

A retrospective analysis of restorative factors that affect prognosis of endodontically treated teeth.

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Abstract

Although there have been many studies concerning endodontically treated teeth (ETT) and the factors affecting prognosis, many have reported different findings. This retrospective study aimed to support the hypothesis that the initial pulpal diagnosis and restorative factors can help determine the prognosis of ETT. The University of Manitoba's data collecting software was used to assess 1,360 ETT from January 2011 to June 2021, a period of 10 years. A Kaplan-Meier survival estimate with an associated P value comparing different prognosis, types of posts, and restorations, respectively, was performed using SPSS statistical software. From this data pool, there was a 94.4% survival rate of ETT with only 5.6% failing. A pre-operative necrotic pulp diagnosis was determined to be clinically significant in affecting prognosis. In descending order, a full coverage crown proved to improve prognosis, then permanent restorations, then temporary restorations. Other factors such as the presence of a post, type of post, amalgam vs composite, and type of crown did not affect prognosis. In descending order of causing failure in ETT, reasons were: 33.33% non-restorable crown fractures, 25% vertical root fractures, 14.29% inadequate restorations, 10.71% periodontal reasons, 9.5% endodontic failure, and 7.14% non-restorable caries. Based on these results, it was concluded that just as the quality of endodontic treatment is important, so is the quality/type of restorations that follows. Based on this paper, patients should be recommended full coverage crowns after endodontic treatment to ensure the best prognosis.

Introduction

With the ever-evolving technology in the field of dentistry, it is important to recognize that the long practiced non-surgical root canal therapy is still a reliable and successful mode of treatment. For endodontically involved teeth, either retention of natural tooth or replacement via a fixed prosthesis was determined to have a more positive psychosocial impact on patients than extraction and no replacement of esthetics and function.¹ Root canal therapy (RCT) aims to preserve natural dentition while eliminating micro-bacterial inflammation that develops within root canals of teeth. Once root canal treated, these teeth require a restoration to replace the tooth structure that was lost during the treatment process and to seal the intaglio canal environment from the oral microflora. This retrospective study aimed to support the hypothesis that pulpal diagnosis and restorative factors can help determine the successful prognosis of ETT.² This study evaluates the survival of ETT by dental students at the University of Manitoba Dr. Gerald Niznick College of Dentistry and included 1,360 ETT over a period of 10 years from January 2011 to June 2021. A very similar retrospective study was done at a dental college where ETT over a period of 10 years were evaluated and age, sex, tooth, and type of coronal restoration were recorded.¹¹ However, seeing as there was a difference in results, it demonstrates the need for an increase in these studies to better grasp and understand root canaled teeth and how restorative factors affect prognosis.

Literature Review

Endodontic treatment and prognosis have been studied in the preceding decades, reflecting different environments, clinicians and patient demographics. This has focused on long

term prognosis and various factors that ultimately affect endodontic “success”. They primarily look at both restorative factors and preoperative diagnosis.

The largest study looking at a retrospective patient pool is often termed the “Delta Dental Study” by Salerhabí et al. The scope of the study assessed over one million endodontic treatments conducted across all 50 states in the USA and defined success as retention of the tooth for 8 years once endodontic treatment was initiated.¹² The definition of success has always been determined independently by each study making them assessed insurance claims over the 8 year period and determined their survival rate. It is difficult to compare the “success” between studies. Some other studies have defined success as the absence of radiographic findings and/or clinical symptoms.^{6,13,14} The term of survival specifically applies to many aspects of dental treatment over success. Due to the general poor recall factors of dental treatment, it is commonly understood that there may be treatments done with no follow up to show evidence of failure (ie. extraction, worsened pathosis, etc.). This can be caused by many reasons such as dental treatment not being prioritized by the patient, patient moving to a different clinic, death of patient, etc. The widely cited systemic review by Ng et al. which looked at retrospective and prospective clinical studies had similar results affected by differing follow up times, which is why they chose to partition their data based on post treatment recall timelines. Despite differences in research methodology, there appears to be agreement regarding general percentages of success and survival rates. Overall survival rate ranges from 86%-97%.^{4,12} Within these long-term, large-scale studies, it has been found that preoperative pulpal diagnosis is perhaps the most important preoperative factor.

The lack of full cuspal coverage restorations (whether direct or indirect) and coronal leakages were noted as the most impactful on survival. This was seen in both the Salerhabí and Ng studies. Salerhabí et al. noted a 4.8x-6.2x increase in extraction rates in ETT without a crown coverage.¹² Furthermore, other studies have validated the importance of a coronal seal via full cuspal restorations such like the Aquilino study which found that root canal treated teeth without cuspal coverage restorations had a 6x greater chance of failure when compared to those that received a crown.¹⁹

Coronal seal has long been implicated in endodontic prognosis with the original Ray and Trope study perhaps being the most impactful. In their study, the absence of peri-radicular inflammation in a tooth with a good coronal restoration was 80% versus 75.7% in those a good endodontic treatment but no coronal restoration.⁵ This suggested that a good coronal restoration could be of more importance than a good endodontic treatment. The coronal seal, which is highly associated with failure, is dependent on the type of the coronal restoration and the seal it offers.^{2,4,5,9,19,24} Therefore, the use of a long term provisional restoration has been linked to increased rates of failure. Traditional temporary restorative materials such as IRM and Cavit have been shown to have coronal leakage in as little as 7-10 days.^{15,16,17} Unfortunately, due to the nature of urgency when receiving endodontic treatment, many patients do not return for their permanent restoration once pain is resolved, and consequently, increase the odds of treatment failure. In addition to coronal leakage, the use of a temporary restoration leaves the tooth in an mechanically vulnerable position as often times, teeth without permanent restorations in place may have remaining unsupported cusps, lack of proper preparation and/or lack of micromechanical bonding.

There are various permanent restorations that are commonly used, direct fillings including composite and amalgam, and indirect restorations such as crowns. Studies demonstrated no difference between amalgam and composite, but a clinically significant difference when comparing direct restorations to full coverage crowns.^{2,18} Stavropoulou et al. demonstrated a survival difference of 81% to 63% when comparing crowned ETT and ETT directly restored with fillings, respectively. This large difference in prognosis does seem to indicate the use of crowns as final restorations over fillings. Since most ETT have already been structurally compromised, a post and core are often required when choosing to restore with a crown. Some studies also analyzed the time from which endodontic treatment was initiated till placement of a final restoration. The study by Pratt et al. demonstrated a higher chance of extraction if a crown was placed more than 4 months from the time of endodontic treatment.⁹ Time till placement of a restoration was not analyzed in our study.

There are many options available to general dentists when choosing a post/core system such as glass fibre posts, prefabricated posts, and cast post and cores. Depending on which system, they may be associated with different failure reasons such debonding and/or fractures. A study by Mentik et al. showed that cast post and core systems led to a higher incidence of failure, when used in anterior teeth compared to posterior teeth.²⁰ This study demonstrated that failure caused by recementation and reresoration were more common than extraction. Tsintsadze et al. reported in their study that compared to metal post systems, glass fibre posts resulted in fewer absolute failures which was defined by but not limited to root fractures, perforations, and post fractures into the root canal.⁸ Conversely, Hatzikyriakos et al. demonstrated no difference in resin cores

with metal posts and cast post and cores.²¹ Similarly, based on the study done by Creugers et al., they demonstrated no difference in survival between cast post and cores, direct post and composite cores, and all composite cores.²² Rather than fractures, debonding and flexure of cores were of more concern in regards to fibre posts.²⁵

Materials and Methods

Using the University of Manitoba's patient management software Axium, all endodontically treated teeth between January 2011 and June 2021 were included in this study. The data collection included the age and sex of patient, tooth, type of post, core, and final restoration placed, along with the reason for failure. Treatments that had an incomplete data within the electronic health record were not included within the study. A Kaplan-Meier survival estimate with an associated P value comparing different prognosis, types of posts, and restorations, respectively, was performed using SPSS statistical software.

Results

A total of 1,360 ETT at the University of Manitoba Dr. Gerald Niznick College of Dentistry from January 2011 to June 2021 were included in this study. There was a 94.4% survival rate with a 5.6% failure rate over the 10-year period. The pulpal diagnosis as necrotic was found to affect the success of endodontic treatment with clinical significance. The failure rate between full coverage restorations, direct restorations and temporary restorations were also found to have a clinical significance. The presence of a post, type of post, amalgam vs composite, and type of crown were found to have no clinical significance in our study. Posts were not found to be related to the greatest incidence of vertical root fractures, with less than 50% being caused

by posts. When ranked on the reason for failure, non-restorable crown fractures were found to be the leading cause at 33.33% of all extracted teeth. The second leading cause at 25% was found to be vertical root fractures. Restorative reasons such as inadequate restorations or loss of restoration were found to be the third leading cause at 14.29%. Subsequently, 10.71% of failed teeth were caused by periodontal reasons, 9.5% due to endodontic failure, and 7.14% due to non-restorable caries.

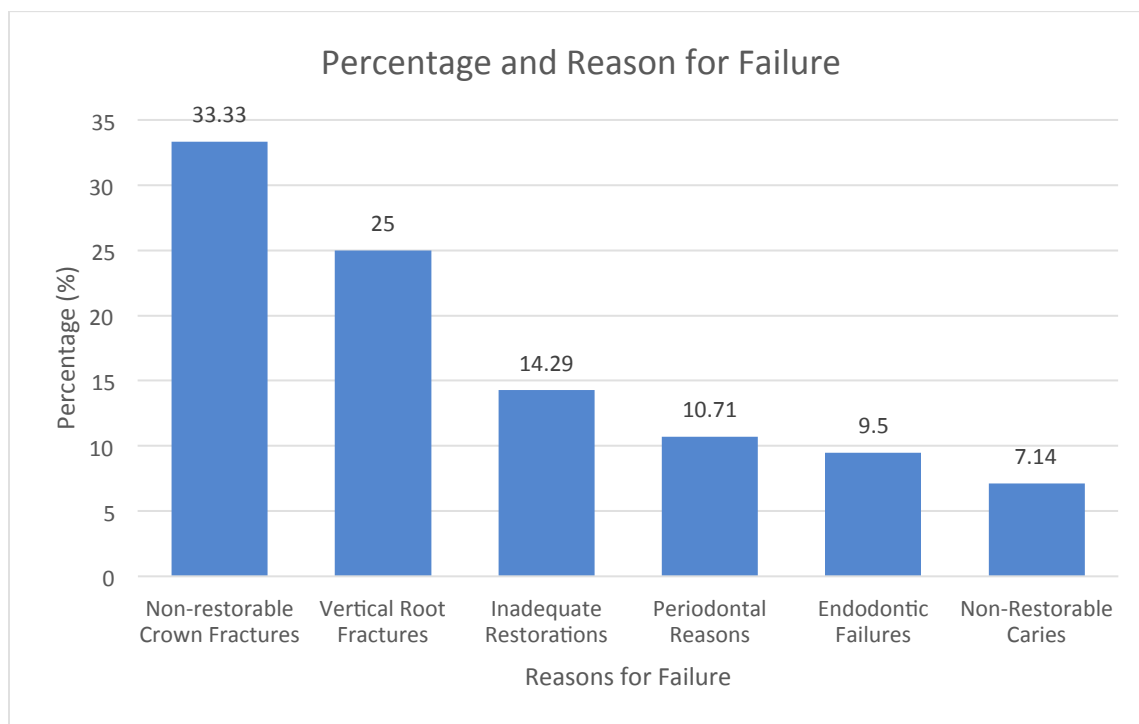


Figure 1. Percentage and reason for failure. Of the 1,360 teeth studied, this table illustrates the distribution of why ETT failed and their respective percentages.

Discussion

Initial non-surgical root canal therapy is a method of treating teeth that have irreversible damage done to the pulp that would otherwise lead to the necrosis of the pulpal tissue. This is

done by chemo-mechanical removal of the pulpal tissue and bacteria while filling the root canal system with an inert obturation material. This retrospective analysis was done to examine what factors affect the prognosis of ETT over the past 10 years at the University of Manitoba Dr. Gerald Niznick College of Dentistry. It was also done to compare the success rate of ETT done at the school relative to what is seen outside of the school. Since there seems to be multiple definitions of what a successful root canal therapy is, this study determined a root canal therapy successful when there was an absence of clinical symptoms such as spontaneous pain or pain on mastication and if the tooth was not extracted.

Reviewing the charts from the last 10 years at the University of Manitoba, 1,360 teeth were endodontically treated between 2011 and 2021 with 94.4% of treated teeth successfully surviving. In comparison, a study done at the University of Oslo dental college had standardized root canal therapy (RCT) done by students that resulted in a success rate of 91%.³ A systemic review of 14 studies demonstrated that the survival after RCT over a period of 2-10 years was 86% to 93%.⁴ The University of Manitoba dental college demonstrated a high level of success in respect to endodontic treatment. However, an important factor to acknowledge is that teeth treated in 2011 had a follow up of 10 years while teeth treated in 2021 only had a one year follow up. As proved by other studies, in ETT a long term follow up is required to accurately determine survival.^{2,19} Furthermore, as is similar to other studies of this nature, an appropriate recall system is necessary for the most accurate results of success/survival. This is largely dependent on the patient population, as endodontic treatment seldom has successive recalls as part of the treatment protocol. If a patient population is stable to that clinic or dental school, it would be relatively be accurate, while populations that are more transient, it is likely to result in a higher survival rate.

This could possibly explain the higher rate noted in our study as our patient population is more transient, resulting loss of ETT's without our knowledge if they sought treatment elsewhere.

Although causes of failure of root canal therapy are well known such as inadequate coronal seal and mechanical debridement a large portion of teeth that were extracted at the University of Manitoba were due to non-endodontic factors. The most common reason a tooth was extracted after a root canal treatment (RCT) was due to a non-restorable crown fractures followed by, vertical root fractures > inadequate restorations > periodontal involvement > endodontic reasons > unrestorable caries. This is in line with what has been found with previous studies of similar nature such as the Pratt et al. study that reported 60% of all extractions caused by crown fractures and only 7.6% caused by endodontic reasons.⁹

This further emphasizes that the prognosis of an ETT is not primarily determined by the quality of the endodontic treatment, rather the type and quality of the subsequent restorative treatment.^{2,5,}

¹⁰ Although the majority of the reasons why these teeth were extracted were due to non-endodontic reasons, the cause of endodontic failure was notable.

Our study showed that indirect full coverage restorations gave the best prognosis, followed by permanent direct restorations such as composite and amalgam, and finally by temporary restorations which gave the worst prognosis. It has been largely explained in the past that coronal leakages from a poor restoration is the main cause of secondary endodontic infections.

Temporary restorations also leave the tooth in its most mechanically vulnerable status. Our results were in agreement with a study done at Temple University Dental School where poor restorations caused more peri-radicular inflammation than poor root fillings.⁵ Stavropoulou and

Koidis also reported in their systemic review that over 10 years, crowned ETT had a survival of 81% while ETT with direct restorations had a survival rate of 63%.² This was also demonstrated by Ray and Trope where a good restoration resulted in better resolution of peri-radicular inflammation than a good endodontic treatment.⁵ Though the significance of the Ray and Trope study has diminished with subsequent studies, this study amongst others continue to show the importance of a permanent cuspal replacement restoration.

Full coverage restorations had a better survival compared to direct restorations as well, the time from once RCT was completed to when the tooth was crowned was also determined to affect the prognosis of teeth.^{9,10} Our findings are directly in line with previous studies suggesting that a tooth without a cuspal coverage restoration would result in a high likelihood of fracture. Unfortunately since our study did not record the time between RCT and crown, we are unable to comment on the significance of this factor. However, some studies have disagreed and reported that restoration quality did not affect prognosis while age and tooth type showed potential for significant prognosis impact.⁶ It is important to note though that this study did not differentiate between types of restorations which proved to be clinically significant both in our study and other studies.^{4,5,19}

Our retrospective analysis did not find age, tooth type, sex, and types of post clinically significant in affecting prognosis. Other studies also agreed that age did not affect prognosis.^{3,9} Some studies reported differences in success based on types of posts, type of tooth, or increased success rate with increased age/sex which was not seen in our study.⁵⁻⁸

Post and core systems may not have been of significance in our study as majority of the teeth crowned at the dental college are also treated with a post and core system and all teeth with a post/core system are crowned. Therefore, only a small fraction of the sample pool would have had crowns without a post/core system, deeming it of no statistical significance. Both Hatzikyriakos et al. and Creuger et al. studies agreed with our study that the type of post/core system did not affect prognosis of a tooth. The Aquilino et al. study has also stated that based on their multivariate analysis, the placement of a crown is more significant than and will negate the effects of the type of post/core system.¹⁹ It is important to note however that Ricucci et al. reported a success rate of 92.7% with posts compared to 89.9% without posts.⁶ In addition, despite the belief that a rigid post system such as a cast post and core or prefabricated post core systems would result in increased fractures, our study did not find that a difference was noted. Despite the reported benefits of increased flexibility of the glass fibre post, it was not associated with increased success rates or decreased rates of vertical root fracture. This could be explained by the limited sample size of glass fibre posts coupled with the increased rates of placements in later years resulting in less clinical data for failure. Another important factor to note was that our study did not identify failed restorations and post, core and crown systems that were replaced by a new restoration, or post, core and crown. Therefore, although the initial restoration may have failed, since the tooth was not deemed hopeless and extracted, it was kept in the data collection.

Limitations

The patient population at the University of Manitoba's dental college is mainly comprised of retired and lower socioeconomic status patients who have financial and accessibility limitations causing them to not partake in regular dental treatment. This often results in patients who have

pulpal irritation but do not seek dental treatment and rather wait till it causes significant pain. This often leads to pulpal diagnosis that are closer to a necrotic pulp with more difficult to remove bacteria than other pulpal diagnosis.^{6,23,24} Furthermore, since necrotic teeth may have more extensive canal preparation, they are highly indicated for post, core and crown treatment. This could have potentially resulted in more necrotic teeth associated with failure than what is seen outside of school environments. Another factor to consider is that nearby clinics run by the Winnipeg Regional Health Authority such as ACCESS do not provide endodontic treatment, and so refer patients to the University of Manitoba dental college. These cases arrive as limited treatments and only the endodontic treatment is completed. The patients are sent back to ACCESS to receive their treatment planned final restoration. Therefore, for these cases, it was recorded as a temporary restoration with no follow up as to if the tooth was permanently restored or not.

Future Directions

In the future, it may be beneficial if a study at the University of Manitoba Dr. Gerald Niznick College of Dentistry differentiated failure caused by a poor root canal filling and a poor coronal restoration similar to other studies. To do this, it would entail radiographic assessment pre and post treatment, along with a standardized assessment of the filling. Furthermore, it may also be beneficial to identify failure in restorations and RCT that were replaced versus failures that resulted in extractions. This would help in understanding which materials can cause irreversible and reversible failures. In a dental college setting, there are limitations to studies since it is a learning facility and the clinicians are a group of students which changes yearly. Furthermore, even with instructor supervision, skill levels can vary from student to student and instructor to

instructor, which can greatly impact results. The method of standardization may prove helpful in potentially increasing success rates and also to differentiate between restorative and endodontic failure.³ Having the study conducted through the graduate programs could result in greater standardization and decreasing untoward treatment events that are related to operator experiences. Once there is a larger patient pool who get treated with glass fibre posts, a set follow up time for each tooth can help accurately assess survival rates of teeth and their respective restorations. Studies stemming from a dental college will have limitations, however, they can also provide information that can contribute to better understanding this area of research.

Conclusion

Based on this retrospective analysis of 1,360 ETT from January 2011 to June 2021, there was a reported 94.4% survival rate and a 5.6% failure rate of endodontic treatment. Survival rate was determined by post treatment complications such as periodontal involvement leading to extraction, vertical root fractures, unrestorable caries indicating extraction, non-restorable crown fractures, and inadequate or loss of restoration. The following was the rank in order of failure:

1. 33.33% from non-restorable crown fractures
2. 25% from vertical root fractures
3. 14.29% from inadequate restorations
4. 10.71% from periodontal reasons (such as excessive bone loss, furcation problems, mobility, or deemed periodontally hopeless)
5. 9.5% from endodontic failures
6. 7.14% from non-restorable caries

It was determined that a necrotic diagnosis was clinically significant for prognosis. Full coverage indirect restorations provided a better chance of survival compared to direct permanent restorations. Compared to indirect full coverage and direct permanent restorations, temporary restorations also increased chances of failure in endodontic treatment. Factors such as age, tooth type, type of posts, type of permanent restorations, type of crowns were deemed as not clinically significant. Although it was determined that there was an insufficient sample size to determine the clinical significance of posts in relation to incidence of vertical root fractures, less than 50% of teeth determined to have a vertical root fracture had posts. Through the conduction of this study, we hoped to contribute and expand the research available in how restorative factors affect the prognosis of endodontically treated teeth.

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