Evaluation of Endodontic Treatments Performed by Students in a Brazilian Dental School


Abstract: The aims of this study were to evaluate the clinical outcomes of root canal treatments performed by final-year students in the Dental School of Piracicaba, State University of Campinas, SP, Brazil, during the year 2000 and to evaluate the success rate of these treatments at follow-ups conducted one and three years later (2001-03). All 579 endodontic treatments performed by final-year students were selected for this investigation. Detailed personal and dental history was obtained from the patient’s records. Clinical and radiographic follow-up examinations were performed. For 78.8 percent of the cases, dental caries was recorded as the cause for performing endodontic treatment; for 8.8 percent, prosthetic reasons were given; and for 12.4 percent, failure of the endodontic treatment was the reason. The largest percentage (30.7 percent) of recalled patients was examined after one year; the success rate at this follow-up evaluation ranged from 83 percent to 96 percent depending on the pulp status prior to the root canal treatment. After three years, only 8 percent of treated patients returned; assessment for them revealed a 75.5 percent success rate. Dental caries is still the main reason for endodontic treatment. This level of success of the root canal treatment in a Brazilian dental school is similar to other reports in the literature.

Dr. De Quadros is a Postgraduate Student; Dr. Gomes is Associate Professor; Dr. Zaia is Associate Professor; Dr. Ferraz is Associate Professor; and Dr. Souza-Filho is Associate Professor—all in the Department of Restorative Dentistry, Piracicaba Dental School, State University of Campinas, UNICAMP, Piracicaba, SP, Brazil. Direct correspondence and requests for reprints to Dr. Brenda Gomes, Endodontics Division, Dental School of Piracicaba, UNICAMP, Avenida Limeira, 901, Piracicaba, SP, 13414-018, Brazil; 55-19-3412-5215 phone; 55-19-3412-5218 fax; bpgomes@fop.unicamp.br.

Key words: root canal treatment, clinical evaluation, follow-up, prognostic factors, undergraduates

Submitted for publication 2/1/05; accepted 7/7/05
Methods

The present study was restricted to patients who attended the Dental School of Piracicaba for root canal treatment. The cohort consisted largely of patients with a general dental treatment plan outlined in the patient’s files. There were also patients who suffered from a specific endodontic disease, which initially needed emergency treatment. If during the initial examination, the endodontic staff noted that the case was too complex to be treated by undergraduate students, they referred such patients to the postgraduate student clinic.

Eighty undergraduate students performed both clinical and periapical radiographic examinations as well as the root canal treatments for 579 patients during the year 2000. All records of endodontic treatment performed by the final-year students were selected for this investigation. Detailed personal and dental history, as well as coronal, pulpal, and periapical status prior to root canal treatment, was obtained from the patient’s records. Final-year students usually did not treat complex cases that involved teeth with a history of root perforation, ledge formation, roots with severe curvatures, and canals with fractured files. On average, three complex cases were referred to the postgraduate student clinic per month. On average, each final-year student treated at least two molars, two premolars, and two anterior teeth.

Endodontic Treatment Methods

This section reviews the typical methods of endodontic treatment provided by final-year students at the Piracicaba Dental School.

Medical history was recorded in order to reveal any medical condition or medication that might influence treatment or may be influenced by dental procedures. Dental history was also utilized to discover factors that may be important for diagnosis and treatment. A brief history of present compliance was also recorded. Pain history was recorded to obtain information regarding its nature, duration, site, periodicity, precipitating or relieving factors, and associated symptoms.

The following features were also noted during the clinical examinations of all treated teeth: tooth type, presence of the restoration and its type (if temporary or permanent), and presence of caries. The following diagnostic tests were employed and recorded: pulp sensitivity tests, percussion, palpation, mobility test, and a periodontal examination.

Periapical radiographs were taken after the clinical examination to assess the presence or absence of periradicular alterations. The long-cone radiographic technique was used, and the films were processed manually using the time/temperature method. If the widening of the periodontal ligament (PDL) space exceeded twice the width of the normal periodontal ligament space, this was interpreted as an initial radiographic sign of periapical pathosis and classified as periapical radiolucency.

The criteria for categorizing the treated teeth, in order to evaluate the results, included tooth type (maxillary or mandibular); age and gender of patients; pulp status (irreversible pulpitis, reversible pulpitis, necrosis); periapical status (normal periapex, widening of the periodontal ligament, or periapical radiolucency); and primary or secondary endodontic treatment (retreatment).

All treatments were performed using a rubber dam and aseptic technique. Cleaning and shaping procedures were executed using a hybrid technique. The coronal two-thirds of the canals were prepared sequentially with size 15-35 K-Flexofile (Dentsply Maillefer Instruments, Ballaigues, Switzerland) and Gates Gliden burs, sizes 2 and 3 (Dentsply Maillefer). The apical third was instrumented to the master apical file. Root canals were further instrumented with step-back enlargement in 1 mm increments to three sizes larger than the master apical file. The irrigants available were 1.0% sodium hypochlorite (1% NaOCl: Milton solution) followed by a final rinse with 17% EDTA or 2.0% chlorhexidine gluconate gel. The sodium hypochlorite solution and EDTA were prepared by the same pharmacy (Proderma Farmácia de Manipulação Ltda., Piracicaba, SP, Brazil). The chlorhexidine gel used was prepared by Essencial Pharma Ltda (Itapetininga, SP, Brazil) and consisted of gel base (1.0% natrosol hydroxyethylcellulose pH 5.5) and chlorhexidine gluconate.

In cases where treatment could not be completed in one session, calcium hydroxide paste mixed with sterile water was used as an intracanal dressing, and a temporary restoration was applied between appointments. The temporary seals available were: a) reinforced zinc oxide temporary cement (IRM, L.D. Caulk Division, Milford, DE, USA); b) zinc oxide and zinc sulphate hydrated temporary cement (Coltosol, Coltène, Altstätten, Switzerland); c) glass chemically cured ionomer (Vidrion R, S.S. White Artigos Dentários Ltda., Rio de Janeiro, Brazil); d) light-cured glass ionomer (Vitremer, 3M Co., St. Paul, MN, USA). The permanent restorative materi-
als available were two types of light-cured composite: Flow-It (Jeneric/Pentron, Inc., USA) and Z100 (3M Co., St. Paul, MN, USA), amalgam and post/crown system.

All root canals were filled with gutta-percha and Endométhasone (Septodont, Aint-Maur, France) sealer using the lateral condensation technique. A layer of Coltosol was placed into the canal orifices after removing 2 mm of gutta-percha and sealer from the entrance of the canal.\textsuperscript{19} If the involved tooth would not receive a prosthetic restoration, a permanent restoration was placed at the end of the root canal treatment at least one week after the procedure. If it was known that there would be a delay in providing a prosthetic restoration, a 2 mm thick Coltosol seal was performed, followed by the placement of resin.

All the 579 patients were recalled for a follow-up appointment. Clinical and radiographic follow-up examinations of the root canal treatment were performed, and post-treatment efficacy was assessed at one and three years after treatment. The final-year students conducted the one-year follow-up evaluation under the supervision of two of the authors (IDQ and BPFAG). The same two authors conducted the three-year follow-up. The students and one of the authors (IDQ) compared the clinical and radiographic features before and after endodontic treatment.

Subsequently, the findings were submitted to the supervisor (BPFAG) to confirm the prognosis and record it in the patient file. The assessment of the endodontic treatments was based on the European Society of Endodontology Quality Guidelines.\textsuperscript{20}

Analysis of Data

Treatment success was identified when the following features were present: absence of pain, swelling and other symptoms, no loss of function, and radiographic evidence of a normal periodontal ligament space around the root.

When radiographs revealed lesions that remained the same or had only diminished in size without the presence of symptoms and signs, the case was considered to be still “in repair” rather than a success.

Treatment failure was identified if radiographs revealed that 1) a lesion appeared after endodontic treatment or a pre-existing lesion increased in size; 2) there was conflicting evidence with respect to symptoms and radiographic evaluations; or 3) there were signs of continuing root canal resorption.

All information was keyed into a computerized database. The system allowed the retrieval of information on the total number of teeth treated; the total number of maxillary and mandibular teeth; the number of each individual tooth group treated; the number of treatment visits; the number of teeth treated in the age groups under twenty-five, between twenty-six and forty-nine, and over fifty. The total number of treatments performed in male and female patients was also extracted from the database, as well as the frequency of dental caries, reversible and irreversible pulpitis, necrosis, teeth that required internal retention of the coronal prosthesis (prosthetic reasons), and retreatments.

Chi-square and Fisher’s Exact analysis of data were performed to examine whether the observed differences of the frequency of variables in relation to time were statistically significant, with a 0.05 level of significance.

Results

Root Canal Treatment in the Year 2000

The treatment frequency of each tooth group is presented in Table 1. In relation to the dental arch, more maxillary than mandibular teeth were endodontically treated. However, lower molars were more involved. Upper incisors formed the second largest group of treated teeth. Table 2 shows that the greatest number of treatments was undertaken for patients with ages ranging from twenty-six to forty-nine years. Female patients presented the highest percentage of treated cases (67 percent).

<table>
<thead>
<tr>
<th>Tooth Types</th>
<th>n (% of 579 patients)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maxillary</td>
<td>325 (56.1%)</td>
</tr>
<tr>
<td>Upper Incisors</td>
<td>130 (22.4%)</td>
</tr>
<tr>
<td>Upper Canines</td>
<td>32 (5.5%)</td>
</tr>
<tr>
<td>Upper Premolars</td>
<td>93 (16.1%)</td>
</tr>
<tr>
<td>Upper Molars</td>
<td>70 (12.1%)</td>
</tr>
<tr>
<td>Mandibular</td>
<td>254 (43.9%)</td>
</tr>
<tr>
<td>Lower Incisors</td>
<td>18 (3.1%)</td>
</tr>
<tr>
<td>Lower Canines</td>
<td>22 (3.7%)</td>
</tr>
<tr>
<td>Lower Premolars</td>
<td>79 (13.6%)</td>
</tr>
<tr>
<td>Lower Molars</td>
<td>133 (22.9%)</td>
</tr>
</tbody>
</table>
The diagnosis of irreversible pulpitis was noted in 32.3 percent of the cases, while necrosis was observed in 29.4 percent (Table 3).

Regarding the reasons for root canal treatment, dental caries was the cause in 78.8 percent, while prosthetic reasons were identified in 8.8 percent of the cases and failure of the previous endodontic treatment in 12.4 percent (Table 4).

One visit treatment was performed in 29.4 percent of total cases, but it was significantly more frequent in single canal treatments (47.1 percent) (p<0.01). Two-visit treatments were performed in almost 40 percent of the cases. Three visit-treatments were performed in 10.9 percent, particularly in teeth with three canals (26 percent) (Table 5). Only twenty-two out of 579 patients (3.8 percent) reported pain between appointments.

Table 6 shows that 1 percent NaOCl and a final rinse of 17 percent EDTA (58.7 percent) were the irrigating substances used most frequently, followed by 1 percent NaOCl alone, and then by 2.0 percent chlorhexidine gluconate gel (5.7 percent).

The main restorative material used was resin (49.9 percent) followed by Coltolsol (21.6 percent). Vidrion was used in 12.1 percent of the cases, IRM in 5.2 percent, amalgam in 1 percent, and post-crown system in 5 percent of the cases (Figure 1).

There were 162 (31.8 percent) primary treatment cases with radiographic signs of periapical lesion. Periapical radiolucency was present in fifteen (21.1 percent) of the cases that exhibited failure of the endodontic treatment (Table 7).

## One-Year Follow-Up

The largest percentage (30.7 percent) of recalled patients (178/579) was examined after one year (Table 8). During the one-year control period, the success rate ranged from 63 percent to 96 percent depending on the pulp status prior to the root canal treatment. The success rate was 96 percent for teeth with healthy pulp prior to the treatment that underwent root canal treatment for prosthetic reasons. This percentage decreased to 81 percent for pulps exposed during restorative procedures, 82 percent for teeth with pulpitis, and 63 percent for teeth with necrotic pulp tissue (Figure 2). Overall, teeth with primary
endodontic treatment had 77.4 percent of success and 6.5 percent of failure; 16.1 percent were in the process of healing. Teeth that had undergone retreatment had 66.7 percent of success and 19 percent of failure; 14.3 percent were in the process of healing. With respect to the periapical status prior to the endodontic treatment, the success rate ranged from 55.6 percent to 87.8 percent (Figure 3). Permanent restorations were present in 78 percent of the cases, and only 7.3 percent of the teeth still had no restoration after the one-year follow-up (Table 9).

### Three-Year Follow-Up

After three years, only 8 percent (49/579) of all treated patients were re-examined (Table 8). According to the pulp status prior to the root canal treatment, the success rate varied from 60 percent to 80 percent (Figure 4). In regards to the periapical status prior to the root canal treatment, 81.5 percent of cases with normal periapical area were considered successful (Figure 5). Overall teeth with primary endodontic treatment (45/49) had 75.5 percent of success and 24.5 percent of failure. Teeth that had undergone retreatment (4/49) had 100 percent of success.

When comparing success rates by tooth arch, maxillary teeth had the highest percentage of success (87.5 percent), while mandibular teeth had the lowest percentage (68 percent); however, this difference was not statistically significant (p>0.05).

The success rate for teeth with permanent restorations was 97.5 percent. There was a statistically significant difference (p<0.001) between permanently restored teeth and the success of endodontic

### Table 6. Irrigants used during the root canal treatment

<table>
<thead>
<tr>
<th>Irrigants</th>
<th>579 Treatments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1% NaOCl</td>
<td>165</td>
</tr>
<tr>
<td>1% NaOCl + 17% EDTA</td>
<td>340</td>
</tr>
<tr>
<td>2.0% chlorhexidine gel</td>
<td>33</td>
</tr>
<tr>
<td>Without any record</td>
<td>41</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Irrigants</th>
<th>n</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1% NaOCl</td>
<td>165</td>
<td>28.5%</td>
</tr>
<tr>
<td>1% NaOCl + 17% EDTA</td>
<td>340</td>
<td>58.7%</td>
</tr>
<tr>
<td>2.0% chlorhexidine gel</td>
<td>33</td>
<td>5.7%</td>
</tr>
<tr>
<td>Without any record</td>
<td>41</td>
<td>7.1%</td>
</tr>
</tbody>
</table>

### Table 7. Periapical radiolucency related to the root canal treatment status

<table>
<thead>
<tr>
<th>Root Canal Treatment (RCT)</th>
<th>Radiolucency</th>
<th>Total Number of Cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary treatment</td>
<td>162/508 (31.8%)</td>
<td>508 (87.6%)</td>
</tr>
<tr>
<td>Failure of the endodontic treatment</td>
<td>15/71 (21.1%)</td>
<td>71 (12.4%)</td>
</tr>
<tr>
<td>Total number of RCT</td>
<td>177/579 (30.5%)</td>
<td>579 (100.0%)</td>
</tr>
</tbody>
</table>

Figure 1. Type of restorative materials used by number of treatments
treatment. All teeth (100 percent) that were restored up to fifteen days after root filling presented successful root canal treatment.

Discussion

Epidemiological data on the frequency and distribution of endodontically treated teeth may reflect attitudes toward such treatment as well as the need and demand for it. Furthermore, an assessment of the clinical outcomes of undergraduate endodontic treatments performed could suggest the need for a critical re-evaluation of teaching methods and philosophy. The study reported in this article was conducted to determine why teeth were endodontically treated in the Piracicaba Dental School-Brazil, assess the quality of root canal treatment performed by students, and determine the success rate of these treatments over one-year and three-year follow-up periods.
Root canal treatments were more frequently undertaken in maxillary teeth than mandibular teeth. The difference between the number of maxillary and mandibular treated teeth was greater than expected. This finding differs from a study conducted by Ingle and Taintor, who reported an occurrence of 68 percent of treated maxillary teeth and 32 percent for mandibular teeth.

The teeth most frequently treated were the mandibular molars (22.9 percent), followed by the maxillary incisors (22.4 percent), agreeing with the findings of Seltzer et al. and Serene and Spolsky. The lower incisors were the least frequently treated teeth (3.1 percent). The high incidence of endodontic treatment in lower molars may be due to the fact that these are the first permanent teeth to erupt in the oral cavity and therefore are more susceptible to dental caries.

Table 8. Number of cases attended during the control period

<table>
<thead>
<tr>
<th></th>
<th>Control Period</th>
<th>One Year</th>
<th>Three Years</th>
<th>Total Number of Cases in 2000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of cases</td>
<td>178</td>
<td>30.7%</td>
<td>49</td>
<td>8.4%</td>
</tr>
</tbody>
</table>

Table 9. Clinical features analyzed during the control period

<table>
<thead>
<tr>
<th>Clinical Features</th>
<th>Control Period</th>
<th>One Year</th>
<th>Three Years</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>No restoration</td>
<td>13</td>
<td>7.3%</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Temporary restoration</td>
<td>2</td>
<td>1.1%</td>
<td>2</td>
<td>4.1%</td>
</tr>
<tr>
<td>Permanent restoration</td>
<td>139</td>
<td>78.0%</td>
<td>37</td>
<td>75.5%</td>
</tr>
<tr>
<td>Tenderness to percussion</td>
<td>4</td>
<td>2.3%</td>
<td>2</td>
<td>4.1%</td>
</tr>
<tr>
<td>Apical palpation sensibility</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Presence of fistula</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Extracted or with extract indications</td>
<td>5</td>
<td>2.8%</td>
<td>8</td>
<td>16.3%</td>
</tr>
<tr>
<td>Without any information</td>
<td>15</td>
<td>8.5%</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>178</td>
<td>100.0%</td>
<td>49</td>
<td>100.0%</td>
</tr>
</tbody>
</table>

The present study shows that the twenty-six to forty-nine age group had the highest incidence of root canal treatment, closely followed by the younger group (age between eight and twenty-five). This is in agreement with Farrel and Burke, who showed the highest incidence of endodontic treatment was

Figure 4. Success rate related to pulp status at the three-year follow-up
for patients between twenty-one and thirty years, and with Saunders and Saunders, who reported fewer treatments for patients younger than twenty-five and over fifty.

The frequency of treatment varied between men and women. Females received 67 percent of the endodontic treatment in this study. This is consistent with the findings of Boucher et al., who reported that 62 percent of the treated individuals were women.

On average, 29.4 percent of the teeth presented with the diagnosis of necrosis, 32.3 percent exhibited irreversible pulpitis, and 3.7 percent had reversible pulpitis. The latter patients received root canal treatment because there was an unexpected exposure of the pulp during the removal of deep caries in fully developed permanent teeth. Serene and Spolsky reported that more than half of the canals (60 percent) were diagnosed as necrotic, whereas Ørstavik and Hörsted-Bindslev reported on average 30 percent as being necrotic pulps. Unfortunately, many of the records made by students did not state initial diagnosis (22.2 percent).

Dental caries and their after-effects were responsible for the majority of the treated cases, which is consistent with the findings of Serene and Spolsky. Prosthetic reasons for root canal treatment were present in 8.8 percent of the cases, and the failure of prior endodontic treatment was responsible in 12.4 percent.

Periapical radiolucency was present in 31.8 percent of teeth with necrotic pulp tissues and in 21.1 percent of previous root treated teeth, which is consistent with Boucher et al. A great number of retreatments (78.9 percent) were performed in teeth where the pulp chamber was exposed to the oral environment or in teeth presenting with defective restorations.

In the Dental School of Piracicaba,
single-appointment endodontic therapy is the first choice of treatment, in the absence of pain, exudation, and/or swelling, in order to eliminate the chances of interappointment microbial contamination and to allow the immediate use of canal space as a retention post, as well as to reduce the number of appointments. However, because this study assessed treatments performed by undergraduates with limited expertise, only 29.4 percent of the endodontic treatments were completed during a single visit, which mainly involved single root canals.

Emphasis is also placed on the quality of the coronal restoration and its relation to the periapical status in root-filled teeth. It has been suggested that the coronal restoration and the root filling serve as barriers against fluid and bacterial penetration into the periapical area. In 1995 a study of 1,010 endodontically treated teeth, Ray and Trope found that the technical quality of coronal restoration was significantly more important than the technical quality of the endodontic treatment for apical periodontal health. For this reason, the main restorative material used in the Dental School of Piracicaba at the time of study was resin (49.9 percent), in order to prevent coronal microleakage and to increase the chances for healing to occur. After three years the success rate for teeth with permanent restorations was 97.5 percent.

Prevention of coronal leakage between appointments is an important goal and can be accomplished by using an adequate amount of a temporary seal or even by using a resin-based material when the treatment will be postponed for more than a week. Care should also be taken to seal the endodontic access with a resin-based material immediately after root canal treatment. Finally, poor permanent coronal restorations will enhance infection and re-infection processes, which favor the maintenance or induction of pulpal and periradicular diseases. All teeth that were restored up to fifteen days after obturation were judged to be successful root canal treatment after three years.

The number of patients who can be followed systematically over long periods of time is usually extremely small. Ingle reported that, at two-year recall, 33.4 percent of patients returned. Selden had 11 percent of treated patients return after eighteen months. In the present study, 178 (30.7 percent) treated teeth were examined after one year, and only forty-nine (8.4 percent) were examined after three years.

In this study the combined percentage of successful and “in repair” cases was 93.5 percent after one year on the basis of radiographic evidence of arrest or elimination of the area of rarefaction, absence of pain, fistula or swelling, and no loss of function. After three years, the success rate was 75.5 percent. Both percentages were related to the primary root canal treatment. The first findings are similar to those seen by Selden. Heling and Tamshe showed 77.8 percent of success related to teeth with vital pulps in root canal treatments performed by students. In this study, the success rate related to teeth with vital pulps (healthy pulp, exposed pulp, and pulpitis) varied from 81.8 percent to 96.3 percent after one year. However, at the three-year follow-up, the success rate of teeth that had healthy pulps was only 60 percent when compared to the teeth with a different diagnosis. Such a result is probably a consequence of teeth that had not received prosthetic treatment at all, or when the teeth presented with an unsatisfactory prosthetic treatment, it revealed to be unsatisfactory. In fact, the majority of such teeth did not have any restorations, had decay, and in some cases, had to be extracted due to fractures.

In relation to the status of the periapical area, successful cases were considered to be those with normal periapices and absence of symptoms. After three years, the success rate was 81.5 percent for normal periapical teeth, 88.9 percent for teeth with previous widened apices, and 66.7 percent for teeth with periapical lesions prior to the endodontic treatment. These percentages were greater than those reported by Heling and Tamshe.

Conclusions

The results of this study indicate that dental caries and their after-effects were responsible for the majority of the root canal treatments. Prosthetic reasons and failure of endodontic treatment were also significant factors. The success rate of root canal treatment in a Brazilian dental school is similar to rates reported previously. However, since an average of 17 percent of the cases were still “in repair” after one year, follow-up should be performed over a period of three years or more.

Acknowledgments

The authors would like to express their sincere gratitude to Professor Harald Eriksen for valuable advice. We would also like to thank Mr. Adailton dos Santos Lima for technical support. This work
was supported by the Brazilian agencies FAPESP (2000/13689-7, 04/05743-2), CNPq (304282/2003-0 & 140113/03-7), and CAPES.

REFERENCES