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Outcomes for teeth following pulpectomy treatment at a dental teaching hospital

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Abstract

Pulpectomy involves removal of vital, inflamed, infected or necrotic pulp, usually followed by the placement of an intracanal medicament. A limited pulpectomy procedure is commonly performed for the relief of acute dental pain. Long-term outcomes following pulpectomy procedures at the University of Otago, Faculty of Dentistry have not previously been reported.

Objective: To track the long-term endodontic treatment outcomes of patients who had pulpectomies performed on permanent teeth and investigate potential differences in treatment outcomes by provider experience and tooth characteristics.

Methods: Ethical approval was obtained and data from electronic records were audited from the year 1998 onwards until June 2015.

Results: 869 pulpectomies were recorded, among which 35 were repeat pulpectomies and for 65 procedures no tooth was specified, leaving a total of 764 pulpectomies for analysis. During the 17 years following pulpectomy until June 2015, about half the teeth that had received pulpectomy in 1998 had root canal treatment (RCT) completed at the same facility (45.5%, n=348). Of all teeth that received a pulpectomy, 33.6% (n=257 of 764) were subsequently extracted, and this included 28.4% (n=73 of 257) of teeth that had RCT completed. No significant differences in survival rates of teeth that were initially treated by staff or students were observed, but differences were observed by tooth type, completion of endodontic obturation, and crowning of teeth.

Conclusion: This research helps quantify risk of tooth loss following pulpectomy treatment if endodontic treatment is not completed promptly, as well as a greater risk of tooth loss if teeth are not crowned following obturation. Clinicians and health services should have strategies in place to ensure good follow-up of patients following pulpectomy procedures, including communication of risks to patients.

Introduction

Endodontic pulpectomy involves removal of the pulp which is commonly performed for the relief of acute dental pain, and the root canal(s) are usually dressed with a medicament. The canals may undergo chemo-mechanical preparation at the same or subsequent appointment, followed by obturation and placement of a definitive coronal restoration. Success of a pulpectomy may be measured by short-term resolution of pain, but endodontic treatment success is usually determined by the absence or improvement of periapical radiolucencies and resolution of clinical signs and symptoms at review appointments (Dammaschke *et al*, 2003). Tooth survival is defined as the retention of function of a treated tooth in the oral cavity without any clinical symptoms irrespective of the health of the periapical tissues as evaluated radiographically (Cheung *et al*, 2013). An endodontically treated tooth may be able to function for a considerable period of time despite the presence of a periapical lesion radiographically (Lee *et al*, 2012).

Multiple re-dressings, as well as an unsatisfactory coronal seal, may impact the microbiological contamination of the root canal (Siren *et al*, 1997) and compromise the prognosis of root canal treatment (RCT). Other factors contributing to the limited success of RCT may include abscess, insufficient chemo-mechanical debridement, perforation and interappointment flare-up (Ng *et al*, 2011). Procedural errors can happen during endodontic treatments and molars are more susceptible to errors such as perforations, transportations and over- and under-instrumentation (Yousuf *et al*, 2015).

Dental students in the fourth and final year of their five-year BDS degree at the University of Otago, New Zealand perform pulpectomies on patients, and these are most frequently performed in the Urgent Care Unit (UCU). Pulpectomies may also be carried out by staff. Depending on the patient presentation, along with the high patient turnaround rate and time constraints at UCU, variable degrees of canal preparation is undertaken and usually a corticosteroid containing medicament is placed. Patients are subsequently placed on waitlists and assigned to the appropriate departments which include undergraduate, postgraduate and specialist clinics. Ideally, patients are advised to return in seven days for the continuation of endodontic treatment, however, the waiting time varies due to high demands.

It has been reported that the confidence level of performing RCT was lower for the more junior students (Murray and Chandler, 2015), and that multi-rooted teeth were the most difficult to treat endodontically (Murray and Chandler, 2015; Awooda *et al*, 2016). A direct correlation between the self-reported confidence level of clinicians and performance has been found (Awooda *et al*, 2016), and confidence level in relation to competency and job satisfaction should not be underestimated (Honey *et al*, 2011). The correlation between the qualification of clinicians and survival of root canal treated teeth has been investigated in several studies but results vary and provide conflicting evidence (Ng *et al*, 2010).

Long-term outcomes following pulpectomy procedures at the Faculty of Dentistry have not previously been reported. This research aimed to describe the long-term treatment outcomes for teeth that had received pulpectomy treatment in the year 1998, and investigate potential differences in treatment outcomes by the characteristics of the teeth and subsequent treatments provided.

Methods

Ethical approval was obtained from the University of Otago Human Ethics Committee (Ref # HD16/027). Data for all pulpectomy cases performed in 1998 were collected from electronic records of the University of Otago, Faculty of Dentistry. Data on subsequent services and their respective dates were collected up until June 2015. Data were managed and analysed using STATA version 13.1.

A total of 869 pulpectomies were recorded as having been performed during 1998. After excluding 35 repeat entries, 65 entries for which no tooth was specified and 5 deciduous teeth, a total of 764 pulpectomies were investigated. Provider codes were matched with provider name, and provider experience levels were identified with Titanium Software and matched against the New Zealand Dental Council register. Providers were classified as undergraduate students and 'others' (a group including postgraduate students, general dentists, and specialists).

For analysis, teeth were categorised as maxillary molar, mandibular molar and non-molar teeth (premolar, canine and incisor teeth which were grouped together and formed the reference group for regression analyses), provider type (staff vs student); patient age (years), patient gender (male vs female); patient self-reported ethnicity (Māori and Pasifika, with all other ethnic groups as the reference group for regression analyses); number of endodontic treatment sessions subsequent to the initial pulpectomy (range 1-11), whether the tooth ever received a crown, and whether an endodontic obturation was performed.

Tooth extraction was defined as 'failure' for the purposes of statistical analyses, regardless of the reason(s) attributing to their extraction (we did not have data available on the clinical status of a given tooth at the time of extraction or the reason for extraction, only the date and tooth identity). Tooth survival was defined as the retention of a treated tooth in the oral cavity. It was also necessary to define the point at which a tooth was lost to follow-up. This was a challenging question, as patients may seek ongoing care elsewhere and data on the extent to which this was an issue was unavailable to us. To address this limitation, two different models were applied to the data. In the first model, it was assumed that teeth were still present at the patient's last visit to the Faculty for any reason unless the tooth was extracted prior. However, the patient may have attended a different clinic for the tooth to be extracted which would represent an overestimate in survival. The second model involved the assumption that teeth were lost to follow-up at the last treatment record for the tooth concerned.

Cox Regression model was used to produce two multivariate models of risk, each following different assumptions to analyse the association between provider factors and RCT long-term outcomes. 64 pulpectomies that had no treatment subsequently were excluded in these models. Robust standard errors were used and log pseudolikelihood was used to assist with selection of model of best fit.

Results

Data for 869 pulpectomy procedures performed in 1998 on permanent teeth were identified. After excluding repeat pulpectomies, entries where no tooth was specified, and deciduous teeth, outcomes for a total of 764 pulpectomies were analysed. Of these, 57.5% (n=439 of 764) were performed by undergraduate students and the remainder by staff members. The lowest frequencies of pulpectomies were performed in January and December, which corresponded to timing of the university summer vacation (Figure 1).

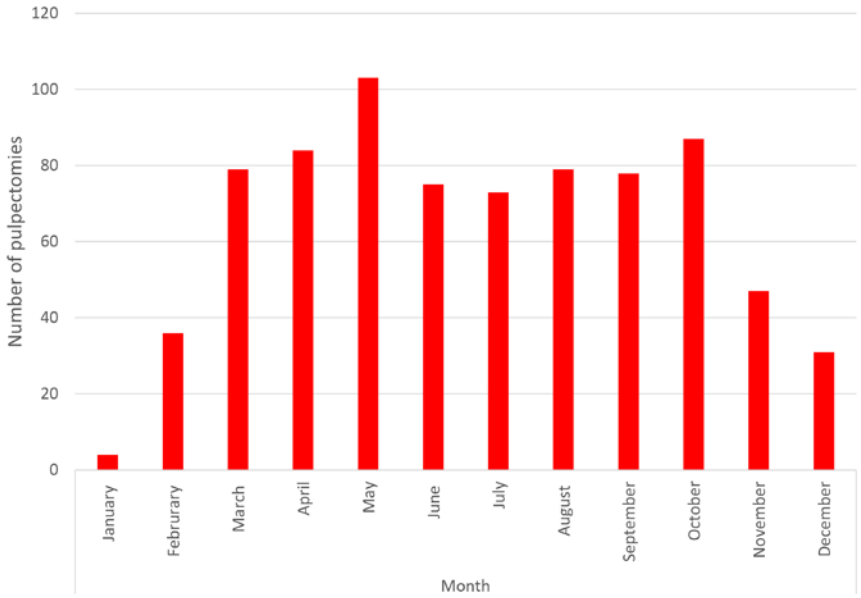

Figure 1: Number of pulpectomies performed in 1998 by month

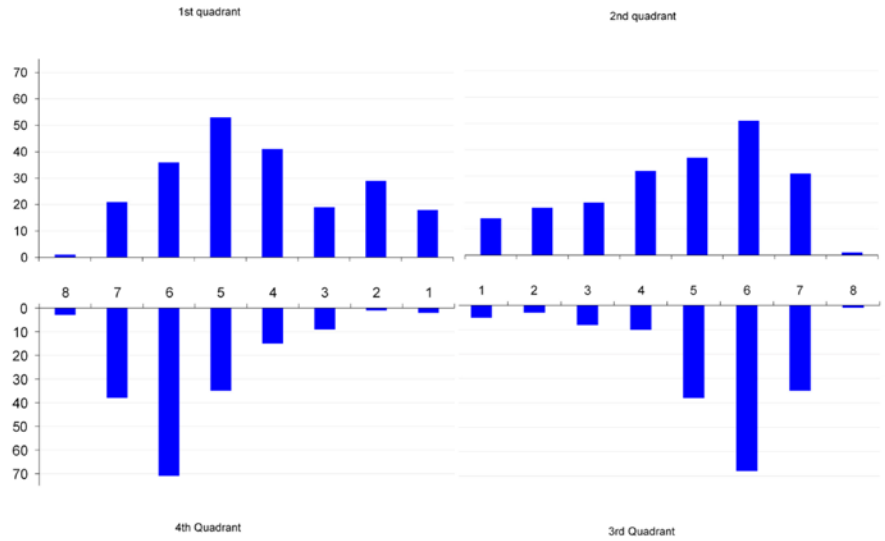

Figure 2: Number of pulpectomies performed in 1998 by tooth

Just under a third of patients were aged < 30 years (n=242 of 764), half were aged 31-49 years (n=377 of 764) and the remainder were aged 50+ years (n=145 of 764). Just under half were male (n=349 of 764) while the remainder were female (401 of 764) or of unknown sex (n=16 of 764). Around two thirds were New Zealand European (n=534 of 764), 4.7% were Māori (n=36 of 764), 2.1% were Pasifika (n=16 of 764), 6.7% were Asian (n=51 of 764) and the remainder (n=127 of 764) were of other/unknown ethnicity. By tooth type, nearly half were molar teeth (n=357 of 764), a third were premolars (n=261 of 764) and the remainder were anterior teeth (n=146 of 764) (Figure 2).

Among the pulpectomies that were completed by undergraduate students, just over half were subsequently obturated (n=231 of 439), while only a third of those completed by staff were obturated (n=117 of 325). Overall, just under half of teeth that had received a pulpectomy had RCT completed (n=348 of 764). Of all pulpectomies performed, 33.6% of these teeth were subsequently extracted, and this included 28.4% (n=73 of 257) of teeth that had RCT completed (Figure 3).

For the 700 pulpectomies that were suitable for Cox Regression analysis (with available data), the longest follow-up period was 17.3 years. When Model 1 was applied, 687 cases were included, with a total

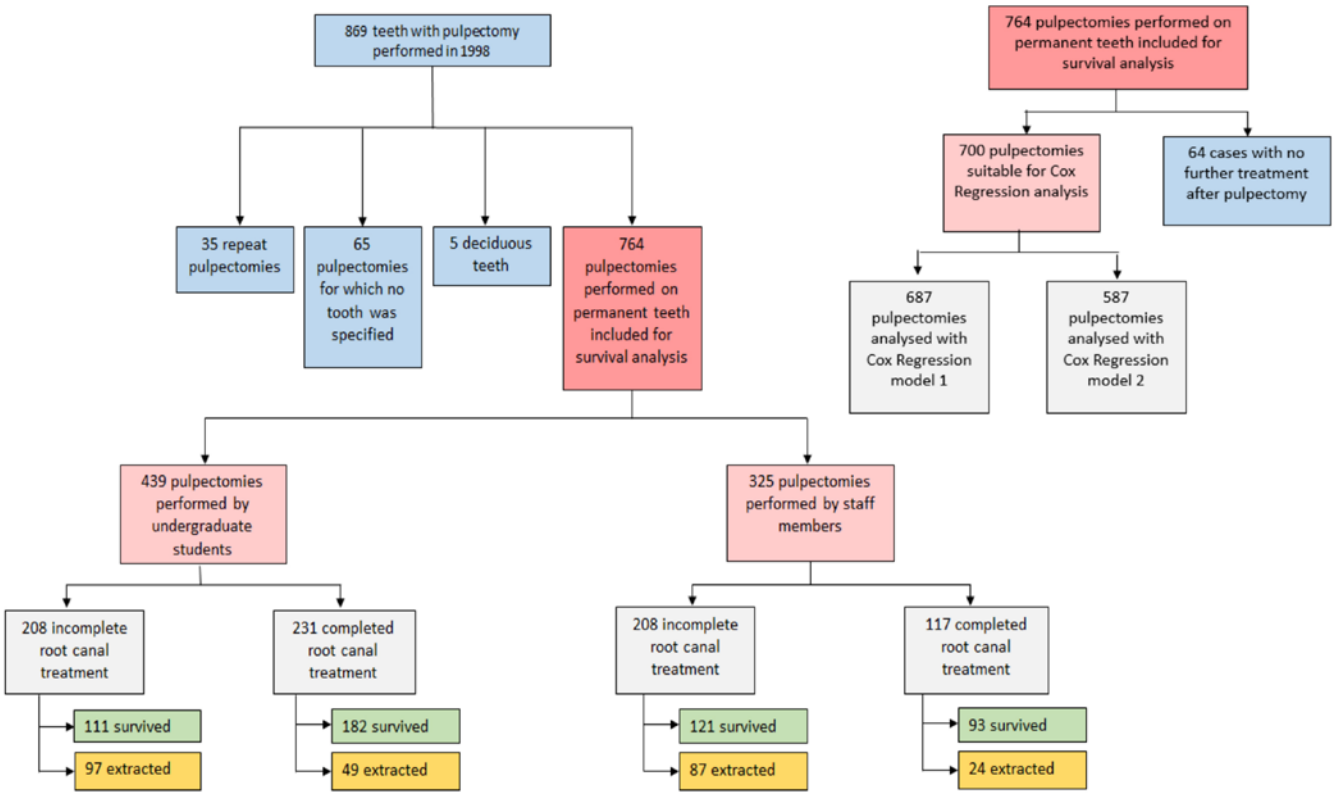

Figure 3: Flowchart summarising outcomes of pulpectomy procedures completed in 1998

of 4,028 years of total time at risk starting from the day of pulpectomy. For Model 2, 587 cases were included, and the total time at risk was 1,815 years. Log pseudolikelihood of Model 2 was more favourable than for model 1, but results generated from both models were complimentary and both are reported.

Staff/student status was not significantly associated with tooth survival, with a hazard ratio of 0.9 where pulpectomies were performed by qualified dentists. The survival of maxillary molar teeth following pulpectomy was significantly worse than for non-molar teeth, while the survival of mandibular molar teeth was not significantly different (Table 1, Table 2). In both models, teeth that were crowned following obturation were 0.2 times as likely to fail (Tables 1 & 2). In both models, teeth where RCT was completed (obturated) were less likely to fail than those with incomplete RCT (Figures 4 & 5). In Model 1, additional root canal dressing(s) were associated with more failures (Table 1) but this difference was not significant in Model 2 (Table 2).

Discussion

Many teeth treated by pulpectomy in 1998 did not subsequently have canal obturation completed; all such teeth (for which complete data were available) were subsequently extracted. Of the teeth that were subsequently obturated survival rates were significantly higher, and teeth that were subsequently crowned had higher survival again.

This study has several limitations that should be acknowledged. Firstly, data for this study were obtained from electronic records, meaning the findings are dependent on the accuracy of the clinical records and billing information. This was a retrospective audit, and data on the clinical and radiographic status of the teeth at time of initial presentation was unavailable. For example, the presence of periapical lesions is a significant prognostic factor for RCT outcome (Dammaschke *et al*, 2003; Lee *et al*, 2012) which may contribute to failure, but we could not investigate this due to the lack of available data. Repeat pulpectomies and pulpectomies for which no tooth was specified were excluded from the study, as their inclusion may have led to misclassification and bias.

Pulpotomy procedures were not considered, and pulpectomy procedures on deciduous teeth were excluded as their loss could be attributed to multiple reasons including natural exfoliation. Pulpectomy was most frequently performed on mandibular molar teeth (28.3%), followed by maxillary premolar teeth (21.3%) and maxillary molar teeth (18.5%) (Figure 2), which is comparable to the study by Salehrabi and Rotstein (2004). It has been suggested that the early eruption and plaque retentive tooth morphology of mandibular first molar teeth could be related to an increased likelihood for endodontic treatment (Yousuf *et al,* 2015). Early caries prevention and detection are important in order to prevent the progression of caries (Yousuf *et al*, 2015). The least common teeth to undergo pulpectomy were third molars, and this finding is consistent with Yousuf *et al* (2015).

Cox Regression was used to model the long-term outcome of pulpectomy procedures. Two models were produced making different assumptions regarding loss to follow-up. For Model 1 (Table 1, Figure 4), the assumption was made that teeth were lost to follow-up at the patient's last-recorded (most recent) visit to the Faculty of Dentistry, no matter the reason for the visit. However, a limitation of this approach is the possibility that some patients may have attended a different clinic and had the tooth extracted, which would lead to an overestimation of survival. For Model 2 (Table 2, Figure 5), teeth were considered lost to follow-up at the time of last treatment record for the tooth involved. The statistical fit of Model 2 was slightly better, with a log pseudolikelihood closer to zero. This has the advantage that it was definitely known that the tooth was present at that point, but this could cause an underestimation of survival, as teeth 'exited' the model at the last appointment some treatment was required, with problem-free teeth being considered lost to follow-up. For this reason, we elected to present both models, and readers should take the relevant assumptions into consideration when interpreting these models.

For this study, providers were broadly categorised into undergraduate students and 'others' (Faculty staff members and postgraduate students). Proportionally more of the pulpectomy procedures performed by undergraduate students were completed by final year students than those in their fourth year, while general dentists accounted for most pulpectomy procedures among staff members. Endodontic specialists and postgraduate students performed only a small proportion of the pulpectomy procedures performed and a subgroup analysis was not feasible, so they were grouped with general dentists and other dental specialists for the purposes of statistical analysis. No differences in provider type (undergraduate vs others) on the survival of teeth treated with pulpectomy were found (Tables 1, Table 2), suggesting that a differences in provider experience by the clinician performing the pulpectomy procedure was not an important driver of endodontic treatment success. It was not possible to account for other aspects of provider experience (e.g. years since graduation) due to a lack of available data and we did not consider the characteristics of the clinician who completed any endodontic procedures in the analysis.

Most didactic endodontic teaching in the Faculty of Dentistry's undergraduate curriculum is provided by endodontic specialists, while relevant clinical teaching is delivered by a mix of general dentists and specialists. The curriculum begins with teaching the theoretical underpinnings of cariology and pulp health management, followed by providing students with preclinical endodontic simulation experience before they commence providing supervised endodontic care to patients. Consistency in training and simulation practice, as well as supervision of students by appropriately qualified dentists, may have contributed to the comparable survival of teeth with pulpectomies carried out by students or staff. The finding that provider experience was not a significant factor affecting the survival of RCT is consistent with previously-published research (Cheung

Table 1. Hazard ratios for tooth loss by patient, tooth, and dental care provider characteristics.
Model 1: Teeth were considered lost to follow-up at last visit for any reason

Variable	Hazard Ratio	Robust Standard Error	P>[z]	95% Confidence Interval
Tooth type				
Non-molar teeth (reference group)	1.00	—		
Maxillary Molar	1.92	0.30	0.00	1.41-2.61
Mandibular Molar	1.34	0.24	0.10	0.94-1.91
Age (years)	1.02	0.01	0.00	1.00-1.03
Ethnic group				
European/Other (reference group)	1.00	—		
Māori	1.44	0.38	0.16	0.86-2.42
Pacific	1.50	0.67	0.36	0.63-3.59
Sex				
Female (reference group)	1.00	—		
Male	0.76	0.11	0.05	0.58-1.00
Number of endodontic canal re-entry procedures	1.12	0.05	0.02	1.02-1.22
Prosthodontic status				
Never crowned (reference group)				
Crowned	0.21	0.06	0.00	0.12-0.38
RCT	0.22	0.04	0.00	0.16-0.31
Endodontic completion				
Never obturated (reference)				
Obturated	0.22	0.04	0.00	0.16-0.31
Provider type for initial pulpectomy				
Undergraduate student (reference group)				
Staff or postgraduate student	0.88	0.12	0.38	0.67-1.16

No. of pulpectomies included: 687
No. of failures (extractions): 252
Time at risk: 4028.27
Log pseudolikelihood: -1395

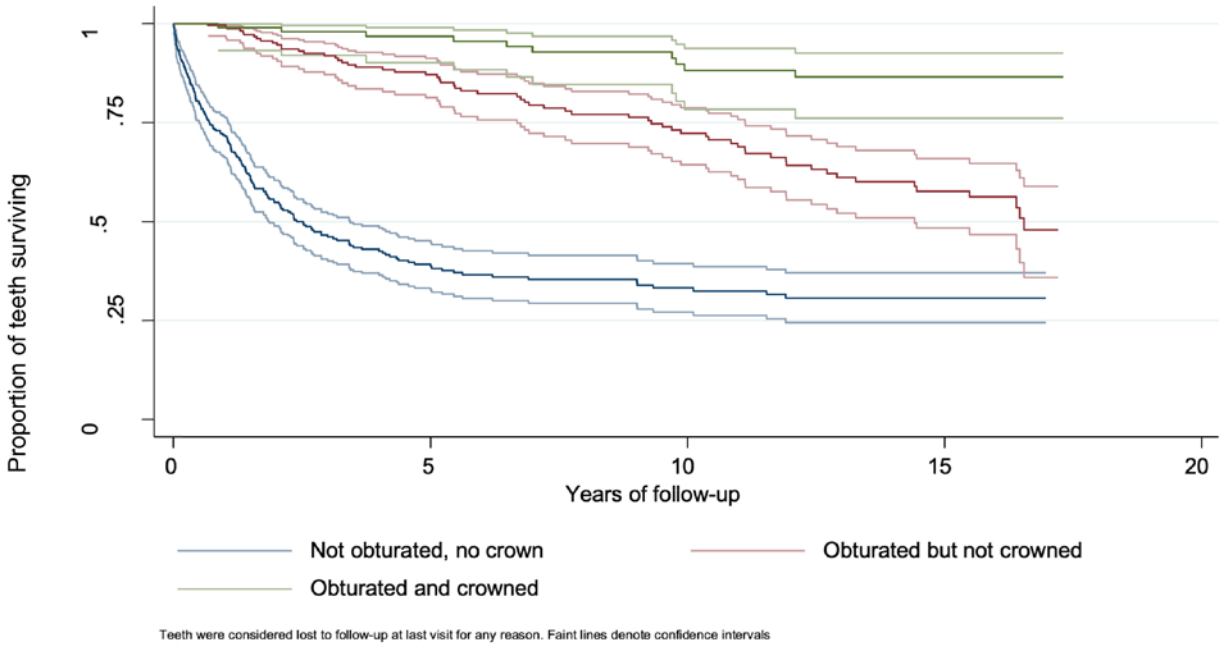

Figure 4. Survival of teeth by completion of endodontic treatment, Model 1.

Table 2: Hazard ratios for tooth loss by patient, tooth, and dental care provider characteristics.
Model 2: teeth were considered lost to follow-up at last treatment record for that tooth

Variable	Hazard Ratio	Robust Standard Error	P>[z]	95% Confidence Interval
Tooth type				
Non-molar teeth (reference group)				
Maxillary Molar	1.50	0.25	0.02	1.08-2.07
Mandibular Molar	1.30	0.24	0.15	0.91-1.85
Age (years)	1.02	0.01	0.00	1.01-1.03
Ethnic group				
European/Other (reference group)				
Māori	0.78	0.26	0.47	0.41-1.50
Pacific	1.55	0.55	0.21	0.78-3.09
Sex				
Female (reference group)				
Male	0.71	0.11	0.02	0.53-0.95
Number of endodontic canal re-entry procedures	1.00	0.05	0.99	0.91-1.09
Prosthodontic status				
Never crowned (reference group)				
Crowned	0.20	0.07	0.00	0.11-0.39
Endodontic completion				
Never obturated (reference)				
Obturated	0.15	0.02	0.00	0.11-0.21
Provider type for initial pulpectomy				
Undergraduate student (reference group)				
Staff or postgraduate student	0.89	0.13	0.40	0.67-1.18

No. of pulpectomies included: 587
No. of failures (extractions): 252
Time at risk: 1815.22
Log pseudolikelihood: -1205.61

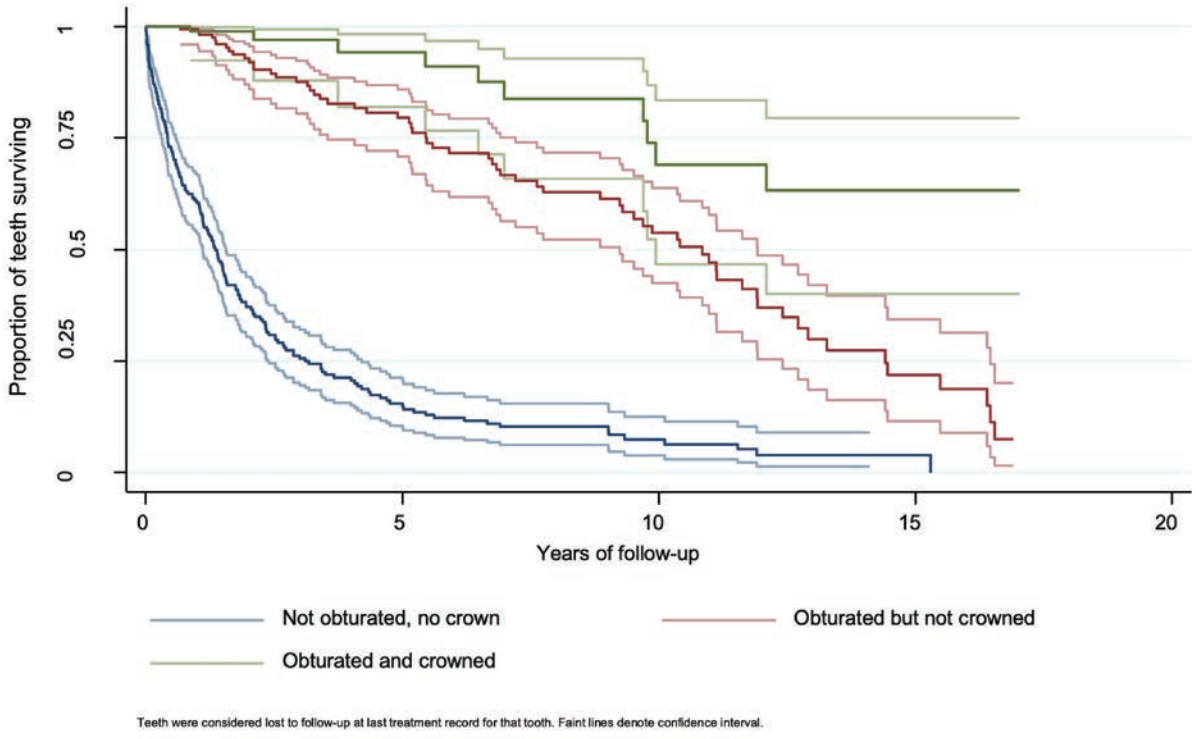

Figure 5: Survival of teeth by completion of endodontic treatment, Model 2.

et al., 2002). As a tooth with pulpectomy performed by a staff member may subsequently have RCT completed by a student and vice versa, investigating the survival of RCT relative to the provider who performed the pulpectomy is a limitation. Challenging cases are frequently referred to endodontic postgraduate staff for completion of treatment. However, endodontic and restorative assessments are carried out prior to pulpectomy, and the establishment of an accurate diagnosis, determination of prognosis and good case selection are crucial to enhancing the outcomes of RCT (Abbott, 2012).

Several covariates included in the statistical models were significantly associated with tooth survival rates. Molar teeth, especially maxillary molars, were considerably more likely to be lost following pulpectomy than non-molar teeth (Table 1, Table 2). These findings are in agreement with Ng *et al*. (2010) and Lee *et al*. (2012), who reported lower survival rates among molar teeth. This may be due to the difficulty in detecting the second mesiobuccal canal (MB2) among maxillary molar teeth or the simple fact that these teeth have more canals and thus a greater likelihood for a subsequent problem with one of these. A study of endodontic treatment performed on extracted teeth found MB2 detection rates were frequently missed using conventional techniques (Smadi and Khraisat, 2007). A lower proportion of maxillary molars with a MB2 were found during initial treatment than during retreatment, reaffirming other evidence that failure to locate and adequately treat all canals may compromise long-term prognosis (Wolcott *et al,* 2005).

The count of root canal dressing(s) a tooth has received was associated with greater risk of failure, a finding that does not feature well in the literature on treatment outcomes. Other research has indicated that enteric bacteria may more frequently be isolated from canals of teeth that had been subjected to a high number of re-dressings (Siren *et al,* 1997). Teeth that had RCT completed, including both chemo-mechanical debridement and obturation, were significantly less likely to fail than those where RCT remained incomplete. Persistent microbiological infection is one of the most common causes of endodontic failure (Tabassum and Khan, 2016) and all efforts must be made to remove all bacteria and prevent further ingress into the tooth, during and after endodontic treatment (Jensen *et al,* 2007).

Survival rates were better for anterior teeth, and this finding held after adjusting for whether or not teeth were crowned. This research did not involve assessment of individual teeth to establish whether they would benefit from treatment with a crown or not and can not be used to make such inferences. Rather, the findings of this study add to the body of evidence that survival rates for endodontic care of anterior teeth are better than for posterior teeth, with or without crowns.

A good coronal seal is crucial to ensure good RCT outcome (Lee *et al*, 2012; Eliyas *et al*, 2015). In the present study, teeth that received a crown were significantly less likely to fail than teeth that remained uncrowned following pulpectomy (Table 1, Table 2). This finding parallels several other studies showing higher survival rates of endodontically treated teeth restored with a crown than teeth restored with direct restorations only (Goga and Purton, 2007; Baba *et al*, 2014; Eliyas *et al*, 2015). This being an audit-type study, there may have been some selection bias in that teeth with the best prognosis may have been more likely to receive a crown than teeth that did not – indeed the Faculty of Dentistry has a crown assessment process in which a patient with an endodontically-treated tooth with poor prognosis would be advised against having a crown.

Conclusion

Clinicians should carefully select cases to perform pulpectomy, have an appropriate plan for ongoing care, and warn their patients of the likely outcomes if appropriate endodontic and restorative care is not completed. Clinical services should be sure to establish routine audit cycles, and these audits should report on the outcomes of pulpectomy procedures and identify potentially inappropriate care.

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