Outcomes of Primary Endodontic Therapy in Medicaid Enrollees

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OUTCOMES OF PRIMARY ENDODONTIC THERAPY IN MEDICAID ENROLLEES

by

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ABSTRACT
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Objective: Previous endodontic survival studies focus mainly on those with private insurance. The objective of this study was to determine factors affecting survival of teeth after nonsurgical root canal therapy (NSRCT) among enrollees of Wisconsin Medicaid during the years 2001-2009.

Methods: Only permanent teeth with NSRCTs and that had permanent restorations within 60 days after treatment completion were included in the analysis. Patients with less than 60 days of insurance coverage after treatment completion were excluded. NSRCTs and untoward events (extraction and other procedures indicative of endodontic failure) were identified based on Code on Dental Procedures and Nomenclature (CDT). Kaplan-Meier methods were used to plot the survival distribution for the overall cohort and subgroups by age, gender, race, tooth location, geographic area (urban vs. rural), and restoration type (crown vs. other). Univariate and multivariable Cox proportional hazards regression were used to model time from root canal restoration to extraction. Clustering within patient (the same patient may have multiple teeth with NSRCTs) was accounted for by using the sandwich estimator to obtain robust standard error estimates The multiple regression model included all baseline covariates: age, gender, race, tooth location, geography, and restoration type.

Results: After applying the inclusion and exclusion criteria, 14,281 teeth among 11,788 patients were included in the final analysis. The overall 5-year survival rate was 88.67%. Survival rates were higher among younger individuals, males, anterior teeth, and when post-operative restoration was a crown as opposed to a different restoration.

Conclusion: This study concludes that the success of primary endodontic therapy in Medicaid enrollees can be significantly improved by using post-operative crown restorations.

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INTRODUCTION

Endodontic procedures are an important part of the dental profession, allowing for the retention of teeth otherwise slated for extraction due to neuronal inflammation, necrosis of pulpal tissue, abscess, resorption, or other pathologies affecting tooth vitality and function. Endodontics as a field has evolved greatly over the centuries to become what it is today, a cutting-edge field with new technologies and a scientific basis to guide procedural changes to reflect new information. Over 15 million endodontic procedures are performed in the United States annually, with 72% performed by general dentists and 28% performed by specialists called endodontists that focus solely on root canal and related procedures (1).

Endodontic treatment is necessitated by irreversible damage to the dentin-pulp complex containing the nerves and blood vessels within the hard, mineralized matrix of the tooth. This damage can be caused by a variety of factors, most commonly large restorations, caries, or trauma. Irreversible pulpitis (inflammation of the pulp that will not resolve without intervention) and pulpal necrosis (devitalization of the pulp) are two common diagnoses that lead to primary endodontic therapy, or an endodontic procedure being performed on a tooth for the first time. Primary endodontic procedures (nonsurgical root canal therapies), despite their complex and detailed nature have a high success rate, about 90% or higher regardless of treatment being rendered by a general dentist or specialist (2). The survival or success of a tooth that has had a primary endodontic procedure has many impacting factors, both pre-operatively and post-operatively.

The following study was undertaken to focus on survival rates of teeth undergoing primary endodontic therapy in persons enrolled in Medicaid. A gap in the current

literature was identified that noted a lack of studies focusing on nonsurgical root canal therapy in Medicaid enrollees as well as its effectiveness and longevity. Nonsurgical root canal therapy was found to be twice as prevalent in those enrolled in Medicaid compared to those with private insurance. This underlies the need for more studies that focus on survival of teeth with endodontic therapy among individuals enrolled in Medicaid (3). The current study used a Wisconsin Medicaid insurance data set for a period of nine years from 2001 to 2009 and was performed using insurance claim records and enrollment data. The claims were analyzed to determine survival of teeth that received primary endodontic therapy in the dataset. Many variables were also analyzed, including age at time of endodontic procedure, patient gender, patient race, tooth location, provider geographical location, and post-operative restoration type. The large dataset along with adequate and diverse variable information allowed for this study to be investigated and analyzed.

LITERATURE REVIEW

Endodontic procedures have several goals including the elimination of microbial pathogens, complete healing of periapical pathosis, and restoration of the tooth to provide a coronal seal, tooth function, and prevention of reinfection (4). Most commonly sought due to pain, endodontic procedures aim to relieve patient symptoms, allow for healing of any pathology and retain long-term function of the tooth (5). As the dentistry has evolved over time so has the field of endodontics. Advances in endodontic treatment including improvements in instrumentation, techniques, materials, and radiography have allowed endodontics to be performed on more teeth with more predictability (6).

As endodontic procedures continue to develop with more science-based research than ever before, it is important to review how the changes affect success and survival rates clinically. Endodontics has come a long way from its recognition by the American Dental Association as a dental specialty in 1964. Organized as the American Association of Endodontists in Chicago in 1943, it oversees and guides endodontic specialty practice in the United States (7). With an emphasis on retention of the natural dentition, endodontics allows treatment of pathology that would otherwise result in extraction and prosthetic replacement. As the field of endodontics has progressed different trends have become more prevalent. These trends have become part of the standard of care or have been transient depending on increased research quality and quantity, some of which has focused on the biology of pulp tissue.

Dentin-Pulp Complex

A tooth is made up of four substances: enamel, dentin, cementum, and pulp.

Because the dentin and pulp are embryologically, histologically, and functionally the same tissue, it is considered a complex (8,9). Dental pulp has three main functions; growth and development of mineralized tissues of the tooth, sensory neural activity, and vitality of the tooth by providing oxygen and nutrients necessary for metabolic activities (10). In addition to nutrition, vital pulp also plays important roles in defense through inflammatory and immune response and protection through formation of secondary and tertiary dentin. When the pulp encounters irritation which it cannot overcome, it becomes irreversibly inflamed and will eventually necrose (10).

Pulpal Injury

Insult to the pulp leads to inflammation, or pulpitis. Depending on its severity, pulpitis can be corrected by the tooth or necessitate endodontic intervention or extraction. Because the pulp tissue is encased in the mineralized hard tissue of dentin and cementum, it is in a low compliance environment with limited ability for swelling and poor lymphatic drainage. This makes the pulp hampered in its ability to adequately defend against microbial attack or other traumas which can lead to chronic inflammation, often presenting as a “toothache” or necrosis. As microbial attack progresses, the environment becomes increasingly more complex with more bacterial diversity, becoming more anaerobic over time. The release of bacterial toxins and increased competition for nutrients causes pulp cell and tissue death (11).

Bacteriology

The goal of endodontic therapy is the relief of dental pulpitis and apical

periodontitis. As proven by Kakehashi, the presence of bacteria in pulp tissue leads to pulpitis and eventual necrosis (12). It has also been shown that bacterial spread throughout the canal system will lead to apical periodontitis (13). The relief of dental pulpitis and apical periodontitis must therefore be directed at removing any tissue in the canal system and disinfecting the area of any bacterial microbes. It is important that during endodontic procedures, that proper mechanical and chemical debridement of the canal system occurs. Despite the best possible chemo-mechanical cleaning of the canal system, bacteria can persist outside the canal system (14). If microbes persist in the apical tissues or the body forms a cyst to contain the infection, it can lead to persistent symptoms that necessitate further treatment in the future, often endodontic retreatment, apical surgery, or extraction (15). Periapical pathology has been shown to contain bacteria, virus' and fungi, showing the difficult nature of complete eradication of pulpal irritants (16–18).

Chemo-mechanical Debridement

The success of endodontic treatment depends greatly on the removal of pulp tissue and microbes from the canal system. This is accomplished through chemo-mechanical debridement in which the bulk of pulp tissue is removed physically though mechanical instrumentation while the remainder is removed through chemical dissolution. The most commonly used chemical irrigant, sodium hypochlorite, has been found to be an effective solution for killing bacteria and dissolving both necrotic and vital pulp tissue (19–21). During instrumentation a smear layer of dentin chips, mineralized collagen matrix, odontoblastic processes, and bacteria or bacterial remnants is spread

over the canal walls (22). This layer harbors irritants and its presence may affect the success of endodontic therapy, so it is often removed with an acid etchant, commonly Ethylenediaminetetraacetic acid (EDTA) (23). Alternating sodium hypochlorite and EDTA has been proven to effectively remove and dissolve pulp tissue, kill bacteria, and remove the smear layer allowing for a clean canal system that is ready to be sealed to prevent re-infection (24).

Obturation

After proper debridement and disinfection of the root canal system, it must be sealed to prevent reinfection. This obturation can be accomplished in a variety of techniques, including single-cone, lateral condensation, vertical condensation, preformed obturators, and injection techniques (25). Regardless of the technique used, they all utilize the same materials; gutta percha and sealer. The bulk of the canal filling, gutta percha, is an inert plastic rubber-like unsaturated hydrocarbon (26). While this constitutes the majority of the obturation, it does not seal well itself and is prone to leakage. An important part of the canal fill is sealer, which has been shown to decrease microleakage apically and provide a seal against reinfection of the canal system (27). No matter the technique or sealer used there will exist some amount of microleakage in the apical part of obturated roots due to the inability of sealer to provide a hermetic seal. Despite this, endodontic treatment regularly has a high level of clinical success which does not depend on the obturation method utilized (25).

Endodontic Outcomes

Endodontic therapy postoperatively can be quantified as being successful, surviving, or failing. Commonly determined based on clinical signs/symptoms and radiographic follow-up, a problem exists in that there is substantial interobserver and intraobserver disagreement in periapical radiographic interpretation of endodontic outcomes (28). A major problem is the subjective interpretation of patient-reported symptoms, quantification of questionable cases, and inherent difficulty in radiographic judgment of a three-dimensional tooth on a two-dimensional radiograph. Wu (29) found that in 2009 that then current methods of determining endodontic outcomes had questionable accuracy and reproducibility and recommended stricter evaluation criteria and long-term cone beam computed tomography (CBCT) longitudinal studies. Unfortunately, due to the relatively recent advancements in and acceptance of CBCT technology in the endodontic community, long-term CBCT outcomes studies are not as prevalent in the literature as traditional two-dimensional radiography outcomes studies.

Variables Affecting Endodontic Outcomes

Endodontic success has been shown to vary greatly depending on a variety of factors. A meta-analysis of 63 articles identified four conditions positively associated with primary root canal therapy outcome: pre-operative absence of periapical radiolucency, root filling with no voids, root filling extending to within 2mm of the radiographic apex, and satisfactory coronal restoration (30). Pre-operative presence of periapical radiolucency, absence of proximal contacts, deep periodontal pockets, and overextension of the filling material past the apex were all found to be associated with decreased prognosis of endodontic therapy (31–34). A prompt permanent coronal

restoration of high quality has been proven to be an important factor in endodontic success (35,36). Gillen found that the best success of endodontic therapy is seen in cases with adequate coronal restoration and adequate root canal filling and that an inadequacy in either of these causes a similar decrease in success rates (37). These studies highlight the effect various technical and clinical factors have on success rates. A downside of insurance-based dataset studies is the limitation of clinical and technical data available. This lack of information of clinical variables that could positively or negatively affect the prognosis of a tooth undergoing endodontic therapy has the potential to skew the results of the study but is unavoidable.

Provider Type vs. Survival Rates

Many studies detail that provider type has a significant effect on treatment success. A retrospective, chart-audit study of three practices in Alabama showed a 98.1% 5-year success rate for teeth treated by endodontists while general dentist treated teeth had a success rate of only 89.7% in the same time span (2). A more involved insurance dataset study of Delta Dental of Wisconsin that followed 487,476 nonsurgical root canals for a period of ten years showed similar results. Overall survival rates of teeth treated by endodontists and general practitioners were found to be 98% at 1 year, 92% at 5 years, and 86% at 10 years. There was a statistical significance of molars at 5 years and all tooth types at 10 years. The most marked difference in survival occurred in molars at 10 years, with endodontist-treated teeth having a higher rate of survival (89%) compared to general practitioners (84%) (38).

The difference in endodontic outcomes is important to consider when studying Medicaid data. Endodontics as a specialty has very low Medicaid acceptance, with only 6% of endodontists in Iowa in 2005 found to fully participate in Medicaid (3). Current polls of Medicaid acceptance by endodontists do not show an increase from the rate studied in 2005. This means endodontic procedures done on those enrolled with Medicaid are much more likely to be done by general dentists. It is uncertain if provider training and proficiency is the main factor in the survival rate differences, as with any insurance data study there are many variables that cannot be measured.

Private Insurance Survival Rates

The gap in the literature this study addresses is the lack of studies looking purely at Medicaid data for survival of primary endodontic therapy for analysis and comparison with studies that look at success and survival in private insurance. A 2001 study by Lazarski found that in persons enrolled with private insurance numbering 44,613 cases, 94.44% of nonsurgical root canal treated teeth remained functional after an average follow-up time of 3.5 years (39). Another private insurance based study by Burry followed 487,476 nonsurgical root canal treatments and found success rates to be 98% at 1 year, 92% at 5 years, and 86% at 10 years (38). Salehrabi's epidemiologic study in 2004 found from a dataset of 1,462,936 teeth that had undergone nonsurgical root canal therapy, 97% of them were retained in the oral cavity after 8 years. He also found that of extracted teeth, 85% of them had no full coronal coverage restoration (crown) (40). This was supported by Friedman's review of outcomes studies in 2004 that found that 10 years after primary endodontic therapy the rate of functional tooth retention approaches or

exceeds 95% (41). Overall, the literature supports that nonsurgical root canal treatment is a procedure with a high probability of success/survival regardless of the many pre-operative and post-operative variables that can affect healing.

Provider Bias

There have been many studies to investigate if provider type (specialist vs. general dentist) has an influence on treatment decisions. Due to high success rates and greater treatment plan flexibility in the future, primary stage endodontic therapy or retreatment are advised prior to extraction and implant placement unless a tooth is deemed unrestorable (42). Regardless of this, there exists a marked difference between dental providers when treatment planning for an endodontically involved tooth. Aminosharieae found that when a tooth presented with endodontic pathology, general dentists were much more likely to recommend extraction and implant placement than nonsurgical endodontic treatment (43). This finding was independent of insurance status, showing that general dentists may have a superior view of implants over endodontic therapy and may subsequently drive treatment more towards implant therapy. With these biases, many teeth that could be retained with appropriate endodontic and restorative therapy are extracted and replaced with prostheses or implants.

Endodontic Therapy vs. Extraction and Implant Placement

A tooth presenting with endodontic pathology has other treatment options, mainly no treatment or extraction. If extracted, often the edentulous space is recommended to have an implant and prosthetic coronal replacement. Many factors must be considered

when treatment planning an endodontic procedure or extraction and implant placement, including pulpal and periodontal conditions, quantity and quality of bone and soft tissue present, potential for procedural complications, required adjunctive procedures, and treatment outcomes. Patient-related factors must also reviewed, notably systemic and oral health, comfort, and perceptions of different treatments (44). In a restorable tooth, nonsurgical root canal therapy was found to have a 22-month success rate of 99.3% compared to a 98.4% success rate of implants at 36 months. This difference was not significant, and even when uncertain findings were factored it, dropping success of implants to 87.6% and endodontic success to 90.2% the difference remained non-significant. It was found, however, that teeth that had endodontics performed only needed post-operative interventions 1.3% of the time, whereas implants needed interventions 12.4% of the time, a statistically significant difference. While endodontic and implant success have no statistical difference, endodontic intervention is generally recommended due to less post-operative treatments needed to maintain success (45). Even when multiple risk factors are present that appear to jeopardize the survival of a compromised tooth in need of endodontic therapy, the survival of such teeth surpasses that of implants over a ten year period (46,47).

Endodontics among Medicaid Enrollees

Medicaid is a federal or state program in the United States that helps provide medical and dental care to patients with low income. A major barrier for Medicaid-eligible persons is the lack of providers who accept their insurance. Medicaid often pays providers well below what they would receive from private insurance or uninsured

patients for procedures and is accompanied by taxing documentation requirements and administrative processes. A 2008 study found that reimbursement increases for Medicaid procedures increased Medicaid provider participation by at least one-third and in some states over doubled. It advocated for reimbursement rates which at least cover a procedure's providing cost, or about 60 to 65 percent of a charged fee at a standard dental office. Even if reimbursement rates were to increase, it was found to be insufficient on its own. The study also advocated for less stringent administrative processes and increased involvement of state dental societies as active partners in providing care to low-income persons (48).

The procedures covered by Medicaid, especially in dentistry, varies greatly from state to state. While many states may have benefits for children or emergency procedures, adult and preventative coverage are seen in far fewer places. An analysis of Medicaid policy from 2000 to 2012 showed that between 22 and 27 states, depending on the year, covered adult preventative and/or restorative dental services. The other 23 to 28 states had no coverage or emergency services only. While emergency service coverage can alleviate pain and infection, the lack of preventative or restorative care makes Medicaid enrollees more vulnerable to dental disease progression and further need for emergency services in the future (49). The lack of preventative services or adult coverage also leads to strains on the medical system as a safety-net caused by dental problems.

Inadequate Medicaid coverage for dental procedures negatively affects the medical system. The elimination of adult dental coverage in California lead to a dramatic and immediate increase in emergency visits for dental pain (50). A 2015 Oregon study found that non-traumatic dental problems accounted for 2.5% of all emergency room

visits, most commonly seen in uninsured and Medicaid enrollees, and costing over $400 in hospital costs on average (51). The emergency department is unable to provide definitive treatment, often only providing analgesics and/or antibiotics, unable to solve the underlying issue. This results in a repeat emergency department visit due to persistent symptoms at a rate of about 20% (52).

Root canal therapy is not considered an emergency procedure by Medicaid and access is often limited due to lack of coverage and providers. If a nonsurgical root canal procedure is covered, it may require a pre-authorization before work can be initiated, especially on a molar tooth. If a person is in pain, they may not be willing or able to wait for the paperwork to be processed and may elect alternative treatment options that can be done quicker, often extraction. A 2005 study comparing dental services received by Medicaid enrollees and privately insured adults found that persons with Medicaid were 300 times more likely to have an extraction than an endodontic procedure compared to a person with private insurance. This vast discrepancy may be due to carious extent and restorability concerns, fewer restorative options, higher periodontal disease rate, and patient concerns about need for multiple visit treatment. It has been shown that Medicaid-accepting providers may also hold a bias towards extraction (3).

A multitude of variables creates barriers for endodontic procedures for Medicaid enrollees. Access to care issues abound with varying coverage by state, age, and procedure, as well as geographical limitations and selective providers who accept Medicaid. Few endodontists if any accept Medicaid and there exist limitations to procedural coverage and possible lengthy pre-authorizations. Those who are enrolled with Medicaid, often those with low-income, have decreased access to endodontic

procedures and are particularly vulnerable to having limited options to treat an endodontically involved tooth. This may lead to many teeth that are restorable with endodontic therapy being extracted due to access, financial, or travel concerns. Overall, extraction of an endodontically involved tooth in Medicaid enrollees is seen much more frequently than an endodontic and restorative procedure (3).

Wisconsin is a progressive state when it comes to Medicaid coverage. It has inclusive coverage for adult preventive and many restorative procedures, allowing for patients to receive comprehensive care including endodontic procedures. Endodontic procedures may be covered, but there may be the need for pre-authorizations of the procedures which may delay treatment or cause a person to choose an extraction which may provide immediate relief. One other deficiency in Wisconsin Medicaid coverage is a lack of coverage for full cuspal restorations. Despite its more expansive coverage than many other states, Wisconsin Medicaid still has many barriers not seen or less frequent in private insurance. As has been shown in previous studies, there exists differences in treatments prescribed and undertaken in Medicaid and private insurance enrollees. Furthermore, there exists a statistically significant difference in endodontic success over time in patients treated by a general dentist and specialist. To address the gap in the literature focusing on primary endodontic treatment outcomes in Medicaid enrollees this study was undertaken.

MATERIALS AND METHODS

The data used for this study was obtained from the Wisconsin Medicaid electronic enrollment and claims database between January 1, 2001 and December 31, 2009. The data set contained 1,550,025 total patients, of which 27,928 had root canal therapy totaling 33,345 teeth. Exclusion criteria filtered out primary teeth, teeth that were not restored within 60 days of the root canal therapy, and patients with less than 60 days of insurance coverage after treatment was completed. Nonsurgical root canals and untoward events (extraction and other evidence of treatment failure) were identified based on Code of Dental Procedures and Nomenclature (CDT) codes, as they are used universally to document dental treatment procedures for patient health records and for insurance claims. After the exclusion criteria were applied, 11,788 eligible patients with nonsurgical root canal therapy and restoration within 60 days of the root canal therapy, totaling 14,281 teeth, were included for the study.

Initiating events for this study (Table 1) were anterior endodontic procedures (D3310), premolar endodontic procedures (D3320) and molar endodontic procedures (D3330) on permanent teeth (#1-32). Any primary tooth, tooth with no evidence of permanent restoration within 60 days of endodontic therapy, and patients without 60 days continual insurance coverage after endodontic therapy were excluded from the study.

CDT Code	Procedure
D3310	Endodontic Therapy- Anterior
D3320	Endodontic Therapy- Premolar
D3330	Endodontic Therapy- Molar

Table 1: Initiating event CDT codes

Treatments were considered successful until the patient's enrollment lapsed, or an untoward event occurred. Untoward events included procedures that indicate failure of endodontic treatment or non-restorability of the tooth including extraction (D7140, D7210, D7250), endodontic retreatment (D3346, D3347, D3348) and root-end surgery (D3410, D3421, D3425).

Untoward Event	CDT code
Extraction	D7140 D7210 D7250
Endodontic Retreatment	D3346 D3347 D3348
Root Surgery- apicoectomy	D3410 D3421 D3425

Table 2: Untoward event CDT codes

Additional information collected for each NSRCT encounter from the insurance data based included patient age, gender, race, tooth location, provider type, provider location (urban vs. rural), and restoration type. Patient age was subdivided into age groups ranging from 5 to 17 years, 18 to 29 years, 30 to 49 years, and fifty years and older. Gender was divided into male and female. Race subdivisions included Hispanic, Non-Hispanic Black, Non-Hispanic White, and Other/Unknown. Tooth location was categorized by anterior (incisors and canines), premolar, and molar teeth. Provider type were all listed under "dentist", so no determination of general dentist or specialist provider type could be determined from the dataset. Provider location was determined to be urban or rural by its classification as a combined statistical area (CSA). An urban designation was given to a CSA area, which a non-CSA area was given a rural designation. Restoration type was differentiated between crown and "other", which was any type of restoration besides a crown.

Data analysis was done via Kaplan-Meier methods to plot the unadjusted survival distribution for the overall cohort and subgroups by pt age, gender, race, tooth location, geographic area, and restoration type. Kaplan-Meier curves were plotted for each variable using a significance value of $p < 0.05$. Univariate and multivariable Cox proportional hazard regressions were used to model time from tooth restoration to extraction. Patient clustering (one patient having multiple teeth that underwent root canal procedures) were accounted for by using a sandwich estimator to obtain robust standard error estimates.

RESULTS

After the exclusion criteria were applied to the dataset, 11,788 patients with 14,281 qualifying nonsurgical root canal treatments were identified (Table 3). The location of teeth in the data set favored anterior teeth (37.3%) over molar (34.8%) and premolar (27.9%) teeth. The data set featured more females (64.8%) and Non-Hispanic Whites (71.7%). The root canals were mostly performed in an urban setting (72.0%) and were restored infrequently with a crown (13.4%).

All Root Canals: N=14281	
Age at RC	
Mean (SD)	30.85 (15.79)
Median [Q1, Q3]	28.00 [17.00, 41.00]
Min, Max	5.00, 97.00
Age at RC (categories)	
5-17	3961 (27.7%)
18-29	3566 (25.0%)
30-49	5006 (35.1%)
50+	1748 (12.2%)
Gender	
Male	5031 (35.2%)
Female	9250 (64.8%)
Race	
Hispanic	604 (4.2%)
Non-Hispanic Black	909 (6.4%)
Non-Hispanic White	10238 (71.7%)
Other/unknown	2530 (17.7%)
RC tooth location	

Anterior	5330 (37.3%)
Pre-Molar	3984 (27.9%)
Molar	4967 (34.8%)
RC provider	
Dentist	14281 (100.0%)
RC provider location	
Rural (Non-CSA)	3996 (28.0%)
Urban (CSA)	10285 (72.0%)
RC restoration type (within 60 days)	
Crown	1912 (13.4%)
Other	12369 (86.6%)
Post-RC follow-up (years)	
Mean (SD)	2.24 (1.79)
Median [Q1, Q3]	1.73 [0.81, 3.20]
Min, Max	0.16, 8.91

Table 3: Summary of Variables for Initiating Events

Of the teeth undergoing nonsurgical root canal therapy, the overall five-year survival rate was found to be 88.67% (Figure 7, Table 4). After five years the data set suffered a lack of accuracy at the individual level due to very few people having stable coverage beyond that time. Because of this, the analyses of the study were performed to include data for five years to increase their accuracy.

Survival rates were found to correlate positively with several of the measured variables. It was found that the younger a patient was at the time of the root canal therapy, the greater were the survival rates compared to those of older age groups (Figure 1). The gap between survival rates and age increased as time elapsed from the root canal therapy. Males were found to have a statistically higher survival rate than females (Figure

2). When race was accounted for, it was found that Hispanics showed the highest level of survival where-as Non-Hispanic Blacks had the lowest survival rates (Figure 3). This was the only statistically significant racial difference; all other race comparisons were not statistically significant (Table 5). Tooth location was shown to play a role in survival, with more anterior teeth surviving at five years than both premolar and molar teeth (Figure 4). A higher degree of five-year survival of endodontically treated teeth was shown in those restored with crowns over teeth receiving "other" restorations (Figure 6). No statistical difference was found between root canals performed in an urban or rural setting (Figure 5).

The Univariate results in the following figures are from Cox proportional hazards regression. They account for no other variables and focus solely on whether a variable in and of itself is significant. The results show significance in the following variables over a five-year span: age at time of root canal therapy (Figure 1), gender (Figure 2), tooth location (Figure 4), and restoration type after root canal (Figure 6).

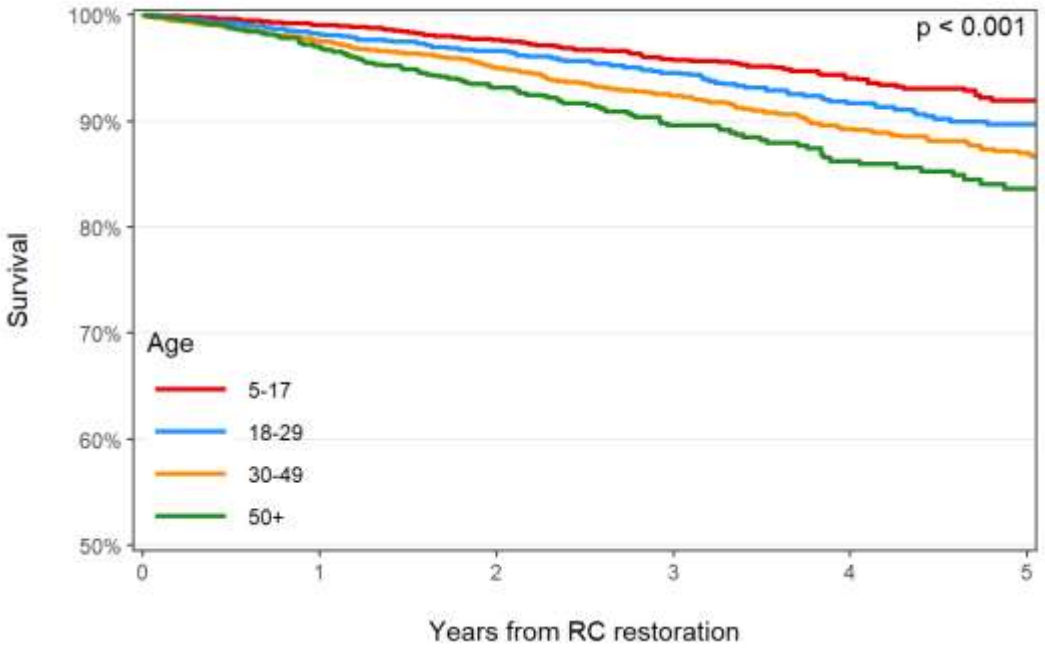

Figure 1: Survival estimates of all teeth based on age

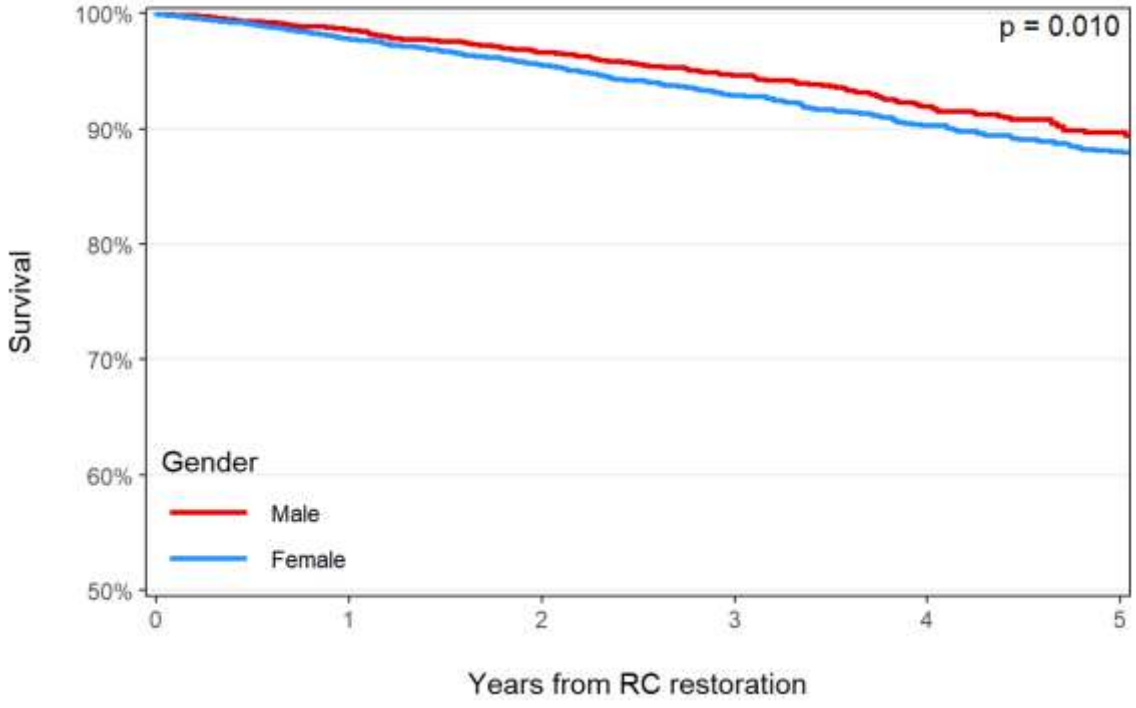

Figure 2: Survival estimates of all teeth based on gender

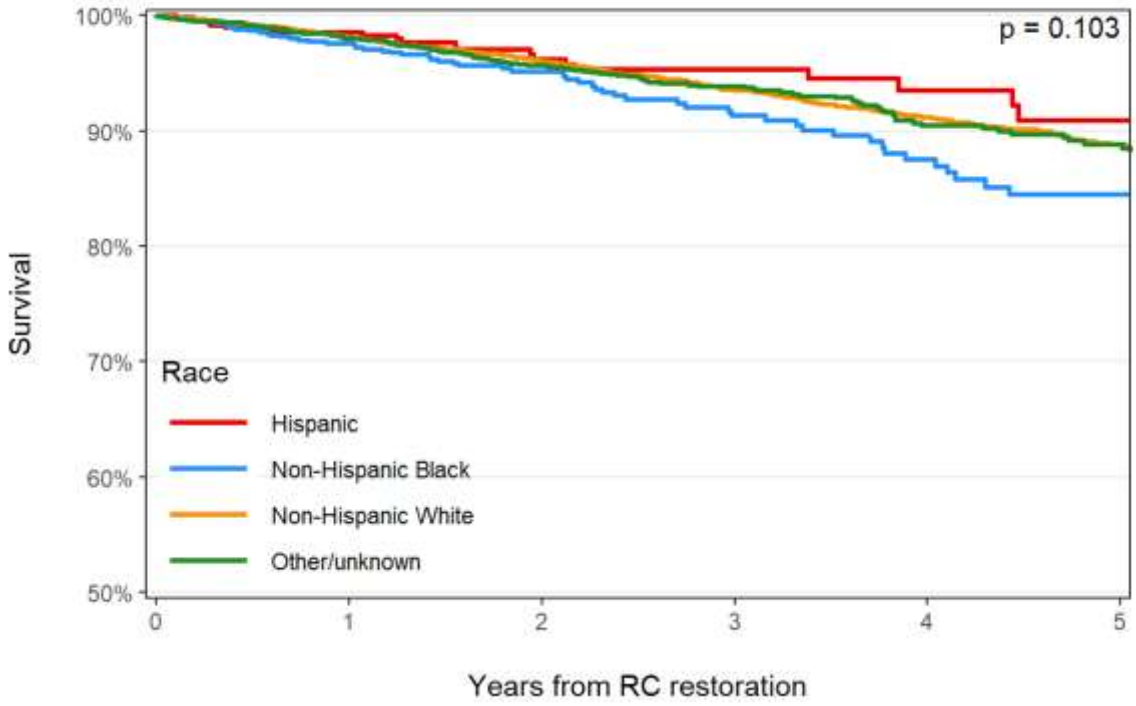

Figure 3: Survival estimates of all teeth based on race

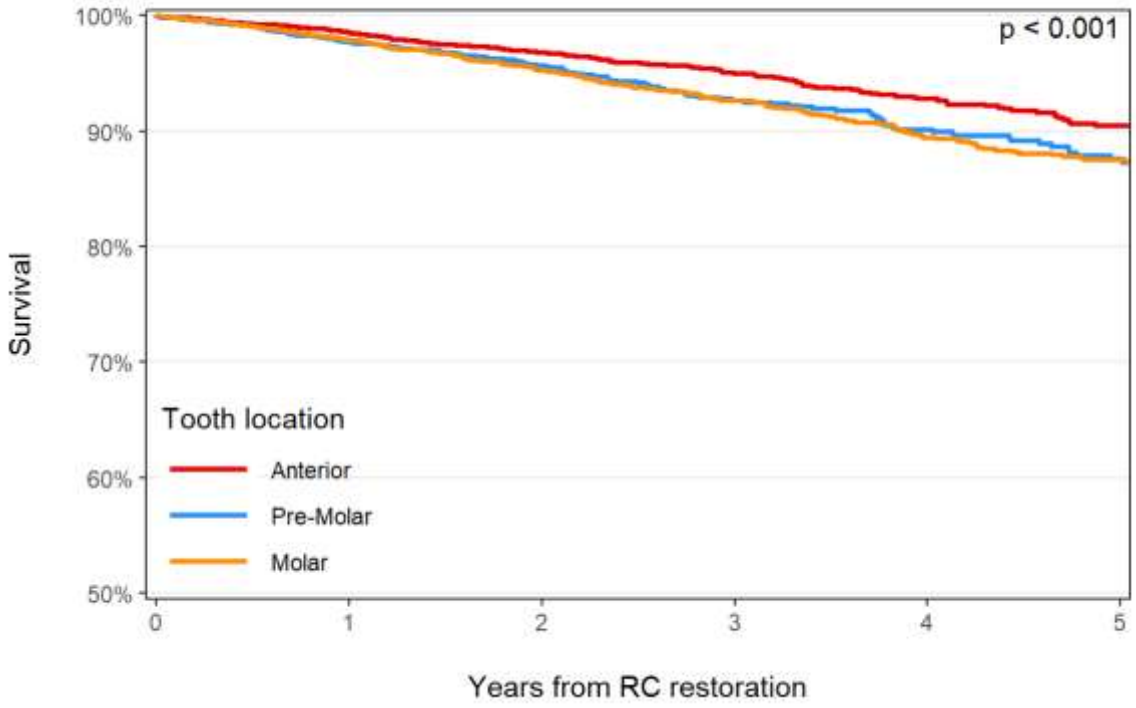

Figure 4: Survival estimates based on tooth location

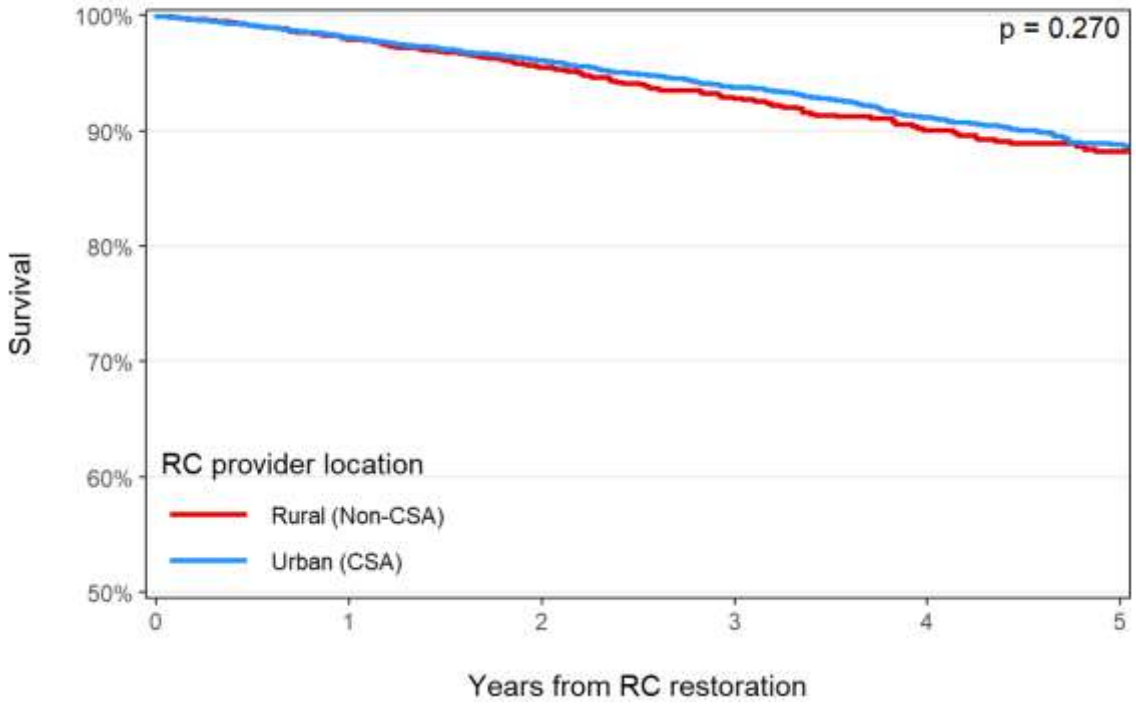

Figure 5: Survival estimates of all teeth based on provider geographic location

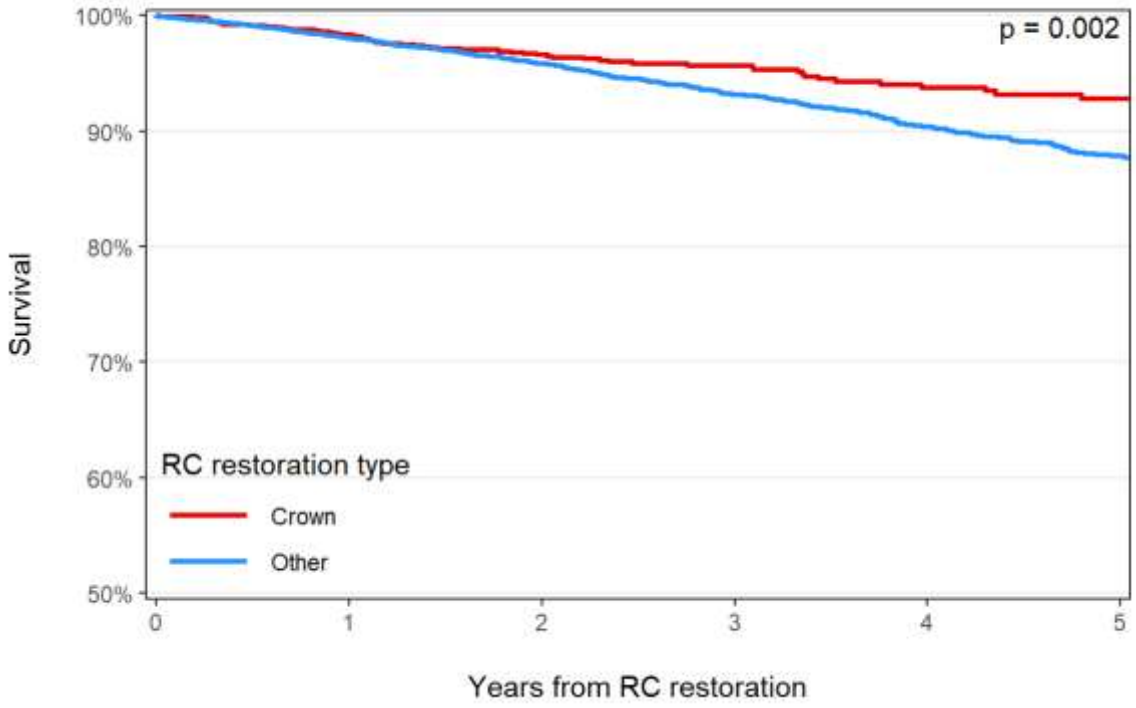

Figure 6: Survival estimates of all teeth based on restoration type

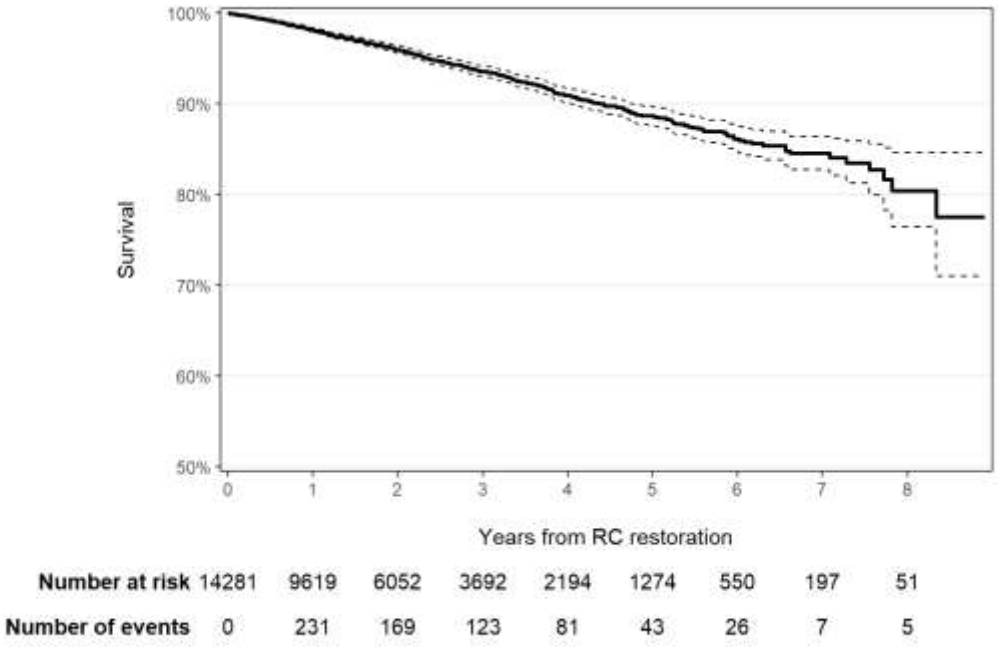

Figure 7: Survival analysis for extraction of all teeth

Year	Survival	N events	N at risk
0	100.00%	0	14281
1	98.09% [97.84%, 98.33%]	231	9619
2	95.96% [95.57%, 96.37%]	169	6052
3	93.55% [92.98%, 94.13%]	123	3692
4	90.89% [90.09%, 91.70%]	81	2194
5	88.67% [87.65%, 89.70%]	43	1274

Table 4: Survival data analysis for extraction of all teeth

Multiple Cox proportional hazard regression analysis allowed for interpretation of the different variables and determination of their significance (Table 5). There was a stronger predilection for tooth survival in younger patients than older patients, showing the importance of age and endodontic procedure survival. The age group 5-17 years of

age was used as reference, with all other age groups (18-29 years, 30-49 years, and fifty years and older) having significantly higher hazard rates. The hazard ratio significance increased dramatically with each age group, from 1.50 in age 18 to 29 years to 2.05 for age 30-49 years to 2.83 for ages fifty years and older. This shows that as the patient age at time of root canal increases, the survival rate decreases.

When gender variables were analyzed it was shown that there was a significant difference between survival rates, with males having more survival than females. Hispanics were used as a reference for the race variable because of their higher survival rates. Survival rates were shown to be statistically significant between Non-Hispanic Blacks vs. Hispanic ($p=0.025$), but no significance was found between Hispanics and Non-Hispanic Whites and Other/unknowns. No statistically significant difference was noted between urban and rural provider geographic location.

Tooth location was found to be a significant factor in survival rate, with anterior teeth showing the best survival and molars showing the worst survival at five years. There was a statistically significant difference between root canal teeth restored with crowns over those with other types of restorations.

Variable	aHR	95% CI	p-value
Age			
18-29 vs. 5-17	1.50	[1.13, 1.99]	0.004
30-49 vs. 5-17	2.05	[1.60, 2.61]	< 0.001
50+ vs. 5-17	2.83	[2.17, 3.70]	< 0.001
Gender			
Female vs. Male	1.15	[0.95, 1.38]	0.145
Race			
Non-Hispanic Black vs. Hispanic	1.82	[1.08, 3.08]	0.025
Non-Hispanic White vs. Hispanic	1.07	[0.67, 1.72]	0.783
Other/unknown vs. Hispanic	1.20	[0.73, 1.96]	0.476
Tooth location			
Pre-Molar vs. Anterior	1.24	[1.00, 1.55]	0.048
Molar vs. Anterior	1.74	[1.43, 2.13]	< 0.001
RC provider location			
Urban (CSA) vs. Rural (Non-CSA)	0.89	[0.74, 1.06]	0.189
RC restoration type			
Other vs. Crown	1.63	[1.21, 2.18]	0.001

Multiple CoxPH Regression, N = 14281, Events = 686

Table 5: Hazard Ratios and Confidence Intervals for Variables

DISCUSSION

This study's primary objective was to identify variables affecting the survival of endodontically-treated teeth in Medicaid enrollees. Use of a Wisconsin Medicaid insurance dataset spanning nine years allowed for a large dataset for analysis, thereby allowing for more meaningful results. This study was undertaken to address a gap in the literature focusing on nonsurgical root canal therapy outcomes in Medicaid enrollees. It looked at several variables included in the dataset to determine if any correlated with improved or decreased survival rates. The Wisconsin Medicaid dataset used provided a large sample size allowing increased power of the findings.

The data used for this study focused on primary endodontic nonsurgical root canal therapy performed on the permanent dentition. Exclusion criteria were applied to remove endodontic therapy on teeth that were not restored within 60 days of endodontic therapy and in persons who did not have insurance coverage for 60 days after completion of endodontic therapy. These exclusion criteria were applied to mitigate possible coronal leakage that may have occurred after the root canal was performed. It has been shown that any non-sealed tooth exposed to the oral environment for more than ninety days would have significant bacterial leakage that would necessitate retreatment (36,53,54). In the period between obturation and ninety days, as shown in the study by Magura et al., it is difficult to determine the amount of microleakage that may have occurred in exposed gutta percha (54). He advocates for clinical judgment to be used in any time between one month and three months of exposed gutta percha to the oral environment due to this difficulty in determining microleakage amount during this time period, as it is unknown if leakage is a gradual phenomenon or if there exists a saliva and bacterial accelerated

penetration spike early on after exposure. Because of the inability to determine the extent of microleakage during this timeframe, sixty days was chosen as the exclusion criteria as it was in between one and three months post-endodontic therapy.

Teeth that were not restored within sixty days of endodontic therapy cannot be assured to have an adequate coronal seal and with an increased likelihood of leakage after endodontic therapy, and hence treatment failure, these teeth were excluded from the study. Any patient who did not have insurance for at least sixty days post-op were also excluded to allow for a more continual, longitudinal data set and assurance that the teeth were restored within sixty days of endodontic treatment completion. Nonsurgical root canal therapy performed on primary teeth was also an exclusion criterion. Primary tooth endodontic procedures are not comparable to those performed in permanent teeth due to different anatomy and root forms, as well as the temporary status intraorally of the primary dentition (55). This study focused solely on endodontic procedures on the permanent dentition.

Untoward events were classified as procedures indicating restorative or endodontic failure: extraction, endodontic retreatment, or endodontic surgery (apicoectomy). These codes indicate further treatment to the tooth and its lack of survival with the initial endodontic therapy thereby revealing its failure. This is consistent with other insurance-based studies and allows comparison between their findings and those of this study (38). By identifying procedures indicative of additional intervention to the tooth it is known that the initial treatment was not successful. This does not, however, allow for a distinction between a failure due to endodontic reasons or restorative reasons, which is one drawback of this study. Failure of primary endodontic procedures, even

those that have been performed well can happened for a variety of reasons. These can include but are not limited to microbial factors (both intraradicular and extraradicular), overfilling canal space, and poor coronal seal (56). Without further information that the dataset does not provide, it is impossible to know the cause of the endodontic failure, whether it is microbial, procedural, or restorative.

There are several other drawbacks to this study which was only possible with an available insurance dataset. There is a lack of clinical information which does not allow for determination of prognosis before the procedure was started. As shown by Oviir, prognosis is affected by many pre-operative factors, including tooth vitality status and the presence or absence of radiographic lesions (57). The dataset did not include information such as pulpal and periapical status, remaining tooth structure or current restorations for analysis. The clinical proficiency of the provider or their procedures are not able to be evaluated so there is no way to determine if the endodontic or subsequent restorative procedures were done to a high clinical standard. These limitations are offset somewhat by the large dataset used but must be considered when evaluating the results.

An insurance-based study relies on coded procedures, in this instance CDT coded procedures due to their universal use among dentists. Despite all precautions taken by provider offices, there could be incorrect code use which could affect data accuracy and lead to erroneous datapoints. There also is no way to determine the cause of an untoward event. Many things can happen the lead to non-restorability of teeth that are unrelated to the success of endodontic therapy and without clinical information, it cannot be known if the loss of tooth retention is due to endodontic, restorative, or other types of failure.

Another factor unable to be accounted for in an insurance-based study is patient driven factors. Endodontic procedures may be successful at removing pathology but in the absence of adequate dental hygiene and proper diet the tooth structure and restoration may be compromised at an accelerated rate. Caplan et. al found that persons with more missing teeth and plaque had accelerated loss of root-canal treated teeth (58). No information about pre-existing medical conditions that may affect the dentition, salivary quantity or quality, or patient ability to perform adequate dental hygiene was available in the dataset and therefore cannot be evaluated along with the other studies variables.

One more potential factor affecting the outcome of this study is the inability to review the pre-operative pulpal and periapical status of the teeth being treated. Success rates at 10 years have been found to vary greatly, from 96% in teeth without periapical lesions to 86% in teeth with periapical lesions and 62% in retreatments on teeth with periapical lesions (31). This wide range of success rates further highlights the importance of preoperative diagnoses to prognosis and treatment outcomes, which are unable to be studied with the insurance dataset therefore potentially skewing the data. Furthermore, many Medicaid plans require pre-authorization for molar teeth, prolonging the period from symptoms to initial diagnosis by a general dentist to referral and/or eventual treatment. The time elapsed allows for disease progression and may contribute to increased incidence of necrosis and periapical lesions.

Despite the limitations inherent in insurance-based data the results of this study detail important information. This is the first study performed on a large scale to look at primary endodontic success rates in those enrolled in Medicaid, allowing comparison with previous studies detailing primary endodontic success rates in private insurance

populations. Of the 14,281 teeth included in the study, after five years it was determined that the primary endodontic survival was 88.67%. This is similar to other studies findings of survival rates at five years between 84% and 92% (38,59,60). This comparable rate in both Medicaid and private insurance enrollees shows that endodontic survival rate is independent of insurance status.

The variables analyzed showed four significant factors for tooth survival. Age (younger patients), gender (male), tooth location (anterior), and post-op restoration (full coverage crown) were all found to positively correlate with tooth survival after endodontic treatment. Race was found to be a significant factor only between Hispanics and non-Hispanic blacks and no other racial comparisons. All these variables have been studied either as the focus or part of other research, allowing for comparisons to be made between the existing literature and our findings.

Age as an affecting factor for root canal treatment success or survival has been heavily studied. According to a very thorough review of the literature, Friedman found that age and gender had no effect in all studies on preoperative apical periodontitis (61). That finding is further backed by a Shakiba through a review of 24 articles finding increased age had no effect on root canal success or survival rates (62). These contrast with our findings which are supported by other studies. Caplan et. al found that older age is found to be a significant factor in root-canal treated tooth loss and posed that it may be due to the increased prevalence of periodontitis in older populations (58). This was supported by Hargreaves et al. who found that for each subsequent decade, a patient's risk, independent of gender, for extraction after endodontic therapy increases 1-2% for each decade until a plateau at age 60 and older (39). With studies finding varying results

as to whether a patients age affects root canal treatment success and survival, it is yet unknown definitively and should be further studied.

The result that males had statistically higher survival rate than females contradicts the findings of many studies that find that gender has no bearing on post-endodontic survival rates (39,63,64). This difference may be due to several factors. The dataset was roughly two-thirds female and one-third male, making each male that dropped out of the study a more significant event. It has also been shown that males are less likely to seek dental care preventatively and when they are asymptomatic (65,66). Males have been shown to have a predilection to seek emergency care for endodontic pain at a much higher proportion than females (67). Since the survival of the endodontically treated tooth is the only information we can glean from the dataset and males are less likely to attend routine appointments, there could be a higher proportion of failing cases that are not in the dataset. A tooth that may be symptomatic enough to warrant a visit to the dentist for a female may be less than that for a male, therefore skewing our results.

Tooth location has been found to be an important prognostic factor in many studies. Imura found that molar teeth had significantly lower success rates than anterior and premolar teeth (68). This was supported by Lee, who found molars to have the highest incidence of post-treatment disease and lowest survival times (63). It has been posed that molar success rates may be less due to them erupting earlier in one's life when oral hygiene may be lacking as well as more complex anatomy. It may also be due to molars being located further posterior and closer to the axis of rotation, therefore being under more forces during function. Our results agreed with Imura and Lee, finding anterior teeth to have significantly higher survival than premolars and molars.

The last variable found to hold significance in tooth survival after root canal therapy was post-operative restoration with a full coverage crown. This supports the findings of Aquilino and Caplan, in which they found that endodontically treated teeth not restored post-operatively with a crown were lost six times faster than if they were (69). Full cuspal coverage restoration post-operatively with satisfactory tooth/restoration margin were found in many studies to positively correlate with endodontic treatment survival and success (63,70). A full coverage restoration provides a good restorative seal as well as fracture resistance, which has been shown to be as important as a high quality obturation in the success of the endodontically treated tooth (37). Our finding and its correlation with other studies supports the notion that endodontically treated teeth should be restored with a full coverage crown post-operatively in a person enrolled in Medicaid.

After five years the data set was not as accurate due to the number of encounters which had lapsed coverage, making them no longer eligible to ensure accuracy in the statistical findings. While this limits the study strength by not having as long of a follow-up time, it still allows for significant evaluation of the data set for comparison with other studies and their five-year survival or success rates. Despite the many drawbacks of an insurance data study, the amount of data and variables available for analysis in the dataset allowed for a good, comprehensive study to be performed. The main finding of the study supports full cuspal coverage restorations after endodontic therapy to improve survival. Further studies are needed to investigate this finding, but if consistent evidence is found supporting crowns after primary endodontic therapy, changes should be made to Medicaid coverage to allow for crowns post-operatively.

CONCLUSION

This study is the first Medicaid-based study to look at factors that affect nonsurgical root canal survival. After the application of exclusion criteria and factoring in discontinued insurance coverage of patients, the analysis of the nine-year dataset allowed for an accurate dataset for of five years duration for study. The study revealed a five-year survival rate of 86.67%. More anterior teeth are surviving at five years and increased survival rates were found in patients who were younger, male, Hispanic, and on teeth located restored with a crown post-operatively. As a patients age, gender, and race are not self-controllable variables, the main result of this study shows a positive correlation between full-coverage crown restorations after nonsurgical root canal therapy and tooth survival. This likely is due to a transfer of forces to the crown margin and negation of the wedging effect seen in non-crowned teeth, therefore make more favorable loading (71). Further research should be performed and if consistent and agreeing results are noted, a push for changes in Medicaid coverage to include post-operative full-coverage coronal restorations should be made for endodontically treated teeth.

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