The aim of the present study was to compare the efficacy of Eucalyptol as organic solvent in removal of gutta-percha from root canal fillings. Twelve single rooted human teeth with only one root canal and one apical foramina were selected and instrumented using a step-back technique. All the teeth were filled using the lateral condensation. Initial periapical X-rays were taken after the root canal treatment. Teeth were retreated with 2 different nickel titanium rotary systems: ProTaper Universal and K3 Endo, and Gates Glidden burs combined with hand K-files in a crown-down technique, with or without the association of Eucalyptol. The quality of the retreatment was assessed by radiographic examination and direct observation under the dental operating microscope. The present study demonstrates that at the present time, no retreatment method allows a complete removal of the root canal filling material from the endodontic space.

Keywords: Organic solvents; Filling material; Endodontic retreatment

The international endodontic literature reports that the success rate of the endodontic retreatment varies between 70-95% [1]. This has been calculated as the percentage of successfully treated teeth comparative to all the teeth with follow-up examination or included in the study [1].

The factors that lead to the success or failure of the endodontic treatment vary and can involve root canal anatomy, bacterial infection resulting from inadequacies in cleaning, shaping and three dimensional filling of the endodontic system, iatrogenic events or reinfection of the root canals when the coronal seal is lost, after the completion of the root canal treatment [2].

Endodontic retreatment is a procedure that removes the filling materials from the root canals followed by their cleaning, shaping and obturation [3]. It also requires the disinfection of the root canals with irrigation solutions and different interim medications.

Removal of root canal filling materials can be achieved by different techniques, which include endodontic rotary files systems, endodontic hand files, ultrasonic instruments and/or the combinations of these with heat or chemical substances. Organic solvents have been used to assist in the removal of gutta-percha and endodontic sealers from the root canals [4].

The most common organic solvents used in endodontic retreatment are: chloroform (CHCL3), Eucalyptol (C_{10}H_{18}O), xylene (C_{8}H_{10}), orange oil and halothane (C_{2}HBrClF_{3}). However when a clinician must choose between one of the above solvents it is important to weight in the balance of toxicity, clinical safety and and chemical solvent capacity.

From the solvents described above both chloroform and Eucalyptol have been used as solvents since 1850 [5]. However even if the most effective solvent for dissolving the gutta-percha is chloroform, different studies classified it as highly toxic and so its use is not encouraged. Even so, Chutich et al. [6] conducted a study in order to assess the toxicity of chloroform, halothane and xylene through a quantification of apically extruded solvent. The study findings indicate that the amount of solvent that has been reached out through the apical foramen is several orders of magnitude below the permissible dose. Regardless, after taking in balance the efficiency of the solvent and its toxic properties, the most promising organic solvent used for gutta-percha dissolving is Eucalyptol (C_{10}H_{18}O).

The aim of the present study was to compare the efficacy of Eucalyptol as organic solvent in endodontic retreatment in association with 2 different nickel titanium rotary systems: ProTaper Universal (Dentsply Maillefer, Ballaigues, Switzerland) and K3 Endo (Sybron Endo, CA, USA), and Gates Glidden (GG) burs combined with hand K-files in a crown-down technique, in teeth obturated with gutta-percha and AH plus sealer in a lateral condensation technique.

Eucalyptol (C_{10}H_{18}O), a widely used substance for flavoring and fragrance, has been used as organic solvent in the present study, because its effectiveness and low toxicity. The evaluation of the efficiency of Eucalyptol in removing gutta-percha and an epoxy resin-based sealer (AH Plus) from the root canal and the assessment of the retreatment quality has been made through radiographic examination and direct observation under the dental operating microscope.

Experimental part

Twelve single rooted human teeth with only one root canal and one apical foramina were selected for the presented study; teeth were instrumented using a hand step-back technique, in order to achieve root canal preparations with a 5% taper and an apical foramen diameter of 0.30 mm. All the teeth were filled with 4% taper gutta-percha master cones and accessory cones and an endodontic sealer (AH Plus, Dentsply DeTrey, Konstanz, Germany) using the lateral condensation technique. Initial periapical X-rays were taken after the root canal treatment to confirm the quality of the root canal fillings.
The crowns of all teeth have been sectioned 2 mm above the cemento-enamel junction and then teeth were divided into 6 groups, each of 2 teeth, in accordance with the technique used for retreatment (table 1). In three of the groups, only mechanical instrumentation and irrigation with sodium hypochlorite NaClO 5.25% was used for retreatment (Groups II, IV and VI), and in Groups I, III and V the retreatment was performed in the same technique and sequence, but in association with a few drops of solvent (Eucalyptol).

For the first two groups, the ProTaper Universal endodontic rotary system (Dentsply Maillefer) was used. The root canals were instrumented in a crown-down technique using the following working sequence: F3-F2-F1, at 500 rpm and a maximum torque of 4.1 N/cm. The F3 (30.09) file was used for the root canal filling removal from the coronal section of the root canal, F2 (25.08) for the middle part and F1 (20.07) for the apical third. After that, the canals were instrumented from F1 to F3 file, until the F3 instrument has reached the entire working length. For Group I, Eucalyptol was used in retreatment in quantity of 1-2 drops, placed in the root canal in each third of the working length (fig.1). In Group II no solvent was used (fig.2).

In Groups III and IV the root canals were prepared using the K3 Endo rotary nickel-titanium system (Sybron Endo). The root canals were prepared using the crown-down technique employing the following working sequence: 25.10 – 25.08 – 25.06 – 30.06 at 500 rpm. The K3 25.10 instrument was used for the root canal filling removal from the coronal section of the root canal, K3 25.08 for the middle section and K3 25.06 for the apical section. After that, the K3 30.06 instrument was used in a rotary motion on the entire working length of the root canals. For Group III, Eucalyptol was used in addition, but not for Group IV.

In Groups V and VI the root canals were retreated using Gates-Glidden burs in association with hand K-files in a crown-down technique. The root canals were prepared following the working sequence: GG no.6 – GG no.5 – GG no.4, at 1000 rpm, followed by GG no.3 – GG no.2 – GG no.1 at 280 rpm. The depth each GG bur reached in preparation was the one allowed by the root canal diameter. After that, the root canals were shaped in a balanced force technique using hand K-files starting with #45 file and descending to #30 file, which reached the end of the working length. Because rests of filling material were still present in the apical part of the canal, teeth were instrumented to a K-file #40, two sizes larger than the initial apical file. Only in Group V Eucalyptol was used to dissolve the gutta-percha and the sealer from the root canals.

For all the study groups the retreatment was considered finalized when the instruments were clean at the removal from the root canal and the irrigation solution NaOCl 5.25% was clear, and no rests of root canal filling material were clinically observed on the canal walls. The organic solvent used was Eucalyptol (C10H18O) and the main irrigating solution was NaOCl with 5.25% concentration, the most commonly used irrigant in endodontic treatment and retreatment.

After the first radiographic examination was performed, some of the samples were positive for the endodontic material, which was highly radiopaque on films, and required a retreatment repeat; the organic solvent was used again in sample 1 and no solvent was used in samples 2,7,8 and 11 in order to better remove the root canal filling material. A second radiography was taken for teeth that were not retreated.

<table>
<thead>
<tr>
<th>Group</th>
<th>Number of samples</th>
<th>System used</th>
<th>Organic Solvent (Eucalyptol)</th>
<th>ID probe</th>
<th>Apical Diameter (after preparation)</th>
<th>Apical Diameter (after retreatment)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group I</td>
<td>2</td>
<td>ProTaper Universal</td>
<td>Yes</td>
<td>1.2</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Group II</td>
<td>2</td>
<td>ProTaper Universal</td>
<td>No</td>
<td>3.6</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Group III</td>
<td>2</td>
<td>K3 Endo</td>
<td>Yes</td>
<td>7.11</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Group IV</td>
<td>2</td>
<td>K3 Endo</td>
<td>No</td>
<td>8.10</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Group V</td>
<td>2</td>
<td>GG+hand K-files</td>
<td>Yes</td>
<td>14.15</td>
<td>30</td>
<td>30</td>
</tr>
<tr>
<td>Group VI</td>
<td>2</td>
<td>GG+hand K-files</td>
<td>No</td>
<td>12.13</td>
<td>30</td>
<td>30</td>
</tr>
</tbody>
</table>

The six study groups

![Sample 2, Group I. Initial and after the retreatment, clinical aspect](image1)

![Sample 3, Group II. Initial and after the retreatment, clinical aspect](image2)

![Sample 2, Group I. Radiographic examination after retreatment. a) initial aspect, b) control radiograph no.1, c) control radiograph no.2](image3)
showed rests of endodontic materials on the first film and positive samples were recorded (figs. 3 and 4). On dental radiographs the sealer cannot be differentiated from gutta-percha, because they have almost the same radiopacity. After the radiologic evaluation, the teeth were longitudinally sectioned using a 0.15 mm thick discus and each half of the teeth was examined under the dental operating microscope (Alltion, Wuzhou Co, China) in each third of the root canal: coronal, middle and apical at 21.25x magnification (figs. 5-7). This resulted in a number of 72 samples, which were analyzed and evaluated for rests of sealer and gutta-percha on the root canals walls, and if their presence was observed, it was registered as positive for gutta-percha and for the endodontic sealer, separately.

Results and discussions

At the microscopic examination, in 10 samples from the apical third, rests of gutta-percha were present after retreatment; rests of sealer were present in 12 of the apical third samples. In the middle third, 6 samples were positive for gutta-percha and 9 for the endodontic sealer. 8 samples were positive for gutta-percha in the coronal part, and only 6 for sealer. This confirmed that the apical part of the root canal is the most difficult to be completely cleaned in endodontic retreatment.

Some of the positive samples evaluated under the dental microscope can be observed in figures 5-7:

At the direct observation of the sectioned teeth under the dental operating microscope, the ProTaper rotary system proved to be more effective comparative to K3 and Gates-Glidden burs in removal of both, gutta-percha and sealer. On the periapical radiographs, only 6 teeth were positive for gutta-percha and sealer in the apical section, 8 in the middle part, and 7 in the coronal third. All positive teeth were retreated again, and a second radiograph was performed. Nonsurgical retreatment of previously endodontic treated teeth demands that both the gutta-percha and the sealer will be totally removed from the root canal walls. This can be achieved by using hand files, endodontic rotary systems files, ultrasonic instruments, heat pluggers, or laser, alone or a combination of those [7]. These techniques can be done with or without the use of solvent solutions.

There is a wide variation of results among endodontic solvents tested in the literature [4,5]. This happens because there is not a standard model to perform the tests; each author is establishing the materials that will be tested, interval of time, temperature and the devices used to measure the results, by using his own criteria [4,5]. However, all the studies demonstrated that a completely removal of the root canal filling material is impossible, regardless of the method of choice [4,9]. When the endodontic filling material is gutta-percha, different solvents were capable of efficiently dissolve it, because gutta-percha chemically is 1,4 trans-polyisoprene [2]. When used to dissolve endodontic sealers, the solvents proved to be less effective, especially in epoxy resin-based sealers, and some of the sealers are even described in the literature as nearly insoluble by solvents [7].

The present comparative analysis of positive samples after the retreatment with and without solvent for the apical, middle and coronal third of the root canal showed that almost all the samples retreated with solvent were positive for filling material in the apical third (fig. 9). A lower number of positive samples was observed in teeth retreated without the association of solvent.

From the total number of analyzed samples, the percentage of positive samples when retreated in...
Fig. 9. Number of positive samples in each third of the root canal

Fig. 10. The percentage of positive samples (%) with or without Eucalyptol

Fig. 11. Proportion of positive samples at the radiographic examination, classified by the endodontic system used in retreatment, with/without solvent

association with solvent was higher than the ones retreated without (fig. 10). The most effective system at the radiographic examination was Gates-Glidden combined with hand instrumentation in the absence of solvent (fig. 11). This can be explained probably because the final instrument that reached the apical region was two sizes larger that in groups of teeth instrumented with ProTaper or K3 systems.

The present study confirmed that regarding of the system used in the retreatment or the technique used, there is no sample among the 12 teeth analyzed that does not contained residues of sealer and gutta-percha. Also the present study demonstrated that there is a major difference between the radiographic evaluation and the direct dental microscopic evaluation. The Rx evaluation can not determine the spreading of the residual root filling material and the type of it; these can only be detected by using the dental operating microscope or other microscopic examination. That is why between the numbers of positive samples recorded at the microscopic examination there is a difference from data recorded at the radiographic analysis.

Conclusions

The present study demonstrates that at present time there is no method that allows a complete removal of the root canal filling material from the endodontic space. All the analyzed samples were positive for the filling material after retreatment. Also, the use of Eucalyptol ($\text{C}_{10}\text{H}_{18}\text{O}$) in association with the ProTaper system has led to no significant improvements in the removal of filling material in the coronal and middle section of the root canal.

A comparison between the efficacy of K3 and Gates Glidden systems alone or associated with Eucalyptol demonstrated that there is no significant difference between their efficiency in removal of endodontic materials.

The dental microscope analysis showed that the use of organic solvents lead to an increase in the residues of gutta-percha and sealer on root canal walls and inside the dentinal tubules. Also it is important to mention that in all the samples retreated with the ProTaper Universal system in association with solvent, positive results were recorded for the presence of the filling material in the apical third of the root canal when compared to those without solvent; no residual filling material in the same section was recorded in teeth instrumented only with ProTaper and irrigant.

However the use of organic solvents to dissolve the filling material in the apical part of the canal is sometimes absolutely necessary in order to reach the working length and to renegotiate the original path of the root canal.

References


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