Lack of correlation between obturation limits and apical leakage

Abstract: The aim of this paper was to evaluate a possible correlation between obturation limits and leakage. Thirty-six extracted human mandibular incisors were used, characterized by straight and single canals, non-anatomical complexities, absence of previous endodontic treatment, complete root formation and patent foramen. For standardization of the specimens for the leakage analysis, foraminal instrumentation was performed up to a Flexofile #25 (Dentsply-Maillefer, Ballaigues, Switzerland). All specimens were instrumented and filled following the same protocol, and the obturation limits were measured using Axiovision 4.5 Software (Carl Zeiss Vision, Hallbergmoos, Germany). The specimens were then separated into three groups (n = 12) according to the following variables: Group I – obturation limits ranging from 0 mm to 0.76 mm of the main apical foramen. Group II – obturation limits ranging from 0.77 mm to 0.98 mm of the main apical foramen. Group III – obturation limits ranging from 0.99 mm to 1.68 mm of the main apical foramen. Apical leakage was quantified by fluid filtration. The analyses were confronted using Pearson’s test (p > 0.05). Groups I, II and III showed Pearson correlation values ($r^2$) of −0.152, −0.186 and 0.058, respectively. No correlation was found between the obturation limits and apical leakage.

Descriptors: Endodontics; Root Canal Obturation; Dental Leakage.

Introduction

Over the years, several studies have shown the importance of correct fillings for achieving higher success rates in endodontics. Most of these studies classify these fillings as appropriate when considering obturation limits ranging from 0 to 3 mm, among other factors.1-4

Insofar as apical seals are the main barriers against tissue fluid leakage and bacterial recontamination, the long-term success of endodontic therapy is directly dependent on the effectiveness of these seals.3,4 Several techniques have been developed over the years to improve their properties, including improved sealing of the apical filling. Although thermoplastic techniques show a certain superiority in achieving gutta-percha density, compared to cold techniques,5 neither technique can effectively prevent the leakage, which has been analyzed by several different methods.2-19 Considering that different filling techniques and sealers have resulted in similar apical seals,20-22 it seems wise to investigate other reasons associated with greater or lesser leakage rates.

To date, no research has evaluated the correlation between obturation
Lack of correlation between obturation limits and apical leakage. Therefore, this was the objective of this paper. The null hypothesis tested is that there is no correlation between these two variables.

Methodology
Sample size: statistical considerations

Based on a simple random sampling, considering a pilot sample of 36 human mandibular incisors with similar anatomical characteristics, the average (0.95) and the standard deviation (0.29) were calculated for the three groups of variable apical limits. Next, the margin of error for a level of significance = 0.05 was calculated, based on the formula for calculating the sample size when the standard deviation is unknown, using the Student’s t distribution, and obtaining an error of 10.4% for n = 36. The sample size was then divided into three groups of n = 12 to stratify the apical limits.

Specimen selection

After approval by the Research Ethics Committee of the University (protocol #5314), 36 extracted human mandibular incisors were selected for this research. They were characterized by straight and single canals, non-anatomical complexities, complete root formation, absence of previous endodontic treatment and patent foramen provided by the tooth bank of the University. Crowns were removed with a diamond-cutting disc (∅ 127 mm × 0.4 mm × 12.7 mm; Buehler Ltd., Lake Bluff, USA) to obtain specimens with a standard length of 12 mm. The specimens were kept in distilled water until use.

Specimen preparation

Access to the canal was performed using a tapered-tip bur 3082 (KG Sorensen, Barueri, Brazil). Working length was established by subtracting 1 mm from the point where the file was just visible at the apical foramen. The coronal and middle thirds of each canal were prepared using Gates Glidden drills (Dentsply-Maillefer, Ballaigues, Switzerland), sizes 4, 3 and 2, by placing each instrument 2 mm deeper than the previous one. The apical foramen were standardized using real length instrumentation of the teeth up to instrument 25 K-Flexofile (Dentsply-Maillefer, Ballaigues, Switzerland) and the apical thirds were prepared with the Profile 04 System (Dentsply-Maillefer, Ballaigues, Switzerland) up to size 35 at the working length. The canals were irrigated between each instrument with 2 mL of freshly prepared 2.5% NaOCl (Fórmula & Ação, São Paulo, Brazil) plus a flush of 3 mL of 17% EDTA (pH 7.7) (Fórmula & Ação, São Paulo, Brazil) for 3 minutes. Five milliliters of sterile water were used as a final rinse.

Canal filling

The prepared canals were filled using the lateral compaction technique to control the methodological variables associated with the filling technique. The root canals were dried with paper points. A pre-fit size 35, 0.04 taper gutta-percha cone (Dentsply-Maillefer, Ballaigues, Switzerland) was used as the master cone. A size 20 file was used to place 20 µL of AH Plus sealer (Dentsply De Trey, Konstanz, Germany) into the canal, using a counter-clockwise rotation. The filled roots were stored at 37°C and 100% humidity for 7 days to allow the sealer to set.

Radiographic analysis of the obturation limits

After obturation and storage, all specimens were radiographed in the buccolingual and mesiodistal views to analyze the quality of the treatments. The buccolingual views were digitized and the obturation limits were analyzed using Axiovision 4.5 Software (Carl Zeiss Vision, Hallbergmoos, Germany), as can be seen in Figure 1.

The specimens were separated into three groups according to the obturation limits:
- Group I (n = 12) – obturation limits ranging from 0 mm to 0.76 mm of the main apical foramen.
- Group II (n = 12) – obturation limits ranging from 0.77 mm to 0.98 mm of the main apical foramen.
- Group III (n = 12) – obturation limits ranging from 0.99 mm to 1.68 mm of the main apical foramen.

Apical leakage analysis by fluid filtration method

The fluid filtration method was used to deter-
mation leakage. The root apex was connected to a Luer type metal needle by a plastic tube. The leakage allowed by the tested groups was quantified according to the movement of a small air bubble inside a 25 µL micropipette (Fisher Scientific, Philadelphia, USA). The inside of the pipette and the entire system was filled with distilled water and a pressure of 10 psi was applied. After ensuring that there was no leakage at the connections, the system was activated and balanced for 4 minutes. The volume of fluid was calculated by observing the air bubble displacements, and was expressed in µL/min.10 psi. Measurements were made at 2-minute intervals over an 8-minute period.17

**Results**

Tables 1 through 3 show the relevant statistical data of the study.

Groups I, II and III showed Pearson correlation values ($r^2$) of −0.152 (Table 1), −0.186 (Table 2) and 0.058 (Table 3), respectively. Furthermore, our results showed that the leakage rates for a given obturation limit, such as about 0.85, ranged from 0.10 to 0.89, indicating lack of correlation between obturation limits and apical leakage.

### Table 1 - Correlation analysis of Group I.

<table>
<thead>
<tr>
<th>Obturation limits</th>
<th>Apical leakage</th>
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<tbody>
<tr>
<td>Pearson correlation</td>
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</tr>
<tr>
<td>Sig. (2 - Tailed)</td>
<td>0.637</td>
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<tr>
<td>n</td>
<td>12</td>
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</tbody>
</table>

### Table 2 - Correlation analysis of Group II.

<table>
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<th>Apical leakage</th>
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</thead>
<tbody>
<tr>
<td>Pearson correlation</td>
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</tr>
<tr>
<td>Sig. (2 - Tailed)</td>
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<td>n</td>
<td>12</td>
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</table>

### Table 3 - Correlation analysis of Group III.

<table>
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<th>Obturation limits</th>
<th>Apical leakage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson correlation</td>
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</tr>
<tr>
<td>Sig. (2 - Tailed)</td>
<td>0.858</td>
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<td>n</td>
<td>12</td>
</tr>
</tbody>
</table>

### Discussion

In recent decades, different researchers have used several leakage models. These models have been criticized for many factors mainly related to preclusion of direct clinical applicability of results.23-25

Several authors also observed divergent results when comparing different types of leakage tests. Barthel et al.26 applied the dye leakage test after
the bacterial test on the same teeth and found no correlation between the tests. Pommel et al.\textsuperscript{27} also compared fluid filtration, electro-chemical and dye leakage tests in evaluating the sealing ability of single-cone and vertical condensation obturation techniques, using the same teeth, and found no correlation among the tests.

However, Wu et al.\textsuperscript{28} compared fluid filtration and dye penetration methods and found fluid transport was a more sensitive method for detecting voids along the root canal filling than dye penetration.

Moreover, Wu et al.\textsuperscript{29} showed a significant correlation between the quality of the fillings and leakage rates. Of a total of 80 mesial roots of mandibular molars observed in the buccolingual direction, 76% had well performed fillings, but this figure fell to 36% when the specimens were also analyzed in the mesiodistal direction. Because these specimens infiltrated less, although effectively, according to the analytic methodology used, we believe it is relevant to investigate others factors associated with leakage rates not just associated with radiographically evident filling voids.

According to Karagenç et al.,\textsuperscript{14} the difference in results obtained when using various methods to assess leakage may be attributed to the differences in the working principles of various tests methods and the different nature of obturation materials.

A factor still not well studied in relation to apical leakage regards the obturation limits. Theoretically, when main cone obturation does not reach instrumentation limits, it can predispose incorrect adaptations in the apical, middle and cervical thirds, leading to voids unfilled by lateral condensation.

Therefore, the purpose of this study was to evaluate this possible predisposition according to fluid filtration tests. The results showed that there was no correlation between obturation limits and apical leakage. We believe these results are related to the effectiveness of the methodology. The fluid filtration test shows leakage only when there is at least one void extending from the apical to the coronal thirds. A root canal filling which looks badly condensed on the radiograph may contain many “cul de sac” type voids and no leakage. On the other hand, very small “through and through” type voids are invisible on radiographs but may be detected by the fluid filtration test as having considerable leakage rates.\textsuperscript{16,28-30}

Our results showed that there were no statistical differences associated with apical leakage in the three groups analyzed. However, our obturation limits ranged from 0 to 1.68 mm of the main apical foramen, and these limits are in conformity with what are considered to be adequate limits in literature.\textsuperscript{3} We believe that more research similar to that conducted in this study, using different obturation limits, is important to compare our results.

**Conclusions**

According to the methodology of this in vitro study, we confirmed the null hypothesis that there is no correlation between the obturation limits and the apical leakage in roots filled with gutta percha and AH Plus sealer, in the three groups analyzed.

**References**