# The Outcome of Endodontic Treatment: A Retrospective Study of 2000 Cases Performed by a Specialist

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## Abstract

The purpose of this study was to evaluate the treatment outcome of initial endodontic treatment and nonsurgical retreatment performed by an endodontic specialist in his private office. A total of 2,000 teeth were examined clinically and radiographically and the results were analyzed statistically by Pearson or Fisher's Exact test and multivariate logistic regression. The multivariate analysis evaluated joint associations among various factors, using logistic regression models. The dependent variable for this analysis was the dichotomous outcome: healed versus disease. The overall endodontic success rate was 91.45%, and the healed rate was significantly higher for initial endodontic treatments than for nonsurgical retreatments; teeth without lesion than for those with lesions; teeth treated without complications than for those with complications; recall period of 18-24 months than for other periods, and teeth with final coronal restoration than for those without. Of the 1376 teeth treated in the initial endodontic treatment sample, the success rate was 94.0%. Multivariate analysis identified the presence of procedural complications (file breakage, perforation and flare-up), as well as the absence of the restorations at follow-ups as the significant predictors of outcome, showing lower rates of success. Of the 624 teeth in the nonsurgical retreatment sample, 85.9% were successful. Stepwise logistic regression analysis revealed that preoperative radiolucency was a strong statistically significant factor to determine lower rates of success than in its absence. Two additional variables (age and tooth type) were found to have a significant influence on the outcome of the retreatment sample. A higher healed rate was observed for the 50-59 years age groups than others, while multirooted (molars) teeth revealed a significantly lower percentage of success than pre-molars and anterior teeth. *(J Endod 2007; 33:1278–1282)*

## Key Words

Initial endodontic treatment, multivariate analysis, nonsurgical retreatment, outcome of endodontic treatment, retrospective study

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Numerous retrospective studies (1-9) have been performed evaluating the success and failure of initial (first-time) endodontic treatment and nonsurgical retreatment based on clinical examination and radiographic appearance. However, reporting outcomes of endodontic treatment have shown considerable differences in the data composition, clinical procedures, and methodology (10).

Therefore, data obtained from significantly large patient samples regarding endodontic treatment outcomes are important, especially in relation to case selection and treatment planning. Such information enables the clinician to make more predictable decisions regarding the long-term prognosis of endodontic treatment, allowing the patient to retain their natural dentition in function. Another approach to assess the outcome of endodontic therapy is the analysis of multiple treatment variables, providing the clinician more tools for clinical decision making and assessment of teeth prognosis. Multivariate methods have been developed to analyze the simultaneous influence of several variables on one dependent variable and allow judgment and discussion of the relative importance of each variable (9).

Despite the numerous retrospective studies (1-9), long-term evaluations for several years of teeth endodontically treated by specialists are rare. Usually, teeth treated by specialists seem to be more technically difficult. Certainly, many factors are considered when referring a patient for specialist care. These include technical difficulty, patient management, and tooth position, among others. The aim of this study was to analyze the outcome of endodontic treatment performed by a specialist in his private office, using logistic regression analysis.

## Materials and Methods

A total of 2000 teeth performed by a specialist (NI) in his private office during a 30-year-period (March 1971-March 2000) were followed up with reference to the dental records. Among all patients who had returned for recall, 2000 teeth were randomly selected for this survey. This study material included a variety of clinical conditions.

### Original Endodontic Therapy Procedure

For each tooth, the following preoperative information was recorded: demographic data, tooth location, number of root canals, previous endodontic treatment, clinical signs and symptoms, response to percussion, vitality tests, and periapical status. Based on these findings, the preoperative condition was classified as one of the following: vital (healthy or irreversibly inflamed pulpitis), nonvital, endodontically treated, with or without periapical lesion, and symptomatic or asymptomatic.

For each tooth, the following intraoperative information was recorded: type of irrigation used, number of treatment sessions; interappointment dressing (if used); occurrence of procedural complications such as perforation, breakage of files, and flare-up; length of canal filling (at apical level, 1 mm short or more and beyond); and temporary restoration placed. Only small modifications were made to clean and shape the canals. After conventional straight-line access preparation was obtained, a modified step-down instrumentation technique was used as the routine procedure in which the coronal two thirds of the canal were enlarged with Gates-Glidden burs. The working length was established at 1 mm from the radiographic apex. The apical third was then prepared by using stainless steel files with step-back increments of 0.5 mm until a final file size #30 or larger could be placed at the working length. Irrigation was copious and frequent using 0.5% or 2.5% sodium hypochlorite. In nonsurgical retreatment cases, full-coverage coronal restorations were either accessed through or cut in half and discarded. Posts when present were vibrated ultrasonically or removed by using burs.

Silver points were preferably bypassed and removed by using Gates-Glidden burs and hand files (K-type and Hedströem). Gutta-percha filling material was also removed manually, and xilol or orange oil were used as a solvent when required. The therapy was completed in single or multiple treatment sessions. In the latter case, a mixture of calcium hydroxide powder and saline solution, a cotton pellet with paramonochlorophenol (PMCC), or a dry cotton pellet were placed in the canals between appointments. Although the former variables are important and can interfere in the outcome, they were not considered in this study. However, other important aspects remained unchanged such as: (1) all canals were enlarged to a minimum size #30 at working length, even in cases of narrow canals; (2) only gutta percha and sealer were used as obturation material; and (3) only the lateral condensation technique was used during the period of this survey.

### Follow-up

For each tooth, the following postoperative information was recorded: the treatment and recall period, the presence or absence of signs and symptoms, the presence or absence of apical lesion, and the presence and type of restoration. Only initial, primary, or original endodontic (teeth treated for the first time) or nonsurgical retreatment followed up cases were considered and a review at 18 months or longer was necessary for teeth to be included in this survey. The follow-up sessions were performed with patients who returned to the office in prescheduled periods or needed to go through other endodontic treatments. Among all patients who had returned for recall, 2000 teeth were randomly selected for this survey. All the recorded information from the files was transferred to a computerized database. The clinical follow-up examinations were performed by the primary author (NI). For teeth examined more than once, only the findings of the final examination were considered. Teeth with open apex, injured with luxation, intrusion, extrusion, avulsion, or horizontal fractures, and teeth requiring endodontic surgery were excluded from this study.

### Criteria of Evaluation

The following criteria of the European Society of Endodontology 1994 (11) were used to judge the success rate of root canal therapy: (1) clinical examination: absence of pain, swelling and other symptoms, no sinus tract, and no loss of function and (2) radiographic examination: the periodontal ligament space was normal on the original diagnostic radiograph, and it remained unchanged on recall radiographs, or healing of a radiolucent area visible on the original preoperative radiograph was observed and the periodontal ligament space had returned to normal.

Therefore, cases were considered as failures in the presence of pain, swelling, and sinus tract. Radiographically, failures were identified when a lesion appeared subsequent to endodontic treatment, when a preexisting lesion increased in size, and when a lesion had remained the same or had only diminished in size. Multirooted teeth were assessed according to the root that appeared the worst.

### Radiographic Method and Evaluation

When evaluating treatment results, the first clinical and radiographic examination was performed by the primary author when the 2000 followed cases were randomly selected from patient files recorded by handwriting. After more than 1 year, all cases were again analyzed by the same author, and the recorded information was transferred to a computerized database. The third and final evaluation was done together with a second observer (FJSF) at the end of the survey using a view box with illumination and a viewer with 3× magnification.

**TABLE 1.** Univariate Distribution of Prognostic Factors of the Endodontic Treatment Sample ($n = 2000$)

| Prognostic Factor | | *n* | % |
|---|---|---|---|
| Preoperative | | | |
| Age | <20 | 150 | 7.5 |
| | 20-29 | 300 | 15 |
| | 30-39 | 615 | 30.7 |
| | 40-49 | 499 | 25.0 |
| | 50-59 | 299 | 15.0 |
| | >60 | 137 | 6.8 |
| Gender | Female | 753 | 37.6 |
| | Male | 1247 | 62.4 |
| Tooth location | Maxilla | 1070 | 53.5 |
| | Mandible | 930 | 46.5 |
| Type of tooth | Molars | 1001 | 50.05 |
| | Premolars | 538 | 26.9 |
| | Anteriors | 461 | 23.05 |
| Apical periodontitis | Absent | 1306 | 65.3 |
| | Present | 694 | 34.7 |
| Pulp vitality | Yes | 957 | 47.85 |
| | No | 1043 | 52.15 |
| Treatment modality | Original | 1376 | 68.8 |
| | Retreatment | 624 | 31.2 |
| Intraoperative | | | |
| Treatment session | 1 | 743 | 37.15 |
| | ≥2 | 1257 | 62.85 |
| Complications | No | 1949 | 97.45 |
| | Yes | 51 | 2.55 |
| Filling level | ≥1 | 1536 | 76.8 |
| | 0 | 335 | 16.75 |
| | Overfilled | 129 | 6.45 |
| Postoperative | | | |
| Recall period | 1-24 mo | 192 | 9.6 |
| | 25-36 mo | 270 | 13.5 |
| | 37-48 mo | 234 | 11.7 |
| | 49-60 mo | 181 | 9.05 |
| | >61 mo | 1123 | 56.15 |
| Restoration | Present | 1871 | 93.55 |
| | Absent | 129 | 6.45 |

### Statistical Analysis

The results were analyzed statistically by a Pearson or Fisher exact test and multivariate logistic regression. The univariate descript the data using percentage frequencies. The bivariate associations were tested between the treatment outcomes and pre-, intra-, and postoperative factors by using contingency tables and a chi-square Pearson test of proportions or Fisher exact test. The multivariate analysis evaluated joint associations among various factors by using logistic-regression models. The dependent variable for this analysis was the dichotomous outcome healed versus disease.

All statistical tests were performed as two tailed and interpreted at a 5% significance level. The complete material was analyzed first followed by a stratified analysis according to initial endodontic treatment or nonsurgical retreatment.

## Results

The sample of 2000 teeth was characterized according to pre-, intra-, and postoperative variables in Table 1. Of all 12 investigated factors, the bivariate analysis (Table 2) identified 8 statistically significant associations. However, stepwise logistic regression (Table 3) revealed only five statistically significant factors. The treatment modality was one of them showing higher success rate after initial treatment than nonsurgical retreatment, with an odds ratio of 10.786. The other four significant associations, with a higher healed rate were (1) presence rather than absence of preoperative periapical radiolucency, (2) presence rather than absence of intraoperative complications/accidents,

**TABLE 2.** Prognostic Factors Related to the Success Rate of the Endodontic Treatment Sample ($n = 2000$)

| Prognostic Factor | | *n* | Success (*n*/%) | p Value |
|---|---|---|---|---|
| Preoperative | | | | |
| Apical periodontitis | Absent | 1306 | 1236/94.6 | **0.000** |
| | Present | 694 | 593/85.4 | |
| Pulp vitality | Yes | 957 | 907/94.8 | **0.000** |
| | No | 1043 | 922/88.4 | |
| Treatment modality | Original | 1376 | 1293/94.0 | **0.000** |
| | Retreatment | 624 | 536/85.9 | |
| Intraoperative | | | | |
| Treatment session | 1 | 743 | 704/94.75 | |
| | ≥2 | 1257 | 1125/89.5 | **0.000** |
| Complications | No | 1949 | 1792/91.9 | **0.000** |
| | Yes | 51 | 37/72.55 | |
| Filling level | ≥1 | 1536 | 1419/92.4 | **0.006** |
| | 0 | 335 | 298/89.0 | 0.086 |
| | Overfilled | 129 | 112/86.8 | **0.033** |
| Postoperative | | | | |
| Recall period | 1-24 mo | 192 | 185/96.3 | **0.009** |
| | 25-36 mo | 270 | 247/91.5 | 1.000 |
| | 37-48 mo | 234 | 210/89.7 | 0.320 |
| | 49-60 mo | 181 | 167/92.2 | 0.781 |
| | >61 mo | 1123 | 1020/90.8 | 0.295 |
| Restoration | Present | 1871 | 1719/91.9 | **0.014** |
| | Absent | 129 | 110/85.3 | |

Bold font highlights statistical significance.

(3) recall period between 18 and 24 months rather than other periods, and (4) presence rather than absence of coronal restoration.

Of the 1376 teeth treated in the original treatment sample, the success rate was 94.0%. Stratified bivariate analysis (Table 4) identified four statistically significant associations (pulp status, number of sessions, complications/accidents, and coronal restoration). Multivariate analysis (Table 5) identified the presence of accidents as well as the absence of the restoration at follow-up as the significant predictors of outcome, showing lower success rates.

Of the 624 teeth in the nonsurgical retreatment sample, the success rate was 85.9%. The stratified bivariate analysis (Table 6) identified five statistically significant associations: age, tooth type, periradicular status, accidents, and recall period. Stepwise logistic regression analysis (Table 7) revealed that preoperative radiolucency was a strong statistically significant factor, with odds ratio of 16.607. Two additional variables (age and tooth type) were associated with statistically significant associations. A higher healed rate was observed for the 50 to 59 age groups than others, whereas multirooted (molars) teeth revealed a significantly lower percentage of success than premolars and anterior teeth.

**TABLE 3.** Stepwise Logistic Regression Analysis ($n = 2000$)

| Prognostic Factor | Ajusted Odds Ratio | 95% CI | p Value |
|---|---|---|---|
| Restoration (absent = 0/ present = 1) | 11.225 | 1.482-4.487 | **0.001** |
| Treatment (retreat = 0/ original = 1) | 10.786 | 1.351-3.288 | **0.001** |
| Periradicular status (with lesion =0/normal = 1) | 13.769 | 1.580-4.405 | **0.000** |
| Recall period 1-24 months | 6.062 | 1.222-5.830 | **0.014** |
| Complications (yes = 1/no = 0) | 20.310 | 2.286- 8.160 | **0.000** |

Bold font highlights statistical significance.

CI = confidence interval.

**TABLE 4.** Prognostic Factors Related to the Success Rate in the Original Treatment Sample ($n = 1376$)

| Prognostic Factor | | *n* | Success (*n*/%) | p Value |
|---|---|---|---|---|
| Preoperative | | | | |
| Pulp | Yes | 956 | 907/94.9 | **0.037** |
| Vitality | No | 420 | 386/91.9 | |
| Intraoperative | | | | |
| Treatment | 1 | 602 | 580/96.3 | **0.001** |
| Sessions | ≥2 | 774 | 713/92.1 | |
| Complications | No | 1342 | 1267/94.4 | **0.001** |
| | Yes | 34 | 26/76.5 | |
| Postoperative | | | | |
| Restoration | Present | 1277 | 1206/94.4 | **0.014** |
| | Absent | 99 | 87/87.9 | |

Bold font highlights statistical significance.

## Discussion

In this retrospective study, initial endodontic treatment and nonsurgical retreatment cases were performed by one specialist in his private office, and the majority of the patients were referred from general clinicians and prosthetic specialists. Therefore, all information regarding pre-, intra-, and posttreatment data was recorded in details.

When the findings observed in this work are compared with those of previous studies, differences in assessment criteria and composition of material must be considered. According to the clinical and radiographic findings of the present study, the overall endodontic success rate was 91.45%, which is similar to that obtained by previous studies (2, 12), including both treatment and nonsurgical retreatment cases. Because there are fundamental differences in prognosis between initial treatment and nonsurgical retreatment, the total material was reanalyzed after grouping of the cases based on the treatment modality.

The analysis of the total material revealed that very few variables affected the treatment outcome. The multivariate logistic regression identified only five significant variables that are discussed later.

The success rate was higher after the initial treatment than retreatment, as previously shown by Sjogren et al (2) in 1990 and Friedman et al (12) in 1995. Nonsurgical root canal retreatment will frequently require the removal of a customized or prefabricated intraradicular post or dowel, silver points, gutta-percha cones, or other foreign objects before the canals can be cleaned and shaped. Removal of the filling material from the apical portion requires specific consideration because care must be taken to avoid ledging, perforating, or stripping the canal during this procedure. In addition, retreatment is undertaken when endodontic therapy has failed. It has been suggested that the poorer prognosis in root canal retreatments may be associated with difficulties in the elimination of the particular microflora in such cases (13). The latter can be characterized as monoinfections predominantly caused by gram-positive microorganisms, in particular *Enterococcus faecalis* (13, 14). Considering all these difficulties, this work showed a markedly lower incidence of success in retreated teeth than in initial endodontic treatment. However, it is important to notice that the success rates for both initial treatment (94.0%) and retreatment (85.9%) in the present study were higher than that reported by university-based studies, 81% to 86% for initial treatment (15, 16) and 81% for nonsurgical retreatment (17). Alley et al (8) in 2004 have previously reported that endodontic treatment performed by specialists was more successful.

Considering preoperative variables, another factor of significant impact was the presence of lesion, confirming its adverse influence on treatment outcome (2, 12). When the total data of this work were analyzed, the success rate dropped from 94.6% to 85.4% in the presence of periapical lesion.

**TABLE 5.** Stepwise Logistic Regression Analysis ($n$ = 1376)

| Prognostic Factor | Ajusted Odds Ratio | 95% CI | P Value |
|---|---|---|---|
| Restoration (absent = 0/present = 1) | 11.185 | 1.632-6.524 | **0.001** |
| Complications | 11.425 | 9.326E-02-0.532 | **0.001** |

Bold font highlights statistical significance.

CI = confidence interval.

Intraoperative complications had a significant negative impact on treatment outcome, confirming previous findings (16), even though the incidence of complications was lower in the present study (2.5%). Procedural errors may prevent the control and prevention of intracanal infection, resulting in endodontic failure (18). Among the 51 complications reported, 11 were file breakage that led to 3 failures (27.3%), 18 were perforations with 7 failures (38.9%), and 22 were flare-ups with 4 failures (18.2%). Usually, the latter failures occurred in infected teeth, especially when these cases exhibited periapical radiolucent areas (19). Moreover, perforated teeth showed a high failure rate, bearing in mind that the prognosis of perforation depends on factors such as time lapsed before defect repair, adequacy of perforation seal, and location and size of perforation.

Considering postoperative variables, the outcome was poorer when teeth had not been permanently restored. Although the mean time for the placement of restorations was not possible to be considered, teeth that did not have permanent restoration placed during the follow-up interval showed a higher percentage of failure. This fact lends credibility to the philosophy of the importance of the coronal restoration in successful endodontic outcomes, which agrees with many studies (5, 18, 20-22) and contradicts others (23, 24). However, it is important to note that the survival rate of endodontically treated teeth can be affected by the type of prosthodontic restoration (25).

In relation to recall time intervals, the recall period of 18 to 24 months showed a higher success rate with a statistically significant difference than the longer recall period groups. This was because of the fact that if the tooth was free of signs and symptoms and presented normal periapical appearance, it was classified as successful and recorded. On the other hand, if there was any doubt of success, the patient was reexamined later in another appointment. Therefore, for teeth examined more than once, only the data obtained during the final examination were considered. Overall, it has been suggested that a shorter recall period (18/24 months) is enough to evaluate the success rate in teeth without lesion (7, 12, 26). However, in the presence of lesions, a long recall period (2-5 years) seems to be needed to evaluate the success of the treatment (1-4). A larger number of patients (51%) were recalled after 5 years and contradicting Benenati and Khajotia (6), this factor had no influence on the outcome of endodontic therapy.

The results for the initial endodontic treatment group were quite similar to those for the total data because they accounted for more than 68% of the cases examined (1376/2000). The present multivariate analysis identified intraoperative complications and posttreatment restoration as significant predictors of outcome. However, the impact of the periapical status in the outcome of the initial endodontic treatment was not confirmed either by bivariate analysis neither by multivariate analysis. This may be because of a small number of cases with apical periodontitis in the sample studied (290/1376). Another possible explanation would be that all cases were treated by a specialist and were original endodontic treatments with no previous iatrogenic errors. Hence, the removal of vital or necrotic pulp (even in the presence of lesion) was easily done. Sjögren et al (2) suggested that the prognosis for initial endodontic treatment of necrotic teeth with periapical lesions was as good as that for vital teeth when the instrumentation and filling of the root canal could be carried out to an optimal level.

When analyzing the nonsurgical retreatment group, the success rate in the presence of lesions was significant lower than without lesions, confirming the adverse influence of preoperative apical periodontitis on the outcome (9, 13, 17). Recently, Sathorn et al (27), in a review article, reported that causes other than intraradicular infections may be responsible for persistent lesions such as extraradicular infection, generally caused by periapical actinomycosis (28, 29); foreign body reactions because of extruded root canal fillings or other materials (30, 31); and true cysts, especially with massive accumulation of cholesterol crystals in periapical lesions (32-34). It should be noted that, in some cases, unresolved periapical radiolucencies may occasionally be caused by healing by scar tissue, which could be mistaken for a sign of failed endodontic treatment (34). The latter factors cannot be managed by orthograde endodontic treatment (27).

The results for the retreatment group were further influenced by tooth type and by age. Although the type of tooth showed no significant

**TABLE 6.** Prognostic Factors Related to the Success Rate in the Nonsurgical Retreatment Sample ($n$ = 624)

| Prognostic Factor | | $n$ | Success ($n$/%) | p Value |
|---|---|---|---|---|
| Preoperative | | | | |
| Age | <20 | 25 | 24/96.0 | 0.235 |
| | 20-29 | 69 | 52/75.4 | **0.015** |
| | 30-39 | 218 | 187/85.8 | 1.000 |
| | 40-49 | 179 | 153/85.5 | 0.899 |
| | 50-59 | 100 | 94/94.0 | **0.011** |
| | ≥60 | 33 | 26/78.8 | 0.208 |
| Tooth type | Molars | 251 | 207/82.5 | **0.047** |
| | Premolars | 190 | 166/87.4 | 0.533 |
| | Anteriors | 183 | 163/89.0 | 0.165 |
| Apical Periodontitis | Absent | 220 | 208/94.5 | **0.000** |
| | Present | 404 | 328/81.2 | |
| Intraoperative Complications | No | 607 | 525/86.5 | **0.022** |
| | Yes | 17 | 11/64.7 | |
| Postoperative | | | | |
| Recall period | 18-24 mo | 65 | 61/93.8 | **0.022** |
| | 25-36 mo | 93 | 75/80.6 | 0.144 |
| | 37-48 mo | 63 | 52/82.5 | 0.444 |
| | 49-60 mo | 58 | 51/87.9 | 0.843 |
| | ≥ 61 mo | 345 | 297/86.1 | 0.908 |

Bold font highlights statistical significance.

**TABLE 7.** Retreatment Stepwise Logistic Regression Analysis ($n$ = 624)

| Prognostic Factor | Ajusted Odds Ratio | 95% CI | p Value |
|---|---|---|---|
| Periradicular status (with lesion = 0/normal = 1) | 16.607 | 2.057-7.834 | **0.000** |
| Age (other = 0/50-59 = 1) | 5.706 | 1.320-1.6651 | **0.017** |
| Tooth type (other = 0/molar = 1) | 6.302 | 0.196-0.818 | **0.012** |

Bold font highlights statistical significance.

CI = confidence interval.

difference in earlier tables, the multirooted (molars) teeth in the nonsurgical retreatment sample had a significantly lower percentage of success than premolars and anterior teeth, in agreement with a previous study (12). It is conceivable that the anatomy of molar teeth presented a greater challenge for elimination of root canal infection, especially in nonsurgical retreatment cases. This difference could also be attributed to the triple probability of disease in molars because the evaluation of success was assessed according to the worst root. Regarding age, multivariate analysis of the retreatment group suggested higher percentage of success in the 50 to 59 age group. Even though similar observations have been reported by Ørstavik et al (9), no explanation could be offered for this result.

Although bivariate analysis showed the negative impact of intraoperative complications on the outcome of retreatment cases, in the logistic regression analysis such complications had no significant effect. Probably a much larger sample would be required to statistically substantiate the impact of this factor on outcome (18). Similarly, the number of cases without restorations was low within the retreatment group (30/624). The prognostic importance of the latter factors on the outcome of the retreatment cases requires further investigation.

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