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# Endodontic Therapy or Single Tooth Implant? A Systematic Review

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**ABSTRACT** Should a tooth with pulpal involvement be saved through endodontic therapy, or extracted and replaced with a single tooth implant? Within the limitations of the existing literature, this systematic review of treatment outcomes found that initial endodontic treatment had a high long-term survival rate, equivalent to replacement of a missing tooth with an implant-supported restoration. Single tooth implants should be considered as the first treatment option for patients requiring extraction and tooth replacement.

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For decades, a primary goal of dentistry has been the preservation of natural dentition. Previously, all efforts would have been made to save teeth, even those severely compromised by caries, pulpal and periodontal diseases. The palpable benefits of dental implants have caused a paradigm shift in treatment planning. The risks and benefits of saving compromised teeth may be outweighed by those associated with extraction and replacement. Clinicians and their patients are sometimes confronted with difficult choices. For example, should a tooth be saved through endodontic therapy or should it be extracted with a single implant? According to the principles of evidence-based practice, as defined by the American Dental Association, such treatment decisions should be based in part on the information from clinical investigations that have evaluated the biological, psychosocial and/or economic outcomes, as well as beneficial or harmful effects of these treatments.[1]

Acquiring complete, unbiased information to help dentists and their patients make such choices requires a systematic review of the literature related to the outcomes of the alternative procedures. A systematic review is a synopsis of the existing evidence on a specific topic and it differs from a narrative literature review.[2] Systematic reviews provide a means for practitioners to keep up with the numerous articles published annually in every health care field. A systematic review concentrates on a very specific, clinically relevant question. In contrast, a narrative literature review covers various aspects of a clinical or nonclinical subject. A systematic review provides an unbiased synopsis of the existing evidence for the specific question.[2]

Clearly, a systematic review that presents synopses of the outcomes of endodontic care and its alternative treatments for a tooth with pulpal pathosis would aid clini-

cians in their evidence-based decision-making. The current lack of such information is reflected in the inclusion of this subject in the ADA Foundation's Request for Proposals related to Systematic Reviews to Support Evidence-based Dentistry and Dental Research. This article, which was supported by the ADA Foundation's RFP, describes a systematic review of the outcomes of endodontic therapy and single tooth implant.

A complete description of a systematic review regarding the outcomes, beneficial and harmful effects of endodontic care, extraction and implant placement, fixed partial denture and extraction without implant placement has recently been published elsewhere in the literature.[3] The purpose of this paper is to summarize the clinically relevant findings of the prior much longer publication with respect to the comparison of the outcomes of endodontic therapy and single tooth implants.

## Methods

The development of a systematic review encompasses eight critical steps: 1) formulating review questions in PICO format; 2) defining inclusion and exclusion criteria; 3) locating studies; 4) selecting studies; 5) assessing quality of studies; 6) extracting data and forming an evidence table; 7) analyzing data; and 8) interpreting the evidence.[4]

### FORMULATING THE REVIEW QUESTIONS

A well-formulated clinical question that provides the basis of a systematic review identifies four crucial population, intervention, comparison, and outcome (PICO) elements.[5]

Based on this concept, one of the questions in the ADA Foundation's RFP was restated in the PICO format as follows: "In patients with periodontally sound teeth who have pulpal and/or periradicular pathosis, does initial root canal therapy, compared to extraction and replacement of the missing tooth with an implant result in better (more beneficial) or worse (more harmful) biological, clinical, psychosocial and/or economic outcomes?"

### INCLUSION AND EXCLUSION CRITERIA

All comparative or noncomparative, prospective or retrospective English language articles describing clinical, biological, psychosocial, and/or economic outcomes, as well as beneficial or harmful effects of endodontic therapy and single tooth implant treatment were included. The population was limited to adults with a permanent tooth receiving initial nonsurgical endodontic therapy, or extraction with, or single-unit threaded-cylinder implant (regardless of surface type).

**TWO SPECIALISTS** and two residents (one each from each discipline) independently screened the titles and abstracts of all articles identified in the electronic and hand searches.

Studies were eligible for inclusion if they reported at least 25 cases with a minimum two-year follow-up (endodontics - from obturation time; implant - from placement); with treatment units described as being single individual, implant-supported restorations, and/or endodontically treated teeth (not individual roots). Studies were excluded if they failed to meet any of the above inclusion criteria, if they did not define criteria for success/survival outcomes, if they reported on treatments no longer used in practice, or if the patients were described as having moderate or severe periodontal disease.

### SEARCH STRATEGY AND PERFORMING THE SEARCH (LOCATING STUDIES)

Searches identified articles in MEDLINE, EMBASE, and the Cochrane database from the inception of the database through December 2006 when possible. Before the search was performed, 10 core articles were designated that, if identified in the search, would validate its accuracy.[3] Those journals identified as containing the top 80 percent of the relevant articles were hand searched for the most recent two years. Hand searching included consideration of references in the identified articles as well as references in relevant textbooks. A second search was performed for each of the two disciplines to retrieve results on psychosocial outcomes. Due to limitations of the available literature regarding economic outcomes the searches pertaining to this aspect were limited to hand searches, citation mining, and expert recommendations.

### SELECTING STUDIES

Two specialists and two residents (one each from each discipline) independently screened the titles and abstracts of all articles identified in the electronic and hand searches. Included articles were photocopied and reviewed by the members of the teams independently in the second stage of the process. In case of disagreement at either step, consensus was reached based on a predetermined protocol for resolving disagreements between reviewers.[4] An external review committee, consisting of four experts, two from each discipline, reviewed the final list and made sure that key studies related to these subjects were not missed.

### ASSESSING QUALITY OF STUDIES

A 31-item data abstraction form was developed that included basic information regarding the study design and outcomes. From items related to the study design,

an overall study quality rating score was developed with each article receiving a quality score with a maximum possible 17 points.[6,7]

### EXTRACTION OF DATA AND FORMING A TABLE OF EVIDENCE

The members of each team independently extracted data and formed a table of evidence from articles that met the inclusion and exclusion criteria. The external review committee reviewed and approved the final evidence tables. Their task was to make sure the search did not miss any key study, that included studies met the inclusion criteria, and that the elements of the studies critical to an assessment of quality in each discipline were abstracted. Outcomes were reported by the included studies in a variety of formats, including crude and cumulative estimates of success, failure, and survival. Success was defined by varying criteria both within and across treatment options. Reviewers calculated appropriate rates when the data were available. In some instances where it was impossible to determine if a reported rate was crude or cumulative, it was treated as though it was cumulative. Crude survival rates are simply computed as 100 percent minus the percentage not surviving; whereas, cumulative survival is the proportion of cases surviving up to the respective time interval, this probability is computed by multiplying out the probabilities of survival across all previous intervals. This distinction becomes important in situations where failure rates differ over time.

### DATA ANALYSIS

Clinical outcomes were grouped into three follow-up intervals: two to four years; four to six years; and more than six years. Individual studies were displayed in a Forest Plot with Wilson Score 95 percent confidence intervals.[8,9] Meta-analyses created pooled point estimates of success and survival using two approaches, the DerSimonian-Laird random pooling method and simple weighting. Because of the variability of the information in the articles addressing psychosocial and economic outcomes, these outcomes could only be described in narrative review format.

**TABLE 1**

**Pooled (Simply Combining) and Weighted (Factoring in Sample Sizes) Survival and Success Rates of Dental Implants and Endodontic Therapy at Two to Four, Four to Six, and More Than Six Years**

| 2-4 year | Success | Survival |
|---|---|---|
| Dental implant (pooled) | 98 (95-99) | 95 (93-97) |
| Dental implant (weighted) | 99 (96-100) | 96 (94-97) |
| Endodontic therapy (pooled) | 90 (88-92) | 94 |
| Endodontic therapy (weighted) | 89 (88-91) | - |
| **4-6 year** | **Success** | **Survival** |
| Dental implant (pooled) | 97 (96-98) | 97 (95-98) |
| Dental implant (weighted) | 98 (97-99) | 97 (95-98) |
| Endodontic therapy (pooled) | 93 (87-97) | 94 (92-96) |
| Endodontic therapy (weighted) | 94 (92-96) | 94 (91-96) |
| **6+ year** | **Success** | **Survival** |
| Dental implant (pooled) | 95 (93-96) | 97 (95-99) |
| Dental implant (weighted) | 95 (93-97) | 97 (96-98) |
| Endodontic therapy (pooled) | 84 (82-87) | 92 (84-97) |
| Endodontic therapy (weighted) | 84 (81-87) | 97 (97-97) |

## Results

### QUANTITY AND QUALITY OF THE EVIDENCE

The preliminary electronic and manual searches identified 5,346 endodontic and 4,361 dental implant studies. After title and abstract screening, full articles for 347 endodontic studies and 327 dental implant studies were retrieved. Following full-text review, 24 endodontic, and 46 implant studies were included.[10-79] A total of 26 studies regarding psychosocial effects of the treatment options were identified.[30,36,41,52,63,66,70-72,80-95] Only three articles addressing economic outcomes of treatment options were found.[41,87,93]

Lower quality case series analyses dominated the included articles. Most studies were of less than six years duration. The mean (±sd) quality rating scores of included papers was 10(±2) for endodontic studies and 7(±2) for papers describing implant studies.

### BIOLOGICAL OUTCOMES

The authors' searches did not locate any comparative or noncomparative articles regarding the biological outcomes and/or biological beneficial and harmful effects of initial nonsurgical endodontic care compared to extraction and placement of implant.

### CLINICAL OUTCOMES

Calculated means for short, medium, and long-term success rates for dental implants were 3-11 percent higher than those for endodontic treatments (**TABLE 1, FIGURES 1 AND 2**). Short, medium, or long-term pooled survival rates of

dental implants were somewhat higher (0-5 percent) than those of endodontic treatments (**TABLE 1, FIGURES 2, AND 4**). Weighted long-term survival was essentially the same (97 percent) for implant and endodontic treatments (**TABLE 1**).

A majority of the implant papers provided survival rates. In contrast, a majority of the endodontic studies provided success rates. Pooled and weighted success and survival rates for each follow-up period, with their associated 95 percent confidence intervals are shown in **TABLE 1**. The Forest Plots at four- to six-year success and survival depict these results in graphic form, and reflect the substantial variability among and within the included studies (**FIGURES 1-4**).

## PSYCHOSOCIAL OUTCOMES

The psychosocial effects of treatments studied in this systematic review were different for the two treatments. Pretreatment apprehension and post-treatment discomfort were commonly addressed in the endodontic literature.[8,1,85,87,88,91,92,94,95] Chewing performance and esthetics were commonly reported in the implant literature.[36,41,63,66,70-72,80,83,84,89,90,93]

Women had more pretreatment endodontic treatment anxiety than men, but this difference decreased with patient age.[88] Pain during endodontic care was usually less than anticipated and did not differ by gender.[94] Overwhelming reduction in pain followed endodontic care. A small minority of patients reported lingering problems after endodontic therapy, the majority of which were pain related.[85-87] Pain associated with dental implants has not been analyzed to the same extent as in the endodontic literature.[52,89] A majority of patients reported no pain following placement of dental implants. Those who experienced pain or unpleasantness rated it as being mild to moderate. Comfort during chewing was almost universal following implant restoration.[66,70,86]

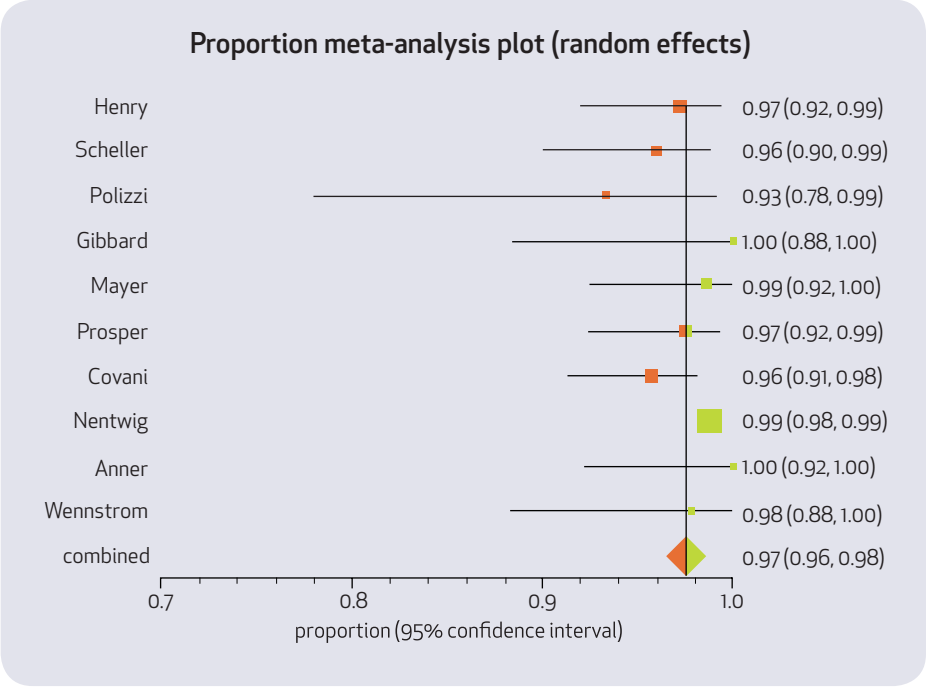


**FIGURE 1.** Forest Plot of implant success at four to six years. Forest Plots display the strength of the quantitative evidence included in meta-analyses. They represent the amount of variation between different studies and estimate the pooled results of the studies. The overall effect of the evidence is indicated by the central vertical line. The center of each square represents the point estimate provided by an individual study. The horizontal lines represent the confidence intervals of the associated data. The lower diamond represents the pooled point estimate.

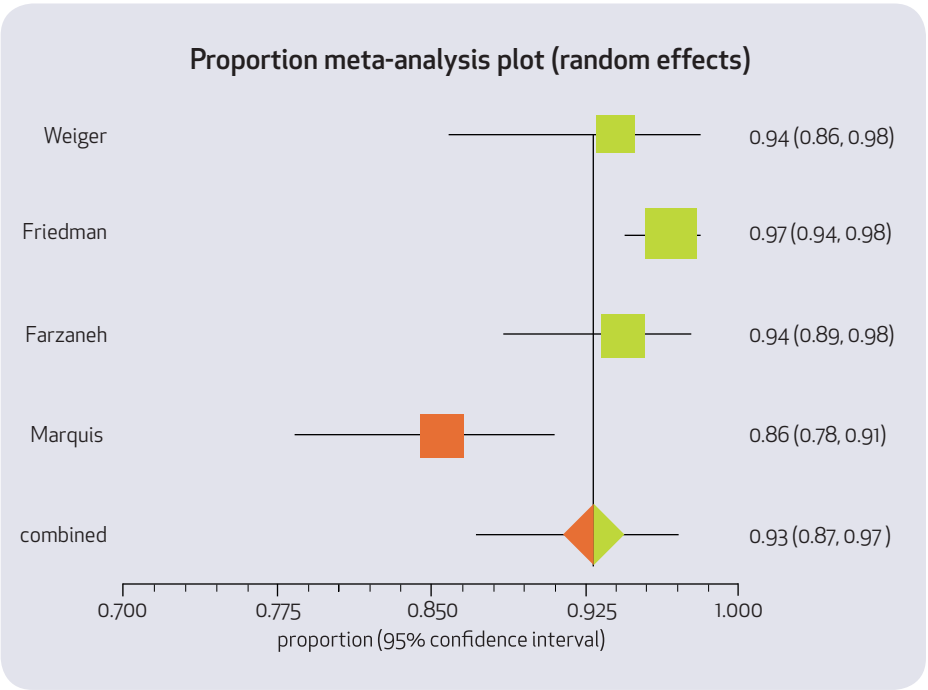


**FIGURE 2.** Forest Plot of endodontic success at four to six years.

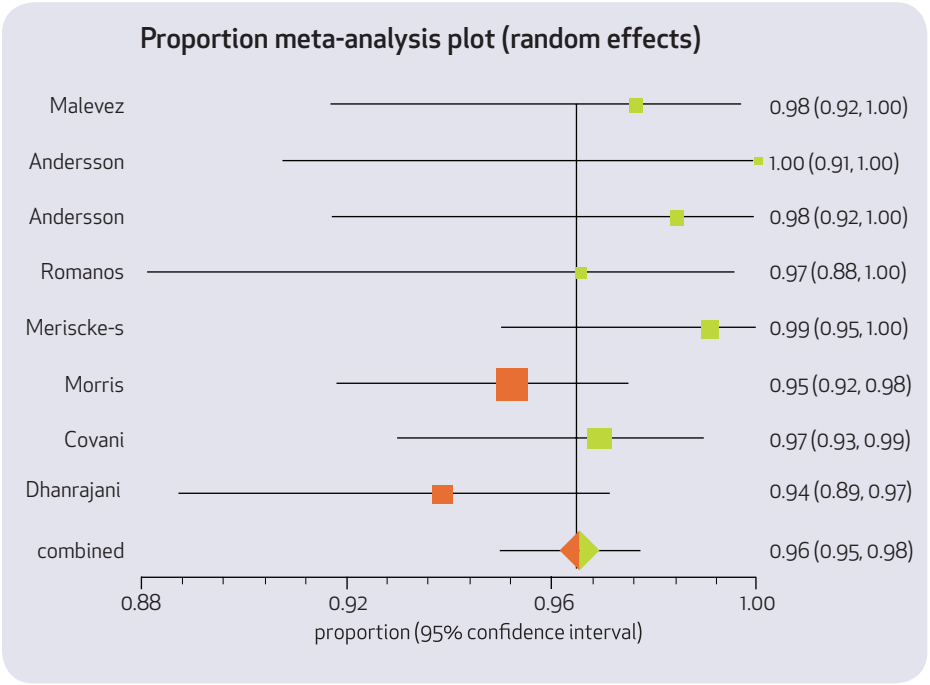


**FIGURE 3.** Forest Plot of implant survival at four to six years.

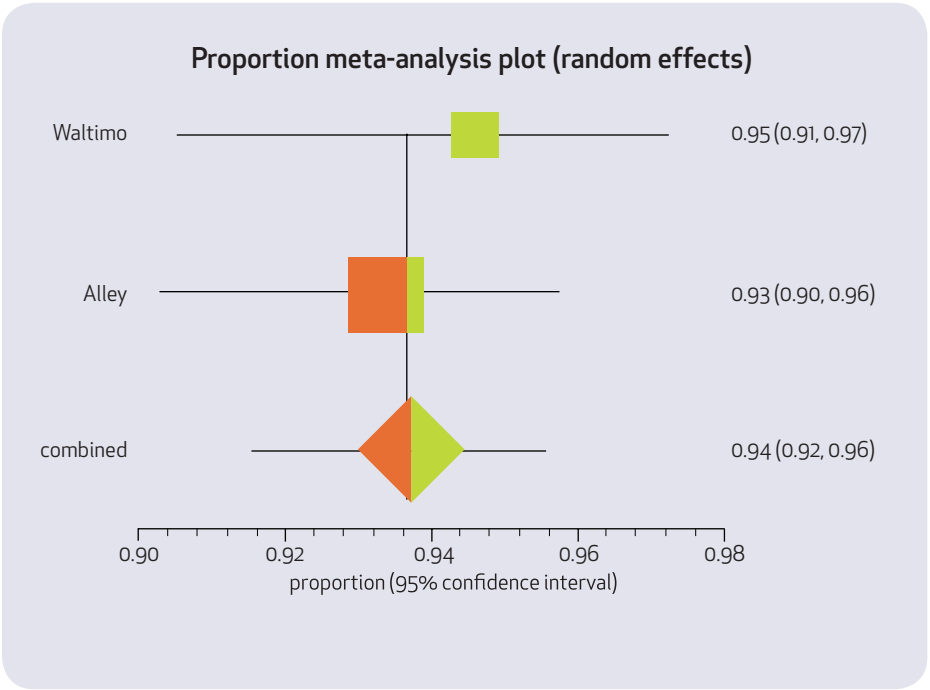


**FIGURE 4.** Forest Plot of endodontic survival at four to six years.

Esthetic outcomes were often examined in the dental implant literature. Very high levels of patient satisfaction were reported in the implant literature.[36,41,63,66,70-72,80,83,84,89,93] Patient perceptions of implant complications were rarely reported; the vast majority of patients felt the number of complications were acceptable.[86] However, endodontic studies did not separately address complications. An endodontic study found that more than 90 percent of subjects would choose to have another endodontic treatment.[87] Cost, distantly followed by pain, were the most important factors for those who would not have another endodontic treatment.[87] Eighty-eight percent of implant patients would chose the same treatment again, and 94 percent of patients who have had implants would recommend it to others.[41,56,70,93] Reasons for tooth loss in these implant satisfaction studies included trauma, periodontal disease, and endodontic complications following trauma. The times from extraction to implant placement varied from six months to 14 years.[41,56] Some of these studies described overall subject satisfaction ratings for both implant and endodontic treatments were above 90 percent.[41,85]

### ECONOMIC OUTCOMES

The authors' search found three papers that assessed economic outcomes of the endodontic and implant treatments.[41,87,93] Cost was the largest determining factor for those patients who chose not to undergo another endodontic treatment.[87] Approximately 90 percent of patients felt the cost of implant treatment was justified or that the cost benefit was positive.[41,93] It is not known whether patients who opted not to have endodontic treatment due to cost would opt for more expensive implant treatment, nor whether patients who opted not to have implant treatment due to cost would opt for endodontic treatment.

## Discussion

Based on collected data from this systematic review, it appears that both pooled (simply combining) and weighted (factoring in sample sizes) success rates consistently were higher for implant therapy than for endodontic treatment. Long-term survival was essentially the same for endodontic and dental implant treatment. The authors' findings are in general agreement with previously published and more narrowly focused systematic reviews on the outcomes of dental implants and endodontic success and survival rates, as well as another recent systematic review comparing the outcomes of dental implants and endodontically treated teeth.[96-101] The authors found only one paper that directly compared the implant and endodontic therapy clinical outcomes.[30]

Based on this paper, which had a retrospective case control design and without random assignment, the authors concluded that restored endodontically treated teeth and single implant-supported restorations had similar survival rates. They also reported that the implant group showed longer time to function and a substantially higher incidence of postoperative complications requiring subsequent treatment intervention. Because this retrospective study did not have detailed information regarding the type of implants used, the authors had to exclude it from the implant evidence table.

Although the data related to outcomes in the authors' systematic review and in those of other reviews represents the best evidence available, the results from these systematic reviews must be used with caution during treatment planning. The principal reasons for this caution are the lower quality of much of the evidence and the heterogeneity of the results. The quality score reflects the extent to which a study was open to one or more threats to the internal validity, and the low scores suggest there were opportunities for results to have been influenced by bias. The major sources for heterogeneity in the studies examined here were differences in definitions of success or failure and in the manner in which treatment complications were incorporated into these outcomes and in the type of operators.

Definitions of success, failure, and their variations in endodontic studies often combine comprehensive clinical, radiographic, and patient symptoms. Endodontic studies measure success in terms of healing an existing disease and failure as the occurrence of new disease. Success criteria used in implant studies varied significantly. Various authors have used biological, clinical, and radiographic criteria for evaluation of dental implants.[102-108]

**THE AUTHORS** concluded that restored endodontically treated teeth and single implant-supported restorations had similar survival rates.

Because the criteria for success varied extensively between the two disciplines as well as among studies of a given treatment, using the more fundamental outcome of survival may present a more straightforward basis for comparison of treatments.[30,96,109,110] Most endodontic studies (88 percent) used a combination of radiographic, clinical, and questionnaire evaluations for determining survival. The majority of implant studies (77 percent) utilized a combination of radiographic and clinical assessments.

Complications can affect both the practitioner's and the patient's assessment of the success of the treatment, and thus should be considered in reports evaluating these treatments. However, the evaluation of complications was not included in this review because of inconsistencies in the reporting of complications between studies both within a treatment modality and between the treatments evaluated. For instance, the reporting of complications other than implant loss has been limited and inconsistently reported in dental implant studies. Additionally, with implants, multiple clinical studies that simultaneously evaluated all or most of the complications that have occurred with dental implants and the associated crowns were not available.[111] Most endodontic studies assigned complications to failure categories.

Grading complications and placing them into categories such as major and minor interventions may be a reasonable way to uniformly address different types of complications among different disciplines in a clinically relevant manner.[30] For example, the lack of osseointegration for implants or nonrepairable root perforations in endodontic treatment should be considered major complications. Loosening of screws in dental implants or presence of small voids in the coronal portion of obturated root canals should be considered minor and correctable complications. However, variations in reporting between the studies or a lack of reported complications prevented such a process from being appropriately implemented.

General practitioners provided most endodontic treatments (63 percent of studies), while specialists overwhelmingly provided implant treatments (87 percent of studies). While it is unclear whether these different distributions contributed to the heterogeneity within a discipline, they do make comparisons between the treatments and generaliza-

tion to dental practice more problematic.

The data collected by the American Dental Association through its Services Rendered Survey estimate the fees (regardless of its provider) for an extraction, implant, abutment, and crown to be approximately $2,850.[3] The same survey estimates the fees for the costs of an anterior endodontic therapy provided by a general dentist with a composite resin restoration, and a molar endodontic therapy provided by an endodontist followed by an amalgam build up and a high noble metal-ceramic crown to be around $743 and $1,765, respectively.[3] The authors' systematic review of the existing literature demonstrated absence of studies specifically designed to assess the cost-benefit of the saving a tooth through endodontic therapy and extraction and placement of single tooth implants.

In addition to the outcome of treatments, the tangible and intangible benefits of retaining teeth should be considered during treatment planning. The benefits of successful treatment of a tooth with pulpal and/or periapical disease include conservation of the remaining crown and root structure, preservation of alveolar bone and accompanying papillae, preservation of the pressure perception and lack of movement of the surrounding teeth. The harmful effects of saving teeth through endodontic care include reduced water content of the afflicted tooth, increased chances for root fracture, and development of future decay.

The main benefits of tooth extraction are pain relief and removal of diseased tissues that may cause local or systemic diseases. The harmful effects of extraction without replacement include bone resorption, shifting of the adjacent teeth, and reduced aesthetics and chewing ability.[112-117] The benefits and harms of retaining teeth should be carefully weighed against extraction and placement of dental implants, fixed partial dentures, or extraction without tooth replacement.

This systematic review of the literature along with others demonstrate the absence of any information describing truly long-term outcomes, benefits or harms of dental implants compared to endodontically treated teeth. Within the confines of the authors' inclusion criteria, no single tooth implant study has reported outcomes longer than 13 years, while at least one endodontic study followed outcomes for 27 years.

## Conclusions

Based on available evidence, it appears that initial endodontic treatment has high long-term survival rate for periodontally sound teeth that have pulpal and/or periapical pathosis. Equivalent long-term survival rates have been also reported for extraction and replacement of the missing tooth with an implant-supported restoration. Presence of many shortcomings in the available literature means that definitive treatment decisions cannot be only based on the available evidence alone. However, within the limitations noted, this systematic review offers evidence that single tooth implant should be incorporated in discussions as first alternative treatment options for patients who require extraction and replacement of a missing tooth. ■■■■

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