only for group I (p<0.01); 6-mm and 9-mm cuts were equal (p>0.05).
Discussion

Because the apical third has the smallest dimension of the root canal, the access of the needle used for irrigation is obstructed, compromising the proper flow and reflux of the irrigant solution. Some authors justified the worst results of the obturation quality, at root canal third, due to this difficulty during cleaning and shaping procedures [23, 40]. However, the results of this study showed that the apical third had a great amount of gutta-percha, displaying the best results.

Considering that the main factor of root canal obturation is the adaptation of the filling material to root canal walls, in order to reach the most possible hermetic sealing and prevent bacterial proliferation, several studies attempted to determine the most efficient obturation technique [1, 5]. Their results, however, were inconclusive, since in none of the studies, the cold techniques were incapable of promoting a proper sealing in microleakage tests.

According to Ramos and Bramante (2001) [28], gutta-percha’s cold condensation results in the points and cement juxtaposition against root canal walls allowing empty spaces formation. This occurs because gutta-percha, in its solid state, does not fit into root canal. In some specimens of this study, this was seen. In these cold techniques, the endodontic cement should fill the most percentage of the root canal. Nevertheless, the cement is the fragile portion of the obturation, being more susceptible to solubilisation, resulting in failures within root canal’s obturation [14].

Previous studies agree that root canal obturation techniques employing heat for filling material thermoplastification result in better adaptation to dentinal walls [8, 9, 39, 41]. Besides, they promote a better sealing of all root canal system, even efficiently filling of lateral canals [15]. Cold root canal techniques do not reach such result, which have been verified and reported by several studies [9, 11, 12].

According to literature findings, the results showed here indicated the thermo-plastic technique superiority regarding to the others. By analysing the thickness of the resulting endodontic cement line within root canals filled by lateral condensation, hydraulic compression, and vertical condensation techniques, De Deus et al. (2003) [8] concluded that thermo-plastic technique showed very thin endodontic cement lines at the junction between the gutta-percha mass and dentinal walls. Although hydraulic technique was superior to lateral condensation, both presented thicker lines [29, 37]. Indirectly, our results corroborate these studies, because the thinner the cement layer, the greater the root canal area filled by gutta-percha.

Cross-section methodologies for analysing the obturation quality have already been previously analysed by other authors [8, 9, 10, 32, 38]. This methodology is appropriate since the specimens are prepared properly, with correct cuts and polishing, associated with devices capable of capturing sharp images. Besides that, image analysis should be executed through software that enables a meticulous measurement of the specimens’ areas. In this study, we attempted to reach these details for obtaining adequate results.

Gutmann and Witherspoon (2002) [18] suggested that the way root canal is prepared is important. Also, they admit that there is no pure filling technique and its excellence is very dependent of the operator. Still according the authors, all methods for root canal obturation could be well-successful if a proper procedure is followed. The clinician should be able to recognize when the application of either a pure or modified specific technique, or both, will facilitate the obtainment of a predictable success.

Conclusion

According to the methodology employed and the results found, it can be concluded that among the tested root canal filling techniques, Tagger’s hybrid is the one presenting the most gutta-percha’s root canal filling capacity, followed by hydraulic compression and lateral condensation technique.
References


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