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

Iadasa De Quadros, D.D.S., M.Sc.; Brenda P.F.A. Gomes, D.D.S., M.Sc., Ph.D.; Alexandre A. Zaia, D.D.S., M.Sc., Ph.D.; Caio C.R. Ferraz, D.D.S., M.Sc., Ph.D.; Francisco J. Souza-Filho, D.D.S., M.Sc., Ph.D.

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

Current information on the quality and prognosis of root canal treatment has been mainly based on clinical studies performed in controlled environments at dental schools or in specialist clinics.[1-6] The results of such longitudinal studies show success rates of up to 96 percent for periapical health after endodontic treatment. However, cross-sectional, population-based studies of endodontic treatments performed by general practitioners show a different picture. They reveal a high frequency of inadequate root fillings and a high rate of apical periodontitis associated with endodontically treated teeth.[7-14] These studies point to an association between the quality of endodontic treatment and the periapical bone status; the authors concluded that there is room to improve endodontic treatment in general dental practice to promote periapical health.[15]

A survey, which evaluated the experience of undergraduates in endodontics in the vocation-training scheme (a scheme that was used to introduce newly qualified dentists to general dental practice in the United Kingdom), suggested considerable variation in the numbers of anterior and posterior teeth treated.[16] Saunders and Saunders[17] reported changes in the pattern of endodontic treatments undertaken in a teaching hospital. They found that the proportion of root treatments performed in older patients and in posterior teeth increased markedly between 1965 and 1985.

The study reported in this article had three goals: 1) identify the reasons why teeth were endodontically treated; 2) evaluate the outcomes of root canal treatments performed during the year 2000 by the final-year students in the Dental School of Piracicaba, State University of Campinas, SP, Brazil; and 3) determine the success rate of the endodontic treatment at follow-up assessments conducted at one and three years after the procedures.

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.[18] 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 hypoclorite (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 hydroxyethilcellulose 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.[19] If the involved tooth would not receive a prosthetic restoration, a permanent restoration was placed at the end of the root canal treatmentor 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.[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 1. Endodontic treatment versus tooth type

Tooth Types	579 Patients	
	n	%
Maxillary	325	56.1%
Upper Incisors	130	22.4%
Upper Canines	32	5.5%
Upper Premolars	93	16.1%
Upper Molars	70	12.1%
Mandibular	254	43.9%
Lower Incisors	18	3.1%
Lower Canines	22	3.7%
Lower Premolars	79	13.6%
Lower Molars	133	22.9%

Table 2. Incidence of root canal treatments related to age and gender

	AGE						GENDER			
	8-25		26-49		50-77		Female		Male	
	n	%	n	%	n	%	n	%	n	%
Number of treatments	197	34%	289	50%	93	16%	388	67%	191	33%

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 Coltosol (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).

Table 3. Number and percentage of endodontic treatments related to pulp status

Diagnosis	n	%
Healthy pulp	51	8.8%
Reversible pulpitis	22	3.7%
Irreversible pulpitis	187	32.3%
Necrosis	170	29.4%
Failure of the endodontic treatment	71	12.4%
Without any information	78	13.4%

Table 4. Reasons for the endodontic treatment

Reasons	n	%
Dental caries	457	78.8%
Prosthetic reasons	51	8.8%
Failure of the endodontic treatment	71	12.4%

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 pulps 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 tissues (Figure 2). Overall, teeth with primary

Table 5. Number of appointments (visits) vs number of root canals per tooth

Number of Canals per Tooth	One Visit	Two Visits	Three Visits	Four Visits	More Visits
One canal	148 (47.1%)	120 (38.2%)	9 (2.9%)	0	2 (0.6%)
Two canals	12 (16.4%)	41 (56.2%)	7 (9.6%)	0	2 (2.7%)
Three canals	10 (5.8%)	68 (39.3%)	45 (26.0%)	13 (7.5%)	15 (8.7%)
Four canals	0	6 (35.3%)	2 (11.8%)	4 (23.5%)	4 (23.5%)
Total number of treatments	170 (29.4%)	236 (40.8%)	63 (10.9%)	18 (3.1%)	23 (4.0%)

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.

Table 6. Irrigants used during the root canal treatment

Irrigants	579 Treatments n	%
1% NaOCl	165	28.5%
1% NaOCl + 17% EDTA	340	58.7%
2.0% chlorhexidine gel	33	5.7%
Without any record	41	7.1%

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 7. Periapical radiolucency related to the root canal treatment status

Root Canal Treatment (RCT)	Radiolucency		Total Number of Cases	
Primary treatment	162/508	(31.8%)	508	(87.6%)
Failure of the endodontic treatment	15/71	(21.1%)	71	(12.4%)
Total number of RCT	177/579	(30.5%)	579	(100.0%)

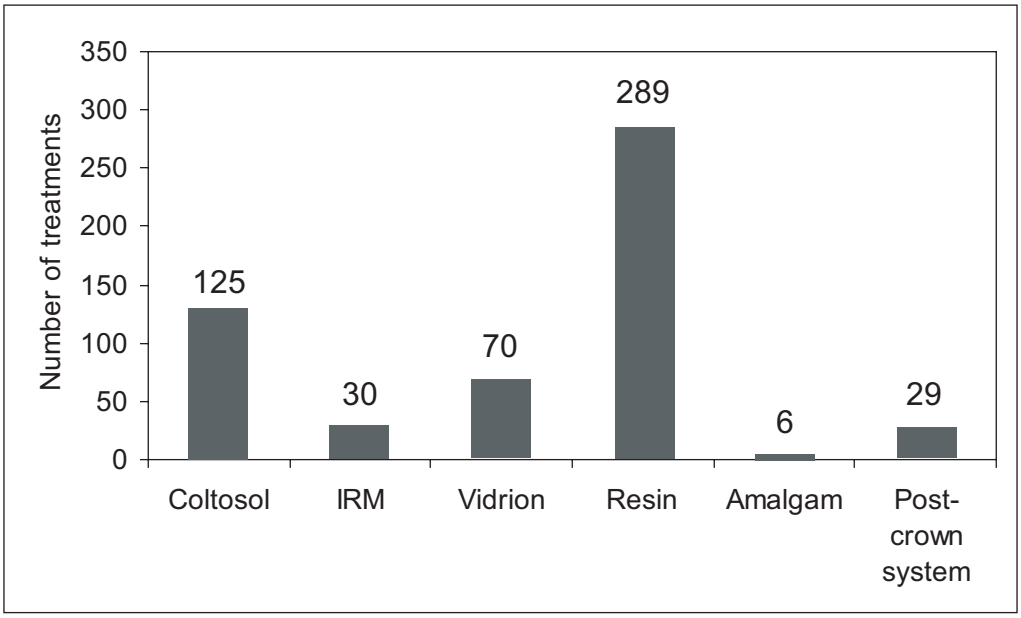

Figure 1. Type of restorative materials used by number of treatments

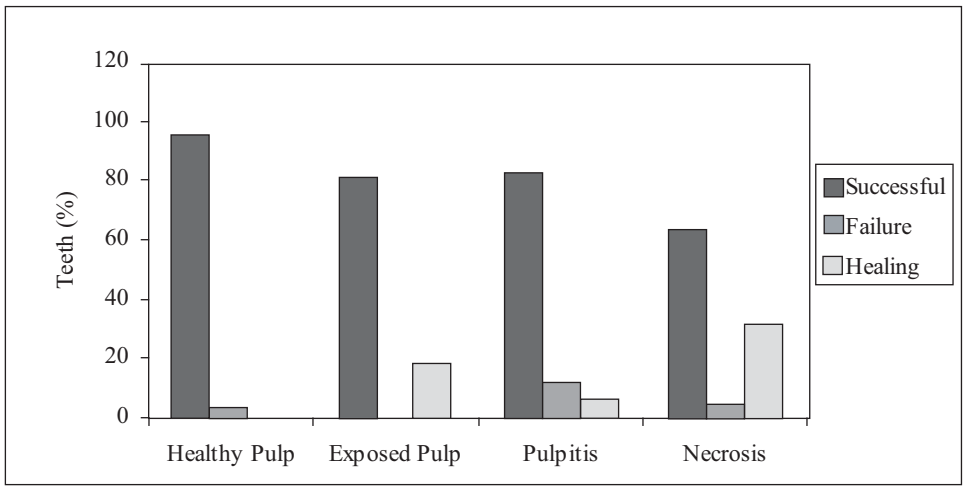

Figure 2. Success rate related to pulp status at the one-year follow-up

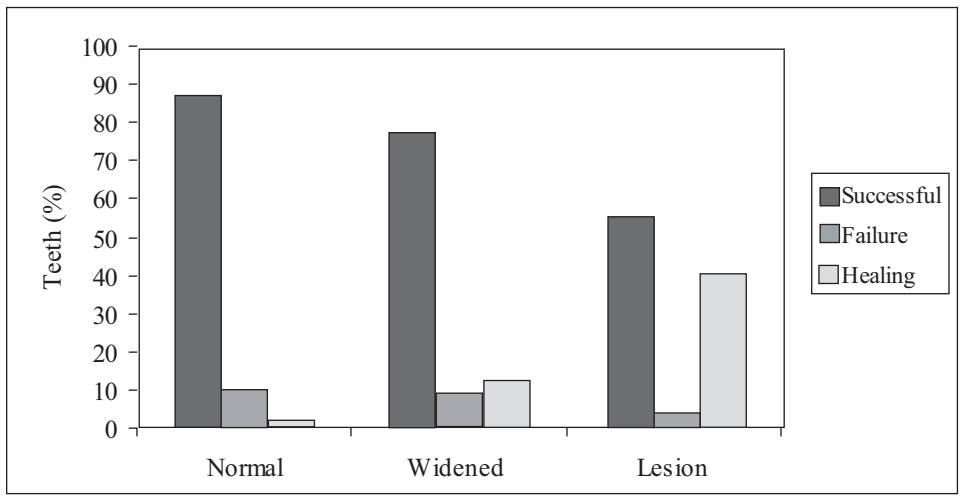

Figure 3. Success rate related to periapical status at the one-year follow-up

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.[21] 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.[22] 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,[23] 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.[24] and Serene and Spolsky.[22] 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

Control Period	One Year		Three Years		Total Number of Cases in 2000
	n	%	n	%	
Number of cases	178	30.7%	49	8.4%	579

Table 9. Clinical features analyzed during the control period

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

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,[25] who showed the highest incidence of endodontic treatment was

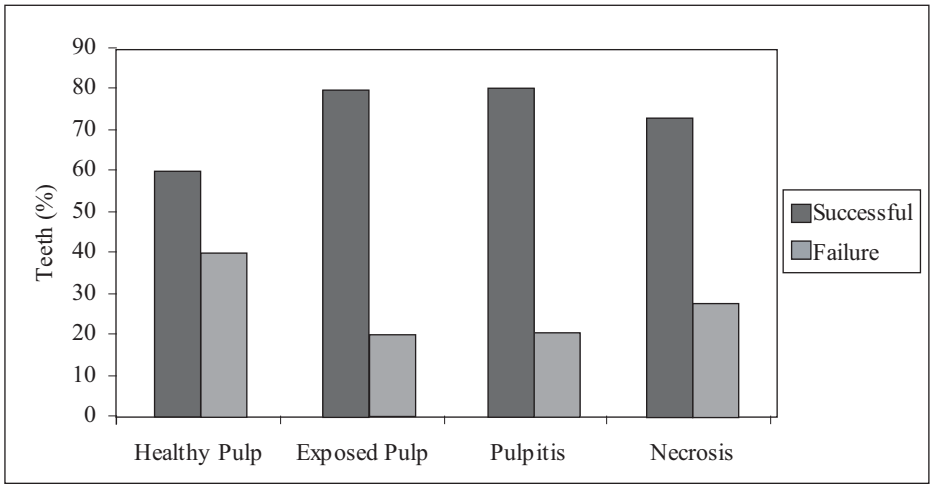

Figure 4. Success rate related to pulp status at the three-year follow-up

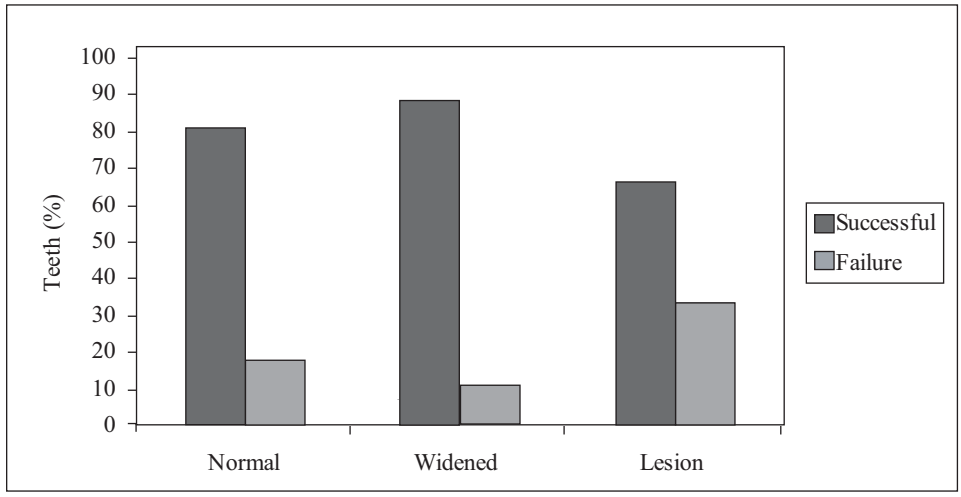

Figure 5. Success rate related to periapical status at the three-year follow-up

for patients between twenty-one and thirty years, and with Saunders and Saunders,[17] 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.,[26] 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[22] reported that more than half of the canals (60 percent) were diagnosed as necrotic, whereas Ørstavik and Hörsted-Bindslev[2] 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.[22] 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.[26] 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,

Table 10. Radiographic features analyzed during the control period

Radiographic Features	Control Period			
	One Year		Three Years	
	n	%	n	%
Absence of lesion	134	75.3%	40	81.7%
Minor lesion	29	16.3%	1	2.0%
Equal lesion	1	0.6%	0	0
Major lesion	5	2.8%	0	0
Without any RX	9	5.0%	8	16.3%
Total	178	100.0%	49	100.0%

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.[27,28] 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.[29,30] In a 1995 study of 1,010 endodontically treated teeth, Ray and Trope[30] 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.[19,31] 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 reinfection 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.[32] Ingle[33] reported that, at two-year recall, 33.4 percent of patients returned. Selden[32] 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.[32]

Heling and Tamshe[34] 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.[20] 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.[34]

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

1. Kerekes K, Tronstad L. Long-term results of endodontic treatment performed with a standardized technique. J Endod 1979;5:83-90.
2. Ørstavik D, Hörsted-Bindeslev P. A comparison of endodontic treatment results at two dental schools. Int Endod J 1993;26:348-54.
3. Friedman S, Löst C, Zarrabian M, Trope M. Evaluation of success and failure after endodontic therapy using a glass ionomer cement sealer. J Endod 1995;21:384-90.
4. Çaliskan MK, Sen BH. Endodontic treatment of teeth with apical periodontitis using calcium hydroxide: a long-term study. Endod Dent Traumatol 1996;12:215-21.
5. Hayes SJ, Gibson M, Hammond M, Bryant ST, Dummer PMH. An audit of root canal treatment performed by undergraduate students. Int Endod J 2001;34:501-5.
6. Petersson K, Olsson H, Söderström C, Fouilloux I, Jegat N, Lévy G. Undergraduate education in endodontology at two European dental schools. Eur J Dent Educ 2002; 6:176-81.
7. Petersson K, Petersson A, Olsson B, Hakansson J, Wennberg A. Technical quality of root fillings in an adult Swedish population. Endod Dent Traumatol 1986;2:99-102.
8. Eckerbom M, Andersson J-E, Magnusson T. Frequency and technical standard of endodontic treatment in a Swedish population. Endod Dent Traumatol 1987;3:245-8.
9. Eriksen HM, Bjertness E, Ærstavik D. Prevalence and quality of endodontic treatment in an urban adult population in Norway. Endod Dent Traumatol 1988;4:122-6.
10. Ödesjö B, Helldén L, Salonen L, Langeland K. Prevalence of previous endodontic treatment, technical standard and occurrence of periapical lesions in a randomly selected adult, general population. Endod Dent Traumatol 1990;6:265-72.
11. Eriksen HM, Bjertness E. Prevalence of apical periodontitis and results of endodontic treatment in middle-aged adults in Norway. Endod Dent Traumatol 1991;7:1-4.
12. De Cleen MJH, Schuurs AHB, Wesselink PR, Wu MK. Periapical status and prevalence of endodontic treatment in an adult Dutch population. Int Endod J 1993;26:112-9.
13. Saunders WP, Saunders EM, Saliq J, Cruickshank E. Technical standard of root canal treatment in an adult Scottish sub-population. Br Dent J 1997;182:382-6.
14. Marques MD, Moreira B, Eriksen HM. Prevalence of apical periodontitis and results of endodontic treatment in an adult, Portuguese population. Int Endod J 1998;31:161-5.
15. Kirkevang L-L, Ærstavik D, Hörsted-Bindslev, Wenzel A. Periapical status and quality of root fillings and coronal restorations in a Danish population. Int Endod J 2000;33:509-15.
16. Brookman DJ. Vocation trainees' views of their undergraduate training and their vocation training experience. Int Endod J 1991;24:179-86.
17. Saunders WP, Saunders EM. Endodontics and the elderly patient. Restorative Dent 1988;4:4-9.
18. Valdrighi L, Biral RR, Pupo J, Souza Filho FJ. Técnicas de instrumentação que incluem instrumentos rotatórios no preparo biomecânico dos canais radiculares. In: Leonardo MR, Leal JM, eds. Endodontia: tratamento de canais radiculares. São Paulo, SP, Brazil: Panamericana, 1991: 290-9.
19. Zaia AA, Nakagawa R, De Quadros I, Gomes BPFA, Ferraz CCR, Teixeira FB, Souza-Filho FJ. An in vitro evaluation of four materials as barriers to coronal microleakage in endodontically treated teeth. Int Endod J 2002;35:729-34.
20. European Society of Endodontology. Consensus report of the European Society of Endodontology on quality guidelines for endodontic treatment. Int Endod J 1994;27:115-24.
21. Molven O. Tooth mortality and endodontic status of a selected population group: observations before and after treatment. Acta Odontol Scand 1976;34:107-16.
22. Serene TP, Spolsky VW. Frequency of endodontic therapy in a dental school setting. J Endod 1981;7:385-7.
23. Ingle JI, Taintor JF. Endodontics. 2nd ed. Philadelphia: Lea & Febiger, 1976.
24. Seltzer S, Bender IB, Turkenkopf S. Factors affecting successful repair after root canal therapy. J Am Dent Assoc 1963;67:651-61.
25. Farrel TH, Burke FJT. Root canal treatment in General Dental Service 1948-1987. Br Dent J 1989;166:203-8.
26. Boucher Y, Matossian L, Rilliard F, Machtou P. Radiographic evaluation of the prevalence and technical quality of root canal treatment in a French subpopulation. Int Endod J 2002;35:229-38.
27. Cohen S, Burns RC. Pathways of the pulp. 7th ed. St. Louis: CV Mosby, 1998.
28. Inamoto K, Kojima K, Nagamatsu K, Hamaguchi A, Nakata K, Nakamura HA. Survey of the incidence of single-visit endodontics. J Endod 2002;28:371-4.
29. Saunders WP, Saunders EM. Assessment of leakage in the restored pulp chamber of endodontically treated multirooted teeth. Int Endod J 1990;23:28-33.
30. Ray HA, Trope M. Periapical status of endodontically treated teeth in relation to the technical quality of the root filling and the coronal restoration. Int Endod J 1995;28:12-8.
31. Gomes BPFA, Sato E, Ferraz CCR, Teixeira FB, Souza-Filho FJ. Evaluation of time required for recontamination of coronally sealed canals medicated with calcium hydroxide and chlorhexidine. Int Endod J 2003;36:604-9.
32. Selden HS. Pulpoperiapical disease: diagnosis and healing—a clinical endodontic study. Oral Surg Oral Med Oral Pathol 1974;37:271-83.
33. Ingle JI. Endodontics. Philadelphia: Lea & Febiger, 1965.
34. Heling B, Tamshe A. Evaluation of success of endodontically treated teeth. Oral Surg Oral Med Oral Pathol 1970;30:533-6.