

Factors Affecting Outcomes for Single-Tooth Implants and Endodontic Restorations

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Abstract

Initial root canal therapy and implant placement are both common treatment modalities, and, as such, prognostic factors that influence the treatment outcomes of these two restorations should be identified. In a retrospective chart review, 196 implant restorations and 196 matched initial nonsurgical root canal treated (NSRCT) teeth in patients were evaluated for four possible outcomes—success, survival, survival with intervention, and failure. Results showed that smokers had fewer successes and more failures in both groups ($p = 0.0001$), whereas NSRCT outcomes were affected by periradicular periodontitis ($p = 0.001$), post placement ($p = 0.013$), and overfilling ($p = 0.003$). Outcomes for both groups were not significantly affected by diabetes, age, or gender. Implant group outcomes were not affected by implant length (from 10 to 16 mm), diameter (from 3.25 to 5.5 mm), or an adjacent endodontically treated tooth, nor were NSRCT outcomes affected by the number of appointments for the procedure. (*J Endod* 2007;33:399–402)

Key Words

Diabetes, endodontic, implant, outcomes, smoking

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Lack of oral health care can result in extensive caries. In these cases, restoration of a patient's poor oral health status often requires endodontic therapy, or even tooth extraction and placement of a single-tooth implant. To provide optimal dental treatment planning, an accurate assessment of the likely outcome of any potential treatment modality is required. When such an assessment is made, it is possible to offer the patient appropriate treatment options (1). It is also important to identify prognostic factors that may influence the outcome of the treatment selected. These factors may vary in their effect on the outcome of each of these treatments. Earlier work on factors affecting endodontic outcomes show no significant difference in outcome based on patient age, gender, or systemic health (2). Recent reports, however, suggest that diabetic patients may have poorer outcomes in teeth with preoperative apical periodontitis (3, 4), and that smoking may be a risk indicator for apical periodontitis (5). Other factors such as preoperative apical periodontitis, length of obturation, number of appointments, and post placement have been suggested as affecting endodontic outcomes. For implant outcomes, adult age, gender, or controlled diabetes do not seem to affect outcome. Patients who are immunosuppressed or who are smokers, however, do seem to have higher implant failure rates (6–8). Other factors such as implant length, width, or the presence of an adjacent endodontically treated tooth have also been suggested as affecting implant outcomes. The purpose of this study was to evaluate some of the factors thought to affect outcomes for single-tooth implants or endodontic restorations.

Methods and Materials

Data for this study were obtained from charts of patients treated at the University of Minnesota School of Dentistry. Expedited approval was obtained from the University of Minnesota's Institutional Review Board. A clinic database was used to identify all patients treated with single-tooth implant restorations within the 10-year period between January 1993 and December 2002. From a total of approximately 2,000 charts of patients receiving implant therapy, 405 implant restorations fit the preliminary inclusion criteria. From this group, a subset of patient charts was collected, consisting of restored implants with at least 1-year recall or those that had an untoward event prior to restoration. Each restored implant that met inclusion criteria had a matched endodontically treated tooth chosen as follows. For an implant restoring tooth number X (using the universal system 1-32), three potential matches were randomly chosen by using the clinic database, according to ADA codes, from among charts where tooth X was endodontically treated. These three endodontic charts were consecutively evaluated until a subject met inclusion criteria; this subject was included as the match and information from the chart was recorded. A total of 196 single-tooth implants in 171 patients and 196 endodontic restorations in 196 patients were evaluated.

Inclusion criteria for the implant group were age of 18 years or older and history of a single tooth implant surgery and subsequent restoration at the University of Minnesota. All implants were surgically placed by staff or resident oral surgeons or periodontists, and restored by staff or resident prosthodontists. The treatment consisted primarily of two-stage treatment, but one-stage and immediate placement procedures were also included. Each included implant was a single-tooth restoration supported by a single implant, with at least one adjacent natural tooth. The 1-year recall period was defined from the time of function, i.e., the time of placement of the final coronal restoration. Untoward events requiring subsequent treatment intervention, including

prosthetic complications, adjunctive surgical procedures, or removal of the implant, that occurred prior to the 1-year recall were recorded for analysis.

Inclusion criteria for the endodontic group were 18 years of age or older and history of an initial nonsurgical root canal treatment (NSRCT) followed by subsequent coronal restoration. Dental students, graduate residents, or staff clinicians performed all endodontic treatment. Each endodontically treated tooth had to have at least one adjacent natural tooth. The 1-year recall period was defined from the time of function, i.e., at the completion of root canal treatment. Untoward events requiring subsequent treatment intervention, including retreatment and extraction, that occurred prior to the 1-year recall were recorded for analysis. Cases of uncertain or incomplete healing were documented and classified accordingly in the “survival” outcome measure (defined below).

The data were then refined into subsets to be analyzed, which included only cases in which initial procedures had greater than 1-year follow-up, or those in which an adjunctive procedure was initiated prior to the 1-year recall period. Recorded clinical and radiographic data were interpreted by a single investigator (S.L.D.) to form an assessment outcome of success, survival with or without subsequent treatment intervention, or failure, using the criteria that follow.

Implants were considered “successful” if radiographic and recorded clinical data demonstrated that the implant was present in the mouth and functional at the time of recall without definite signs of absolute failure, such as peri-implant radiolucency or implant mobility. Implants were considered to be “surviving” if present in the mouth with subsequent posttreatment intervention or adjunctive procedures. “Failure” was assumed if the implant was removed or planned for removal.

Endodontically treated teeth were considered “successful” if radiographic and recorded clinical data demonstrated that the tooth was present in the mouth without the presence of apical periodontitis or symptoms. For assessing survival, the periapical index (PAI) was used to evaluate the presence or absence of apical periodontitis following treatment. The PAI is an accurate and reproducible method that minimizes variability and bias and has been designed for and used in clinical trials (9) and epidemiologic surveys (10). The PAI is an ordinal scale ranging from 1 (healthy) to 5 (severe apical periodontitis with exacerbating features). The presence of apical periodontitis was considered absent or minimal if a low score (PAI = 1-2) was given, whereas higher scores were deemed to represent greater severity of apical periodontitis (11). Endodontically treated teeth were considered to be “surviving” if present in the mouth, including those with uncertain healing (PAI ≤ 3) or evidence of healing since treatment, and those that had subsequent posttreatment intervention. “Failure” was assumed if the tooth was extracted or planned for extraction.

Patient characteristics came from the patient charts. Smoking and diabetes were assessed using “yes/no” self-reports. Collected data included the determination between Type I and Type II diabetes. Patient age and sex, as well as the length and width of the implant, the presence of an endodontically treated tooth adjacent to the implant, the presence of preoperative apical periodontitis, the length of obturation (overfill = material beyond radiographic apex, adequate = material 0-2 mm from radiographic apex, underfill = material >2 mm from radiographic apex), number of endodontic appointments, and post placement were all recorded from the patient charts and radiographs.

Statistical Methods

When simultaneously testing the association of the group (endodontic vs. implant) and another variable (e.g., diabetes) with outcome, we used ordinal polytomous regression—like logistic regression, except the dependent variable has more than two categories that

TABLE 1. Frequency of success and failure by treatment and smoking status

Treatment	Smoker	n	Fraction success	Fraction failure
Endodontic	No	158	0.860	0.030
Endodontic	Yes	38	0.662	0.192
Implant	No	186	0.748	0.050
Implant	Yes	10	0.485	0.271

fall into a natural order (success/survival/survival with intervention/failure)—with likelihood ratio tests. One-way analysis of variance (ANOVA) using outcome (success/survival/survival with intervention/failure) as the grouping variable was used to determine the association with the outcome of implant width, implant length, and number of endodontic appointments.

Results

Several factors affected both groups similarly, whereas other factors are relevant only to the endodontic group or the implant group. To determine whether smoking is associated with the outcome of patients undergoing NSRCT and single-tooth implant restorations, we examined the association between smoking and outcome (Table 1). Ignoring the treatment group for the moment, smokers tended to have more failures (p = 0.0001), with 21% of smokers experiencing treatment failure, whereas only 4% of the nonsmokers experienced treatment failure (these fractions are from combining smoker vs. nonsmoker rows in Table 1). The endodontic group had a higher fraction of smokers than the implant group (19.4% vs. 5.1%, p < 0.0001). A combined analysis testing the effects of treatment group and smokers simultaneously found both treatment group and smoking were related to outcome (p < 0.0001 and p = 0.0007, respectively). To interpret these tests, consider Table 1, where the subjects are broken into categories according to both treatment group and smoking status. Table 1 shows that for both smokers and nonsmokers, the endodontic group had fewer failures than the implant group. Similarly, for both the endodontic and implant groups, smokers had more failures than nonsmokers.

The effect of age and gender on the treatment outcome of initial NSRCT followed by coronal restoration or single-tooth implant restorations was compared. The endodontic and implant groups had similar fractions in each gender (p = 0.36), whereas the endodontic group tended to be older than the implant group (53.9 vs. 47.5 years). A combined analysis was done testing group, sex and age simultaneously (using ordinal polytomous regression with likelihood ratio tests). Sex was not related to outcome (p = 0.84), nor was age (p = 0.064).

To evaluate whether diabetes was associated with the outcome of patients undergoing NSRCT and single-tooth implant restorations, we examined the association between diabetes and outcome. First, ignoring the treatment group, the four-category outcome (success/survival/survival with intervention/failure) was borderline significantly related to diabetes (p = 0.063; Pearson’s χ^2 test). The treatments undertaken in diabetics were more likely to fail, though this did not reach the 0.05 significance threshold. For analysis, a yes/no diabetes test was used, because there was only one Type I diabetic in the study sample, and the results were similar when Type I and Type II were separated. There were more diabetics in the endodontic group compared to the implant group (22 vs. 3 patients; p = 0.0001). A combined analysis was done testing group and diabetes simultaneously (using polytomous regression with likelihood ratio tests), resulting in diabetes appearing as a less significant factor (p = 0.15).

Some factors evaluated that might affect only the endodontic group included the presence of periradicular periodontitis, length of obturation, post placement, and number of appointments. Table 2 presents

TABLE 2. Outcome of endodontically treated teeth according to presence of preoperative periradicular periodontitis

Outcome	Preoperative periradicular periodontitis	
	No	Yes
Success	86.6%	75.3%
Survival	2.5%	16.9%
Survival with intervention	2.5%	5.2%
Failure	8.4%	2.6%
Total	119 teeth	77 teeth

data relevant to whether preoperative periradicular periodontitis affects the outcome of initial NSRCT. Teeth with preoperative periradicular periodontitis are more likely to survive and less likely to either succeed or fail ($p = 0.001$).

The effect of obturation length on the outcome of initial NSRCT (overfilled, underfilled, adequate) was also examined (Table 3). When compared to adequate length of obturation, overfilling was associated with less success and more mere survival, whereas underfilling was associated with more success and less of the other three outcomes ($p = 0.003$).

To determine the effect of post placement on the outcome of initial NSRCT (Table 4), we compared outcomes for endodontically treated teeth restored with and without posts. The endodontically treated teeth with posts were less likely to succeed, about equally likely to fail, and more likely to merely survive ($p = 0.014$).

The association of the number of appointments with the outcome of initial NSRCT was examined, with outcome as the independent variable. A comparison of the four possible outcomes according to the number of appointments revealed no association with outcome using one-way ANOVA ($p = 0.69$).

Factors evaluated that could affect only the implant group included the presence of an adjacent endodontically treated tooth and the length and width of the implant. Table 5 presents data relevant to whether adjacent teeth with NSRCT are associated with the outcome of single-tooth implant restorations (i.e., considering the implant group only). The presence of adjacent endodontically treated teeth was not associated with the outcomes of implant treatment ($p = 0.42$).

To determine the association of implant length and diameter with the outcome of implants, we compared implants having the four possible outcomes according to their average implant widths and lengths. All the implants used within this set of patients were 10 to 16 mm long, and 3.25 to 5.5 mm wide. Within these ranges, neither length nor width shows an association with outcome ($p = 0.69$ for length, $p = 0.56$ for width).

Discussion

Our previous study using this data set found a 6.1% failure rate for both endodontic and implant groups, with a higher proportion of implants having the “survival with intervention” outcome (12). For both

TABLE 3. Outcome of endodontically treated teeth related to length of obturation

Outcome	Length of obturation		
	Overfilled	Underfilled	Adequate
Success	60.0%	94.4%	81.4%
Survival	33.3%	0%	7.6%
Survival with intervention	0%	5.6%	3.5%
Failure	6.7%	0%	7.6
Total	15 teeth	36 teeth	145 teeth

TABLE 4. Outcome of endodontically treated teeth with posts

Outcome	Post placed?	
	No	Yes
Success	84.5%	73.2%
Survival	5.2%	19.5%
Survival with intervention	4.5%	0%
Failure	5.8%	7.3%
Total	155 teeth	41 teeth

groups, the rates of outright failure were low, consistent with previous reports in the endodontic literature (13–16) and implant literature (17, 18).

Interestingly, the present study found an association of smoking with outcome for both groups. The literature suggests that smoking may be a risk factor in the outcome of implant treatment (7, 19) and in endodontic outcomes in some (5, 20) but not all studies (21). Unfortunately, these and our results cannot establish causation. In addition, the amount of smoking and the total time of patient smoking cannot be determined retrospectively. Several studies have shown that cigarette smoking can be associated with higher implant failure rates, complications, and altered soft tissue conditions (8, 22). Previous literature suggests smokers show approximately twice the number of implant failures compared with nonsmokers (18, 23). The comparative incidence of implant failure in smokers versus nonsmokers has been evaluated in trials with the following results: 11.28% versus 4.28% (7), and 31% versus 4% (8). When assessing the effect of smoking on implant loss (18), smokers had an 11% loss and nonsmokers had a 5% loss (7, 8).

Other variables were found to have no association with the outcome of treatment for the two groups. We found no association of age or gender with the outcome of either the implant or endodontic group. We also found no association of diabetes with outcome for both groups. This is in disagreement with reports in the endodontic literature (3, 4), although these studies considered only teeth demonstrating apical periodontitis. The present study did not attempt to simultaneously relate outcome with diabetes and apical periodontitis. The lack of association of diabetes with outcome for the endodontic group is in agreement with some reports (22), although these conclusions are based on well-controlled diabetics; we did not assess extent of diabetes control.

For factors evaluated only in the endodontic group, the presence of preoperative periradicular periodontitis was associated with the outcome. Specifically, fewer successes were noted. This agrees with the endodontic literature (15, 24–26). In general, when teeth without apical periodontitis are treated, the status of the pulp does not significantly influence the outcome (13). It has been reported that teeth with vital pulps have a better outcome than those with necrotic pulps (1, 25, 27). In the absence of apical periodontitis, many studies show no difference (15, 26, 28). Elimination, or at least significant reduction, of bacteria may produce results similar to those expected

TABLE 5. Outcome of implants according to presence of adjacent endodontically treated teeth

Outcome	Presence of adjacent endodontically-treated tooth	
	No	Yes
Success	71.3%	84.4%
Survival	3.0%	0%
Survival with intervention	18.9%	12.5%
Failure	6.7%	3.1%
Total	164 implants	32 implants

when noninfected canals are treated. One factor that consistently has proved to significantly influence the treatment outcome is the presence of apical periodontitis (1).

The length of the obturation in the endodontic group was also shown to be associated with the outcome. When evaluating the length, "adequate" was determined when the obturation was 0 to 2 mm from the radiographic apex. With short obturation (>2 mm from radiographic apex), the endodontic group had more successes.

Endodontically treated teeth with posts compared to those without posts were less likely to succeed, about equally likely to fail, and much more likely to merely survive ($p = 0.014$). A recent report suggests that teeth restored with posts are at higher risk for failure when used as abutment teeth (29). In addition, the number of appointments is not associated with the outcome in the endodontic group.

For factors evaluated only in the implant group, the presence of an adjacent endodontically-treated tooth was not associated with the outcome of implants. Although previous studies (30, 31) have shown that shorter implants (e.g., 7 mm) tend to have worse outcome, all the implants within this study were 10 to 16 mm long and 3.25 to 5.5 mm wide. The length and width of the implant (within the ranges examined) did not affect the implant outcomes, but previous reports including much shorter and more widely varying diameters of implants have shown association with failure rates (30–32). In a review of implant complications (18), a 10% implant loss was identified with implants ≤ 10 mm in length, whereas ≥ 10 mm in length had a 3% loss (33). Width of the implant has also been implicated in affecting implant outcomes, with implants < 4 mm in diameter showing lower mean survival rates (30).

With such high survival rates, both implant and endodontic restorations are sound options when required. Selection of either treatment should be based on many factors, including time to function, postoperative complications, and other prognostic factors that affect survival. Although most factors can be identified before treatment, several are only identifiable after treatment (i.e., length of obturation, post placement). All patients who smoke should be counseled to quit smoking and have explained to them that the success rate of either of these treatment options decreases in patients who smoke.

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