Endodontic therapy or extract and place an implant: an evidence-based review of the literature

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Abstract

This systematic review of the literature investigated success rates of both endodontic therapy and extraction of the tooth and placement of an implant, with the intent of determining the superior treatment modality. Three electronic databases, Pubmed, Cochrane Library and Web of Science were used to comprehensively search the literature. All studies found were sorted according to strict inclusion criteria and a checklist was used to score included studies in order to assess their validities as measures of therapeutic success. The initial systematic search for articles relating to both root canal therapy and implants yielded 339 studies but only one study containing primary evidence was found and included in the evidence tables. The search was expanded to endodontic therapy success and implant success individually, yielding 532 and 384 studies, respectively. Two endodontic studies and two implant studies met inclusion criteria and were included in the evidence tables. Results of the two endodontic therapy studies and two implant placement studies showed success rates of 86%, 84%, 91% and 94% respectively. The comparative study showed success rates of 82.1% and 73.5% for endodontic therapy and implant placement, respectively. Both treatment modalities produced similar success rates, with implants generally showing slightly higher success rates. Randomized controlled trials are required to provide high level evidence to determine which treatment modality is superior.

Keywords: root canal therapy, endodontics, implant, success

The preservation of the natural dentition and the prevention of oral disease is the main objective of dental practice. Traditionally, the standard of care for a tooth with pathological pulp and questionable strength has been endodontic therapy, usually followed by a post, core and crown restoration. Extraction was considered the action of last resort. (1) The development of successful osseointegrated implants has offered an additional treatment option. (2) The dentist has the responsibility to "discuss with the patient treatment recommendations including benefits, prognosis and risks, reasonable alternatives and associated costs to allow the patient to make an informed choice."(3) In order to carry out these duties, it is incumbent upon the dentist to be current in his knowledge about available treatment options and be able to sufficiently inform and advise the patient. "An ideal treatment plan should address the chief complaints of the patient; provide the longest-lasting, most cost-effective treatment; and meet or exceed the patients expectations whenever possible."(4)

When considering the complex question of whether a tooth should be treated endodontically or extracted and replaced with an implant, there are many factors to consider. Coronal breakdown of the involved tooth, type and condition of the bone supporting the affected tooth, occlusion, gingival health, the presence of periodontal disease, the patient's overall health, the time required for treatment and the practitioner's proficiency must all be considered before rendering a decision. (5)

The best decisions are evidence-based, implying the availability of valid studies, ideally, randomized controlled trials which compare two treatment modalities. Numerous studies including nonsurgical root canal treatment and the placement of osseointegrated

implants have suggested that both methods are viable treatment options, but the success rates are variable for each treatment modality. (6)

Methods

In order to identify relevant articles, a systematic search process was performed. Initially, database searches were conducted using Pubmed, Cochrane Library and Web of Science, using the following key words: endodontic, endodontics, root canal and implant. The searches yielded 300, 24 and 15 articles respectively. After excluding articles based on relevance of their titles and after reading their abstracts, only one article was found that contained primary research and was considered appropriate to include in the evidence table. The topic was discussed with several members of the Faculty of Dentistry at the University of Toronto, confirming that there were unlikely to be more articles containing primary research that had not been located through the database searches.

A different approach was then taken to locate more evidence to answer the question. Separate searches were performed to determine the overall success rates of root canal therapy and implants, on an individual basis.

For the root canal therapy search, three approaches to locating articles were taken. Firstly, database searches were performed. Two Pubmed searches, a search of the Cochrane Library database and a Web of Science search were executed using the following key words, respectively: (nonsurgical root canal therapy OR endodontic treatment) AND treatment outcome; root canal, endodontic, success, failure; root canal, endodontic, outcome; endodontic outcome. The searches yielded 304, 125, 5 and 68 articles, respectively. After excluding articles based on relevance of title, abstracts and

finally after reading their full texts (see Table 1), one article was deemed appropriate to include in the evidence tables. Secondly, a search of the references of articles that made it to full text stage was performed, yielding 30 articles based on title. After excluding duplicates and eliminating articles based on abstract and full text, one article was deemed appropriate to include in the evidence tables. Finally, a search through the references of an endodontics textbook, *Pathways of the Pulp* (7), was performed, yielding five articles based on title. However, four were eliminated as duplicates and the remaining article was deemed inappropriate to include in the evidence tables. The articles were subjected to the following inclusion criteria in order to be included in the evidence table: 1) the treatment involved first-time, nonsurgical root canal treatment; 2) treatments involved both the anterior and posterior dentition, in the maxilla and mandible; 3) only healthy patients were included in the treatment population; 4) study measured 'success rate', based on both clinical and radiographic evidence; 5) study involved primary research; 6) follow-up period of four or more years, based on criteria by Strindberg (8), who stated that a minimum of 4 years of recall is considered adequate; 7) article available to UofT students; 8) article published in English.

For the implant search, Pubmed was searched using the search term, 'single-tooth dental implant success,' while both the Cochrane Library and Web of Science were searched using the term, 'single-tooth dental implant.' The searches yielded 122, 38 and 216 articles, respectively. After eliminating articles based on relevance of title, abstract and full text, one article was included in the evidence table. A search of the references of the articles was then performed, yielding 8 titles. One was deemed relevant for inclusion in the evidence table. The articles were subjected to the following inclusion criteria in

order to be included in the evidence table: 1) the treatment involved single tooth implants; 2) treatments involved both the anterior and posterior dentition, in the maxilla and mandible; 3) only healthy patients and non-smokers were included in the treatment population; 4) study measured 'success rate', based on both clinical and radiographic evidence; 5) minimum sample size of 100 patients; 6) article available to UofT students; 7) article published in English. Articles were excluded if only survival rates were given or if the treatment involved immediately-loaded or specialty implants.

Results

Five articles were included in the evidence tables: one pertaining to the success rates of both root canal therapy and implants, two articles evaluating the success rates of root canal therapy and two articles assessing the success rates of single-tooth implants.

Doyle et al. (6) (see Table 2) studied patients treated at the University of Minnesota School of Dentistry from January 1, 1993 to December 31, 2002. The authors matched 196 implanted teeth and 196 endodontically treated teeth and compared success rates, based on clinical as well as radiographic evidence. The implant group consisted of patients, aged 18 years or older that had single tooth implants and restorations. Multi-unit restorations were excluded and all implants had at least one adjacent natural tooth. The endodontic group consisted of patients 18 years of age or older that had initial nonsurgical root canal treatment followed by coronal restoration. All endodontically treated teeth included in the study had at least one adjacent natural tooth. Overall, implant and endodontic success rates were found to be 73.5% and 82.1%, respectively ($p<0.0001$). Both groups had the same number of failures, but the implant group had

fewer successes, indicating more surviving teeth requiring subsequent treatment. Implants tended to fail sooner than endodontic treatment, however, no significant difference was found. The location of implant/root canal in the mouth (maxillary anterior, maxillary posterior, mandibular posterior) did not affect outcome for either treatment type. Implants had a longer time, on average, to function than endodontically treated teeth, but the endodontic group had a longer upper tail (i.e. the 90^{th} percentile of endodontically treated teeth took longer to function than the implant group). This study was included for analysis as it was the only study consisting of primary research directly comparing root canal therapy and implants. As a retrospective study, was susceptible to more bias than a prospective study, potentially impacting the results. Secondly, it included endodontic treatments with a minimum of one year of follow-up, a time period argued to be insufficient to assess adequate healing (8).

Marquis et al. (9) (see Table 3) used a sample including all patients receiving endodontic treatment at University of Toronto graduate endodontic clinic (phase I: Sep 1993-Sep 1994; phase II: Jan 1996-Dec 1997; phase III: Jan 1998-Dec 1999). A pooled inception cohort of 1370 teeth in 1151 patients treated by graduate endodontic students was collected over the three phases, and after excluding those lost to follow-up, the pooled sample included 373 teeth in 325 patients. The patients ranged in age, with 25% less than or equal to 45 years of age and 75% over 45 years of age. Fifty-five percent were female and 45% male. Overall, 86% were considered healed, whereas 14% were considered diseased. However, 95% were deemed functional. Statistically significant outcome predictors were found to be the following: patients without preoperative radiolucency were more successful than with preoperative radiolucency (93% healed and

80% healed, respectively) and single-rooted teeth were more successful than multi-rooted teeth (89% healed and 76% healed, respectively). Three critical appraisal issues were identified. Firstly, there was a 50% lost to follow-up rate. In order to address this problem, authors performed a recall bias analysis, comparing the sample and the patients lost-to-follow up. It was found that there was a significantly higher proportion of patients under the age of 45 years in the lost-to-follow up group, however, in this study, age was not found to be significant factor in the outcome. Secondly, the population studied was that of a dental school and might not be representative of the community at large. Finally, as the sample was comprised of patients pooled from three phases of treatment, there were some differences between phases. The treatment technique was changed for phase III, however, overall healed rates for phase III was found to be similar to the healed rates of phases I and II.

In Smith et al. (10) (see Table 4), the study included patients receiving endodontic treatment at the Eastman Dental Hospital between 1970 and 1982. The sample size used was 821 teeth with patients ranging in age from 16 to over 60 years of age, with 33% ages 16-29 years, 36% ages 30-44 years, 26% ages 45-59, 5% over 60 years of age. Fifty-four percent were female and 46 % male. Overall, 84.29% were successful, while 15.71% failed. No significant difference was found relating to the following: age, but the trend showed more success in older patients; anterior versus posterior teeth; maxillary versus mandibular teeth; preoperative periapical thickening versus normal radiographic appearance of periapical region. A significant difference was found between the following variables: males were more successful than females; there were more failures in the lower right quadrant than any other quadrant; teeth that were

vital preoperatively were more successful than teeth that were non-vital; teeth with normal radiographic appearance of periapical region more successful than teeth with periapical change prior to treatment. In terms of critical appraisal of the study, the retrospective study design lowers the potential of the study to deliver a high level of evidence.

Romeo et al. (11) (see table 5) included patients receiving implants for missing single teeth at positions between the 2nd molars on either the maxillary or mandibular arches, at the Dental Clinic of the Institute of Biomedical Sciences at the San Paolo Hospital in Milan, Italy between January 1993 and January 1999. The study was made up of 40 males and 69 females, ranging in age from 19-68 years (average of 41.3 years). One hundred and thirty mandibular restorations (69.5%) and 57 maxillary restorations (30.5%) were performed. (There were only posterior mandibular implants, no anterior). The patients included in the study underwent rigorous exclusion criteria, such that they could not have periodontal disease at time of selection; no systemic diseases that could contraindicate surgery or affect prognosis; and no heavy smokers or alcohol or drug users. The patients had to have healing of 6 months for those who had tooth extraction; sufficient bone at implant site; no unfavourable skeletal-intermaxillary relation; no patients with reduced compliance or poor oral hygiene. One hundred and nine patients were originally selected with 187 implants. The cumulative success rate following loading was 93.6% when early healing failures were included and 96.18% when early healing failures were excluded. The success rate for all mandibular implants was 90.51% and 94.45% when only loaded implants were considered. The success rate for all mandibular implants was 100% as all were loaded and all remained successful. The

study used two different types of implants at the beginning of the study period, one of which (hollow screw implants) was discontinued from use in July 1997 due to clinical evidence that showed a growing rate of late complications due to infections in the hollow part of the implant that were difficult to eradicate. This change in technique may have an impact on the overall success rates found by the authors.

In Lindh et al. (12) (see Table 6), a meta-analysis was generated. A literature search of the database MEDLINE was searched for the years 1980 – 1996. The search terms used were: dental implants, cylindrical intraosseous, osseointegration, edentulous, partial, single, fixed bridges, fixed partial dentures, prosthodontic treatment and survival. Sixty-six studies were found and reviewed, with 19 studies used for the analysis. In total, 570 single implants were included in the meta-analysis. Success rates were analyzed both after 3 and 8 years, with the success rates being over 95% and 91.3%, respectively. As a meta-analysis, the study design contributed to the strength of the evidence presented by the authors, especially due to the fact that studies were selected by adhering to well defined inclusion criteria, ensuring that only the highest quality studies were included for analysis. Life-table analyses were constructed using the pooled data from each study and the results were reported with a 95% confidence interval, however, some articles included by Lindh et al. were retrospective, lowering the quality of the results.

Discussion

All articles included in the evidence tables were subjected to a checklist to assess the efficacy of the treatment in order to assess validity (see Appendix 1). The majority of articles scored 6 out of a possible 17, with the exception of the meta-analysis by Lindh et

al., which could not be scored using the checklist. The designs of the studies were primarily responsible for the low scores, as the studies did not include control groups and just measured success rates. As a result, none of the studies could be considered true prospective cohort studies or true retrospective case-control studies, also affecting their level of evidence scores.

A difficulty encountered when reviewing articles to address the subject was the lack of standardized criteria to assess the success of either endodontic treatment or implants. Many articles used either clinical evidence or radiographic measures to assess success, but many did not use both methods (14-20). As well, many articles discussed survival rates of the tooth or implant as opposed to success rates, which does not necessarily indicate functionality, but merely indicates presence in the mouth and may require further treatments, technically considered a treatment failure (21-24). Moreover, different definitions of success in each of the selected studies prevented a direct comparison being made between the two therapies.

Both endodontics and implant dentistry require higher quality of evidence, however, the nature of the treatments limits its availability. An ideal study would involve a randomized controlled trial wherein a patient with no preference for either root canal therapy or extraction and the placement of an implant would be randomized to either treatment having been stratified into various groups based on pre-treatment criteria. Furthermore, end points and success using a standard measures need to be defined in order to do valid comparisons.

Conclusion

At the present time, it would appear that the success rates for implant therapy and for endodontic therapy are very high, with implants slightly more successful than root canal therapy. It is, however, difficult to conclude that implant therapy is the superior treatment option. Many factors must be considered on a case by case basis and the practioner must make an informed decision based on the specific facts of each patient's case, as the decision whether to choose an implant therapy or an endodontic therapy is influenced by many factors such as cost, coronal breakdown of tooth involved, type of bone supporting the tooth, occlusion, esthetics, periodontal condition, patient motivation, oral hygiene, overall health, time and skill of the practitioner and these multiple factors must be used in developing randomized controlled trials to validly determine success rates.

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Table 1 - Reasons for excluding articles

Tilashki et al., 2004; Lazarski et al., 2001; Salehrabi and Rotstein, 2004; Stoll et al., 2005; Dammaschke et al., 2003.	No radiographs to assess (at final point)
Kojima et al., 2004; De Quadros et al., 2005; Field et al., 2004; Orstavik et al., 2004; Cheung, 2002; Travassos et al., 2003; Kerekes and Tronstad, 1979; Swartz et al., 1983; Heling, 1970.	Less than 4 years recall
Petersson et al., 1991.	No info about endo technique
Peak, 1994.	Not available to UofT students
Boltacz-Rzepkowska and Pawlicka, 2003; Sjogren et al., 1990.	No clinical assessment
Thomas and Beagle, 2006; Norton, 2001;	Not primary research
Romeo et al., 2004; Creugers et al., 2000; Buser et al., 1997; Davarpanah et al., 2002	Did not report success rates
Weng et al., 2003;	Did not include both anterior and posterior dentition
Mayer et al., 2002; Norton, 2001; Gibbard and Zarb, 2002; Palmer et al., 1997; Scheller et al, 1998; Henry et al., 1996; Wennstrom et al., 2005; Davis et al., 2004; Johnson and Persson, 2001; Johnson and Persson, 2000; Watson et al. 1999; Avivi-Arber and Zarb, 1996;	Sample size too small

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Table 2 - Evidence table [6]

AUTHORS, LOCATION, TIME PERIOD	STUDY DESIGN	POPULATION	SAMPLE SIZE	FOLLOW-UP PERIOD	LOST TO FOLLOW-UP	DEFINTION OF SUCCESS	OUTCOME	CRITICAL APPRAISAL COMMENTS	LEVEL OF EVIDENCE, GRADE, CHECKLIST SCORE
- Doyle et al. - Univ of Minn. School of Dent - Jan 1, 1993 to Dec 31, 2002	retrospective	- patients aged 18 or older - had initial nonsurg root canal therapy followed by coronal restoration or single tooth restoration supported by implant	- matched 196 implant teeth with 196 endodontically treated teeth	- min. 1 yr from time of function (placement of coronal restoration for implant group, completion of root canal tx for endo group)	N/a	Clinical & radiographic evidence implants: functional at time of recall w/o signs of failure, such as peri-implant radiolucency or implant mobility. Failure if implant removed or planned for removal. endo tx: present w/o apical periodontitis /symptoms, using periapical index (PAI). Failure if tooth extracted or planned for extraction.	- overall implant success 73.5% - overall endo success 82.1%	- minimum of 1 year follow-up - retrospective study design	- II-2 - C - 6/17

Table 3 - Evidence Table [9]

AUTHORS, LOCATION, TIME PERIOD	STUDY DESIGN	POPULATION	SAMPLE SIZE	FOLLOW-UP PERIOD	LOST TO FOLLOW-UP	DEFINTION OF SUCCESS	OUTCOME	CRITICAL APPRAISAL COMMENTS	LEVEL OF EVIDENCE, GRADE, CHECKLIST SCORE
- Marquis et al. - Univ of Toronto grad endo clinic - phase I: Sep '93-'94 - phase II: Jan '96-Dec '97 - phase III: Jan '98-Dec '99	prospective	- 25% ≤ 45 years of age, 75% > 45 years of age - 55% female, 45% male	- pooled inception cohort of 1370 teeth in 1151 pts - pooled examined sample of 373 teeth in 325 pts	4-6 years	50%	- clinical & radiograph measures - "healed" (absence of radiograph apical periodontitis (PAI score <3) & absence of clinical signs and symptoms other than tenderness to percussion) - "disease" (any other condition - all asymp teeth, regardless of PAI score classif as "functional"	- 86% healed - 14% disease - 95% functional	- 50% lost-to-follow up - dental school pop'n that might not be rep. sample - treatment technique changed for phase III	- II-3 - C - 6/17

Table 4 - Evidence table [10]

AUTHORS, LOCATION, TIME PERIOD	STUDY DESIGN	POPULATION	SAMPLE SIZE	FOLLOW-UP PERIOD	LOST TO FOLLOW-UP	DEFINTION OF SUCCESS	OUTCOME	CRITICAL APPRAISAL COMMENTS	LEVEL OF EVIDENCE, GRADE, CHECKLIST SCORE
- Smith et al. - Eastman Dental Hospital - between 1970 and 1982	retrospective	- 33% ages 16-29 years, 36% ages 30-44 years, 26% ages 45-59, 5% over 60 years of age - 54% female, 46 % male	- 821 teeth	- min. 5 years	None (retrospective study)	- clinical and radiographic evidence - a) clinically symptomless w/o evidence of sinus tract or tenderness to palpation in vestib sulcus & b) upon radiographic examination, PDL space normal on original diagnostic radiograph & remained unchanged on recall radiographs or if healing of radiolucent area visible on diagnostic radiographs that returned to normal or showed reduction in size	- 84.29% successful - 15.71% failed	retrospective design	- II-3 - C - 6/17

Table 5 - Evidence table [11]

AUTHORS, LOCATION, TIME PERIOD	STUDY DESIGN	POPULATION	SAMPLE SIZE	FOLLOW-UP PERIOD	LOST TO FOLLOW-UP	DEFINTION OF SUCCESS	OUTCOME	CRITICAL APPRAISAL COMMENTS	LEVEL OF EVIDENCE, GRADE, CHECKLIST SCORE
- Romeo et al. - Dental Clinic of Institute of Biomed Sciences at San Paolo Hospital in Milan, Italy - between Jan 1993 and Jan 1999	retrospective	- 40 males, 69 females - aged 19-68 years (avg 41.3 years)	-109 patients originally selected with 187 implants	- follow-up period of 3-6 months to assess early healing period - follow-up of 1-7 years to assess long-term clinical effectiveness	- 5.9% (11 dropouts)	- clinically and radiographically - according to criteria by Albrektsson et al. (1986) (13) : absence of mobility and radiolucency, low rates of vertical bone loss, absence of signs/symptoms	Cumulative success rate following loading: 93.6% when early healing failures included, 96.18% when early healing failures excluded	- implant type which was discontinued from use in July 1997 due to clinical evidence showing increased rate of late complications	- II-3 - C - 6/17

Table 6 - Evidence table [12]

AUTHORS, LOCATION, TIME PERIOD	STUDY DESIGN	POPULATION	SAMPLE SIZE	FOLLOW-UP PERIOD	LOST TO FOLLOW-UP	DEFINTION OF SUCCESS	OUTCOME	CRITICAL APPRAISAL COMMENTS	LEVEL OF EVIDENCE, GRADE, CHECKLIST SCORE
Lindh et al.	Meta-analysis	- literature survey of the database MEDLINE for the years 1980 – 1996 - search terms: dental implants, cylindrical intraosseous, osseointegration,edentulous, partial, single, fixed bridges, fixed partial dentures, prosthodontic treatment,survival	- 66 studies found and reviewed - 9 studies on implants supporting single crowns & 9 studies on implants supporting fixed partial dentures used for the analysis	-In all studies, apart from two, implants were followed for 3 years or longer	N/a	- Implants considered successful if fulfill criteria by Albrektsson et al. (1986). - Implant could be categorized as survived, but not successful if present in mouth but accompanied by signs of path or radiolucency	- survival of implants supporting single crown restorations after 3 years was 91.3%	- studies selected by adhering strictly to well defined inclusion criteria - some articles were retrospective	- II-3 - C - N/a

Appendix 1 - Checklist to Assess Evidence of Efficacy of Therapy or Prevention

1. Was the study ethical? ___

2. Was a strong design used to assess efficacy? ___

3. Were outcomes (benefits and harms) validly and reliably measured? ___

4. Were interventions validly and reliably measured? ___

5. What were the results?

Was the treatment effect large enough to be clinically important? ___

Was the estimate of the treatment effect beyond chance and relatively precise? ___

If the findings were "no difference" was the power of the study 80% or better ___

6. Are the results of the study valid?

• Was the assignment of patients to treatments randomised? ___

• Were all patients who entered the trial properly accounted for and

attributed at its conclusion?

i) Was loss to follow-up less than 20% and balanced between test and controls ___

ii) Were patients analysed in the groups to which they were randomised? ___

• Was the study of sufficient duration? ___

• Were patients, health workers, and study personnel "blind" to treatment? ___

• Were the groups similar at the start of the trial? ___

• Aside from the experimental intervention, were the groups treated equally? ___

• Was care received outside the study identified and controlled for ___

7. Will the results help in caring for your patients?

Were all clinically important outcomes considered? ___

Are the likely benefits of treatment worth the potential harms and costs? ___

Adapted from: Fletcher, Fletcher and Wagner. Clinical epidemiology – the essentials. 3rd ed. 1996, and Sackett et al. Evidence-based medicine: how to practice and teach EBM. 1997.