SUMMARY

Curved root canals are challenge for instrumentation, preparation, irrigation and obturation. The aim of the present study was to find the working length (WL) and irrigation efficiency in root canals with curvatures 30°-45° and in root canals with anatomical abnormalities 45°-90°.

68 human, matured, extracted molars with 201 root canals were included in the study. Molars were placed in 3 groups in relation to the angle between the root and the axis. The first group were teeth with straight canals (25°-30°, a control group; 14 teeth - 45 root canals), the second group were teeth with curved canals (30°-45°; 22 teeth – 66 root canals) and third group were teeth with severely curved canals (45°-90°; 31 teeth with 96 root canals). Measurements: mesio-distal buccal size of the chamber in its largest part and both bucco-lingual sizes - mesial as L1 and distal as L2.

Root canal preparation: removal of the root pulp with K endofiles number 6, 8 and 10, with Step-Down and Balance-force techniques. Canals length was measured radiographically by intra-oral radiographs, preparation continuous after X-ray analysis of the level of penetration of irrigants with contrast solution of diluted Urografin 66%. Regime of active irrigation: same for all groups with 2% H₂O₂ and 1% NaOCl and paper points drying. To follow up the results a fourth radiograph was made and a second one with Urograffin. The applied criteria for WL and for penetration of the irrigant was as follows: 3 - the whole WL; 2 - 1 mm shorter than WL; 1 - 2 mm shorter than WL; and 0 - more than 2 mm shorter than WL.

The active irrigation was more efficient in curved root canals, because in straight canals most of the irrigant was lost, back in the mouth or periapically. In straight root canals, only moisturizing (Miller pins) of the canal can be effective and less dangerous.

Keywords: Endodontics; Working Length; Root Canals, curved

Introduction

Curved root canals are well known challenge for instrumentation, preparation, irrigation and obturation. Root curvatures with abnormalities over 45° are not investigated from this point of view at all. Iatrogenic errors are often associated with these teeth. In the last 15 years, between 1995 and 2010, only 13 articles are related to this problem, excluding those with extreme methodology as the use of 6.25% NaOCl.

All published articles are researches from in vitro studies and surprisingly the curvatures are from 20° up to 40°. Teeth with curvatures between 25° and 45°, as we found in our previous studies, are from 16-19% of all teeth, and those with curvature of 45° are more than 1.3%. The number of experimental teeth in most of the studies varies between 30 and 135, while the average numbers are 59-621-14. In most studies, the preparation technique was reported to be Step-Down12,5,9,11,12. Different instrumentations with hand files6,13 and machine rotary files10,11,14 were used.

Apical preparation size varied from № 10-25 to № 40-45, in relation to the degree of curvature. In these papers, the differences are not only in the irrigation regimes but in type of medication. NaOCl was used as 2.5-5%3,7,10 and in combination with EDTA5,6. In all
H₂O₂ was used for irrigation. The followed up methods were x-ray³, SEM⁸, bioluminescence⁷,⁹, intra-operative microscopy², stereomicroscopy¹³ and light microscopy⁶.

In most of the cases, the results were predictable and mostly a logical result from the design of the experiment. Summarizing the results, it can be concluded that the type of preparation is a major factor for the degree of removal of the smear layer and penetration of irrigants and medicines. The highest efficiency was 70% in one group in one article. In most articles, penetration of irrigants was not complete among curvatures between 30-40°.

The aim of the present study was to find the working length and irrigation efficacy in root canals with curvatures 30°-45° and in those with anatomical abnormalities 45°-90°.

**Material and Methods**

**Teeth:** 68 human matured extracted molars with 201 root canals are included in the study. All teeth are from the same geographical region.

**Groups:** Molars are separated in 3 groups in relation to the angle between the root and the axis. Molars with straight roots (25°-30°) were a control group (14 teeth with 45 root canals), the second group were molars with curved roots (30°-45°; 22 teeth with 66 root canals), and the third group were teeth with severely curved roots (45°-90°; 31 teeth with 96 root canals).

**Measurements:** Mesio-distal buccal size of the chamber in its largest part and both bucco-lingual sizes - mesial as L1 and distal like L2, and the average of last two as L.

**Root canal preparation:** Started with opening the orifices with manual Orifice Openers and removal of the root pulp with K endofiles number 6, 8 and 10, using Step-Down and Balance force techniques. Root canal length was measured radiographically with K files, and preparation continued after X-ray analysis of the level of penetration of irrigants with contrast solution of diluted Urograffin 66%.

**Regime of active irrigation:** It was the same for all groups - with 2% H₂O₂ and 1% NaOCl and paper points drying. The aim of root canal preparation was even in roots with 90° curvatures the apical stop to be number 20-25, and for the rest of the teeth 30-40. To follow up the results, a fourth radiograph was made and a second one with Urograffin. Instrument fractures and canal blockage were registered too.

**X-ray regimes:** Dental X-ray unit was Phot-XII (Takara Belmont Corp, Japan) and intraoral digital sensor Eva (Dent-X Co.) was used. All radiographs were exposed under the same conditions (exposure settings – 60 kv, 7mA and time 0.04s).

Irrigation measurements scale: The applied criteria for working length (WL) and for penetration of the irrigant were as follows: 3 - the whole WL, 2 - 1 mm shorter than WL, 1 - 2 mm shorter than WL, and 0 - more than 2 mm shorter than WL. All measurements were performed by the same examiner, 3 times with at least 3 days intervals between.

**Results**

4 root canals from 207 were not found - 2%. 7 instruments were fractured, 4 in group 2, 3 in group 3, and none in the control group. In 7 canals, dentine debris formed intracanal blockage, from them 3 in group 1 (control group), 1 in group 2 and 3 in group 3.

As is shown in table 1, most mistakes were made in the control group, nearly in one third of the cases. This fact can be explained in 3 different ways. The first explanation could be frequent ramifications, the second - difficulties related to the most accurate choice of the size of an instrument, and the third could be hyper-instrumentation, made more often in straight root canals. In all in vitro studies there is a lack of data on age and sex of the teeth and anthropometrical data. In the experimental groups, this percentage was 10% and 9%, or 3 times less.

The same trend persisted when irrigants were tested. In the control group, in 50% of the cases the irrigant was not present in the canal system (table 2). Still high but lower were cases in the experimental groups - 33% in group 2 and 20% in group 3.

<table>
<thead>
<tr>
<th>GROUPS WL</th>
<th>3 (the whole WL)</th>
<th>2 (1mm from WL)</th>
<th>1 (2mm from WL)</th>
<th>0 (&gt;2mm from WL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Controls (n=45)</td>
<td>26</td>
<td>7</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>30° to 45° (n=66)</td>
<td>42</td>
<td>1</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td>45° to 90° (n=96)</td>
<td>65</td>
<td>9</td>
<td>8</td>
<td>1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>GROUPS WL</th>
<th>WL3</th>
<th>WL2</th>
<th>WL1</th>
<th>WL0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Controls n=45</td>
<td>17</td>
<td>3</td>
<td>-</td>
<td>21</td>
</tr>
<tr>
<td>30° to 45°n=66</td>
<td>43</td>
<td>1</td>
<td>9</td>
<td>13</td>
</tr>
<tr>
<td>45° to 90°n=96</td>
<td>65</td>
<td>9</td>
<td>8</td>
<td>14</td>
</tr>
</tbody>
</table>

Figures 1-3 depict X-rays of the WL detection, as well as irrigant penetration in different groups.
Under the conditions of this study, designed on the basis of realistic clinical approach to difficult teeth, it is difficult to favours the role of irrigants in the root canal preparation. In straight canals, especially in young patients, the extrusion of the irrigant periapically is more often. Clinically, this leads to toxic periodontitis and later to creation of chronic periapical lesions.

In curved canals, penetration of irrigants is more difficult, which has its positive and negative aspects. Practically, more severe is the curvature more the instrumentation is related to moisturizing the internal root canal surface and the use of new flexible files with proper sizes. This finding is similar as in some other studies.

Non-effective irrigation could happen even in curved canals only with 24-28° and 30-33°.

The separation of teeth in groups of lower and upper teeth in this study was found to be useless.

Conclusions

X-ray WL detection of molars with root canal curvatures is more accurate, compared to molars with straight roots.

The active irrigation is more efficient in curved root canals, because in straight canals most of the irrigant is lost back in the mouth or periapically.

In straight root canals only moisturizing (Miller pins) the canal can be effective and less dangerous.
References


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