OUTCOME OF ENDODONTICALLY TREATED CRACKED TEETH

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CERTIFICATE OF APPROVAL

MASTER'S THESIS

This is to certify that the Master's thesis of

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NAVAL POSTGRADUATE DENTAL SCHOOL
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ABSTRACT

OUTCOME OF ENDODONTICALLY TREATED CRACKED TEETH

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Introduction: The American Association of Endodontists defines a crack tooth as a thin surface disruption of enamel, dentin, and possibly cementum, of unknown depth and extension. When pulpal or apical disease is present, non-surgical root canal treatment (NSRCT) is often indicated. To date, there are limited studies evaluating the outcomes of endodontically treated cracked teeth. **Objectives**: This in-vivo, observational study evaluated: 1) the outcome of cracked teeth receiving initial NSRCT, and 2) co-variant factors affecting the outcome. **Method**: Patients diagnosed with a crack tooth requiring NSRCT were asked to enroll as subjects. Data related to subject demographics, clinical presentation, and treatment details were collected on standardized forms. Annual follow up examinations collecting clinical and radiographic data were completed for 5 years. Radiographic scoring, using a modified PAI scoring system (1-5), was preformed by 3 calibrated, board certified endodontists. Treatment outcomes, survival and functionality

were assessed. A sample size of 250 teeth is required to adequately power the study. **Results**: Forty-three teeth were available for interim analysis, 10 were verified as extracted and 1 excluded from outcome assessment due to a PAI score of 3 (unsure). The subject's tooth was considered healed in the absence of clinical symptoms and a PAI score of 1 or 2. The healed rate was determined to be 81% (n=26). Functional teeth made up 91% (n=30) which was defined by lack of clinical symptoms. The survivability was determined to be 77% (n=33). There was insufficient data to evaluate co-variant factors affecting the outcome. **Conclusion**: This interim analysis of retrospective and prospective data indicated cracked teeth requiring NSRCT had an 81% healed rate, a 91% functional rate, and a 77% survival rate indicative of a favorable outcome.

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INTRODUCTION

Gibbs, in 1954, first described the clinical symptoms associated with incomplete fractures of posterior teeth involving the cusp and termed this "cuspal fracture odontalgia." Cases of incomplete fracture with pulpitis were subsequently reported by Ritchey et al. in 1957 and Cameron introduced the term "cracked-tooth syndrome" in 1964 (Hasan, et al. 2015). Numerous classification systems have been proposed to describe the subset of clinical manifestations presenting as "cracked tooth" (American Association of Endodontists 2008). To date however, the cracked tooth continues to remain a difficult entity for all practitioners, including those highly experienced, to correctly diagnose and successfully treat.

It has been stated that the crack is not the disease, rather it is the cause of one or more diseases (Abbott and Leow 2009). The present standard for defining the subset of causes of disease is the American Association of Endodontists (AAE) publication, "Cracking the Cracked Tooth Code." The AAE defines five types of longitudinal tooth fractures; craze lines, fractured cusp, cracked tooth, spilt tooth and vertical root fracture. Craze lines only affect the enamel; they cause no pain and are of no concern beyond aesthetic. Fractured cusp is defined as a complete or incomplete fracture initiated from the crown and extending subgingivally. Cracked tooth is an incomplete fracture initiating from the crown, extending subgingivally, and usually oriented in a mesiodistal direction. Split tooth is a complete fracture initiating from the crown and extending subgingivally, usually directed mesiodistally through both marginal ridges and proximal surfaces. A "true" vertical root fracture is a complete or incomplete fracture initiating from the root at any level and usually directed buccolingually (American Association of Endodontists 2008). This

manuscript details the diagnostic clues, prognosis and treatment planning considerations for each of the five categories of tooth fracture.

ETIOLOGY

There are multiple variables associated with the 5 categories previously defined and each variables level of importance is weighed differently in the literature. According to Hasan et el., cracked tooth syndrome has a multi-factorial etiology that can be divided into four categories; restorative procedures, occlusal factors, developmental factors, and miscellaneous factors (Hasan, et al. 2015). Abou-Rass categorized probable causes of tooth cracks to include structural design of cavity preparations, trauma from parafunctional forces, restorative procedures, injury to the face or mouth and thermal expansion (Abou-Rass 1983).

Throughout the literature on crack teeth, it has been stated that wear was present on the occlusal surface of all teeth with cracks in older patients. Hiatt et al. described as wear occurs, the broadened cusps exerts tension stress on the opposing fossa, which is not as well tolerated as compression forces acting on the cusp (Hiatt 1973). Cameron noted a direct relationship between restoration size and the number of cracked teeth (Cameron 1976). Silvestri described excessive cavity preparation depth and lateral masticatory forces combined to significantly weaken tooth structure leading to partial or complete vertical root fractures (Silvestri 1976). Ratcliff et al. suggested that existing restorations place teeth at 29 times greater risk for crack development (Ratcliff, et al. 2001). Even though the restoration of teeth has been noted as a primary cause of cracked teeth, other investigators have found unrestored teeth exhibit the same frequency of cracks as restored teeth (Hiatt 1973). Opdam et al. reported that 60% of teeth with cracks had no restoration (Opdam, et al. 2008).

Patient related variables contributing to tooth fracture include masticatory accidents, tight cusp-fossa relationships, steep intercuspation, bruxism and oral temperature change (Gutmann and Rakusin 1994). Parafunctional habits combined with the inherent cuspal inclinations and tooth proximity to the temporomandibular joint have also been shown to be important etiologic determinants of tooth cracks (Hiatt 1973, Qian, et al. 2013, Kang, et al. 2016). In an in vitro study evaluating the effect of temperature change on fractures, thermocycling of extracted teeth (7,000 cycles, ±50C) revealed that small cracks developed into larger ones with increased cycling (Silvestri 1976).

DIAGNOSIS

Proper diagnosis is key to successful treatment of diseases causing tooth fracture. Cameron was one of the first to promote tapping various cusps in different directions, wedging along a margin of the restoration with a sharp instrument, biting on a wooden toothpick, applying stain (methylene blue), and transillumination (Cameron 1976). Other diagnostic testing options include; removal of an existing restoration to trace the crack origin, radiographs, fragment separation, patient history, pulp testing and surgical exploration (Abou-Rass 1983). Clinical manifestations of a cracked tooth include presentation of acute pain on mastication or early brief pain to cold, normal to deep periodontal probing associated with the crack, the presence or absence of cusp movement using an explorer and the presence or absence of a restoration (Kim, et al. 2013). Seo et al. reported that 51% of the patients diagnosed with cracked tooth experienced bite pain and 82% responded positively on bite testing (Seo, et al. 2012). Cold sensitivity is believed to result from chronic pulpal inflammation, possibly due to the leakage of noxious agents through a crack, in the vicinity of the pulp (Davis and Overton 2000). One unique diagnostic method involved the placement of a thin layer of composite resin over the occlusal surface to splint the tooth segments

together. Relief of symptoms confirms a diagnosis of incomplete fracture (Banerji, et al. 2010). Detection of cracked teeth can be challenging. By using appropriate testing methods, a correct diagnosis can be achieved in a more predicable manner.

PREVALENCE

Two articles evaluating large samples of teeth reported a similar overall prevalence of cracked teeth. Krell and Rivera examined 8,175 teeth from a private endodontic practice population over a 6-year period. They found 796 cases diagnosed with cracked teeth for a prevalence of 9.7% (Krell and Rivera 2007). Kang and Kim reported an 8.9% prevalence after examining 1977 teeth and diagnosing 175 teeth as having cracked tooth (Kang, et al. 2016). A few articles report the maxillary first molar as the tooth most frequently diagnosed with cracked tooth (Roh and Lee 2006, Seo, et al. 2012). However, the majority of investigations identify mandibular molars as the most likely to be diagnosed with a cracked tooth. These include studies by Abou-Rass (1983), Banerji et al. (2010), and Davis and Overton (2000). Davis and Overton (2000) stated that 60% of fractured teeth occur in the mandibular molar region. The investigations differ on which mandibular molar is most frequently affected. The majority of the articles identify the mandibular second molar as having the highest incidence of fracture (Cameron 1964, Krell and Rivera 2007, Kang, et al. 2016). Others point to the mandibular first as the most prevalent (Kim, et al. 2013). The direction of the crack on the tooth and the age of the individual with the cracked tooth have also been quantified. The most common direction of a crack was 70.1% in the mesiodistal direction in both jaws (Roh and Lee 2006). One study found the highest frequency of longitudinal tooth fractures among patients in their 40s followed by individuals in their 30s and 50s. A dramatic decrease of longitudinal fractured teeth in patients in the 60s may be the result of earlier dental treatment or a decrease in the number of teeth in older populations (Seo, et al. 2012).

HISTOPATHOLOGY

Only one reviewed paper addressed the histopathology of cracks. A common observation in the article was that tooth cracks, regardless of their location, direction, and extent, were always colonized by bacterial biofilms. The intensity of inflammation was directly proportional to the depth of bacterial invasion in the tubules, i.e. the deeper the tubular infection the more severe the pulpal inflammatory response (Ricucci, et al. 2015).

TREATMENT

Prior to irreversible pulp damage, numerous proposed treatment methods can relieve the symptoms resulting from the presence of a cracked tooth. In general, provided there is an accurate diagnosis of the pulp status and its cause, teeth with reversible pulpitis due to cracks can be treated conservatively without endodontic treatment in 80% of cases (Abbott and Leow 2009). The most conservative approach is occlusal adjustment. It was shown that steep cuspal anatomy results in an increment of unfavorable stress and the occurrence of cracked tooth syndrome would be magnified, stressing the benefit of effective reduction of cuspal inclination to compromised teeth (Qian, et al. 2013). Ratcliff et al. (2001) recommended equilibrating the occlusion to ensure the maximum number of teeth touch in centric relation and eliminating interferences during excursive movements wherever appropriate to effectively eliminate etiologic factors that contribute to the propagation of cracks. It was demonstrated that both bonded and non-bonded complex amalgam restorations effectively eliminate chewing pain in molars with incomplete fractures. At 3 and 12 months, cold sensitivity was significantly reduced from a baseline score for the bonded amalgam restorations (Davis and Overton 2000). At 7 years following treatment, teeth with cuspal coverage showed a significant increase in survival rate (100%) compared to teeth without cuspal coverage.

In this study the teeth lacking cuspal coverage had an annual failure rate of 6% (Opdam, et al. 2008). Another study reported a 6 year survival rate of 93.2% of bonded indirect resin composite onlays to successfully treat symptomatic cracked teeth (Signore, et al. 2007). The most aggressive approach recommended full crown restorations as preventive treatment for teeth with asymptomatic cracks (Abou-Rass 1983).

ENDODONTIC INVOLVEMENT

Deciding how to treat a cracked tooth with reversible pulpitis can be very challenging for the clinician. For extensive cracks with prolonged symptoms, thermal hypersensitivity, and pulpal and periapical pathosis, root canal treatment is required prior to tooth restoration (Kang, et al. 2016). Other reasons for endodontic involvement of a cracked tooth involve requirements for mechanical or restorative dental reasons or when pulp exposure is suspected. A pulp exposure can usually be determined by removing any restorations and cracks from the tooth (Abbott and Leow 2009). Krell et al. demonstrated that 21% of cases diagnosed with reversible pulpitis and a crack eventually required root canal treatment (Krell and Rivera 2007).

PROGNOSIS

Root canal therapy is the most important treatment option to restore symptomatic cracked teeth diagnosed with irreversible pulpitis or pulp necrosis. Prior to the work by Kang et al. (2016), there was a lack of information regarding the endodontic prognosis of cracked teeth. Kang et al. (2016) found that root canal treatment was a reliable treatment for cracked teeth, with a 2-year survival rate of 90.0%. A separate study found 95.2% of teeth with coronal cracks survived at 5 years whereas those with cracks with radicular extensions had a 81.8% 5-year survival (Sim, et al.

2016). Literature analyzing the endodontic outcome and long term survival of endodontically treated cracked teeth is lacking and requires further study.

CHAPTER II: OBJECTIVES

Despite a high prevalence of cracked teeth in recent years, there are few studies regarding the diagnosis, treatment, and outcomes of cracked teeth. In vivo research is needed to elucidate the mechanisms by which cracks initiate and propagate in teeth. Also, a better understanding of outcomes is needed to understand the prognosis of the treatment modalities employed by practitioners. The purpose of this in vivo study was to determine the outcome of cracked teeth following initial non-surgical root canal treatment using clinical and radiographic data. A secondary objective was to determine associated variables that may also affect the outcome. The endodontic outcome, defined as healed or not healed, was based on clinical and radiographic findings at annual follow-up examinations for 5 years following the completion of treatment.

CHAPTER III: MATERIALS AND METHODS

[This section was adapted from WRNMMC IRB #410603-2, "Outcome of Endodontically Treated Cracked Teeth." (Version 2 17 Jan 16)].

This study retrospectively and prospectively collected data from subjects referred to the endodontic clinic at the Naval Postgraduate Dental School (NPDS). Inclusion criteria for the study included the following: the subject 1) was at least 18 years of age; 2) willingly provided consent; 3) was diagnosed with a cracked tooth at the NPDS endodontic clinic; 4) required endodontic treatment on the cracked tooth; and 5) all endodontic treatment was performed by a NPDS endodontic resident or faculty member.

A thorough pre-operative radiographic and clinical examination was performed. Various methods were employed in the diagnosis of a cracked tooth including direct visualization (with or without the use of magnification or a dental operating microscope), transillumination, methylene-blue dye application, or tooth slooth application. For the prospective portion of the study, subjects were enrolled when a diagnosis of cracked tooth was made before the initiation of endodontic treatment or following the access preparation if a crack was noted. For the retrospective portion, subjects were enrolled if cracked tooth details were noted retrospectively in the patient's record during a routine follow-up examination. An associate investigator obtained informed consent from the subject and all subjects were enrolled in the NPDS Endodontic Treatment Registry; WRNMMC #352271, a database of patients maintained in the NPDS Endodontic Department. The Endodontic Treatment Registry collects information on patient demographics, health history, initial exam findings, perioperative notes, and follow-up data. Additional cracked tooth information was collected during the initial evaluation including

tooth characteristics, diagnostic methods, and fracture location (see APPENDIX A, B, D). Following the collection of pre-treatment data, non-surgical root canal therapy was provided. Subjects with previously initiated therapy from other clinics (i.e. pulpotomy or pulpectomy) were excluded from this study. No specified instrumentation technique, irrigation technique, or obturation technique was required, and all were documented on standardized data forms (see APPENDIX E). Teeth were accessed using rubber dam isolation; information regarding crack location and extent was collected after access (see APPENDIX C). Following completion of treatment and temporization, subjects were referred for the definitive restoration of the tooth. At a minimum of twelve months after the endodontic treatment, subjects returned for a follow-up clinical and radiographic examination (see APPENDIX F). Each year following treatment, subjects were asked to return for subsequent follow-up examinations with data collection for up to five years.

Assessment of the clinical and radiographic data determined the outcome. The clinical examination included percussion, palpation, periodontal probing, mobility, and sensibility testing. The radiographic examination included a minimum of one periapical radiograph. Three calibrated, board-certified endodontists individually assessed the randomized immediate post-treatment and most recent follow-up radiographs on a shared laptop with image enhancement capabilities using the Periapical Index (PAI) (Orstavik, et al. 1986). A dichotomous classification system of healed or non-healed was used for each tooth. A tooth was considered healed if the following criteria were met: 1) the tooth was asymptomatic (no pain, mobility, swelling, sinus tract, percussion sensitivity, and palpation sensitivity) and 2) the PAI score was 1 or 2. A tooth was considered non-healed if: 1) the tooth presented with symptoms or 2) the PAI score was 4, or 5. Teeth designated a PAI score of 3 were excluded from both the healed, and

non-healed categories unless clinical symptoms were present, in which case the tooth was diagnosed as non-healed. In a separate analysis, all asymptomatic teeth, regardless of PAI score, were considered functional (clinical success) and all present (non-extracted) teeth regardless of symptoms were considered survived. The data were analyzed using R statistical software.

Based on previously published literature, a healed rate of 70% with a 95% confidence interval produced the need for 93 subjects with 5 year follow ups for analysis. Those assumptions and a 5 year recall rate assumed at 45% were used to preform power analysis giving a target sample size of 250 subjects.

CHAPTER IV: RESULTS

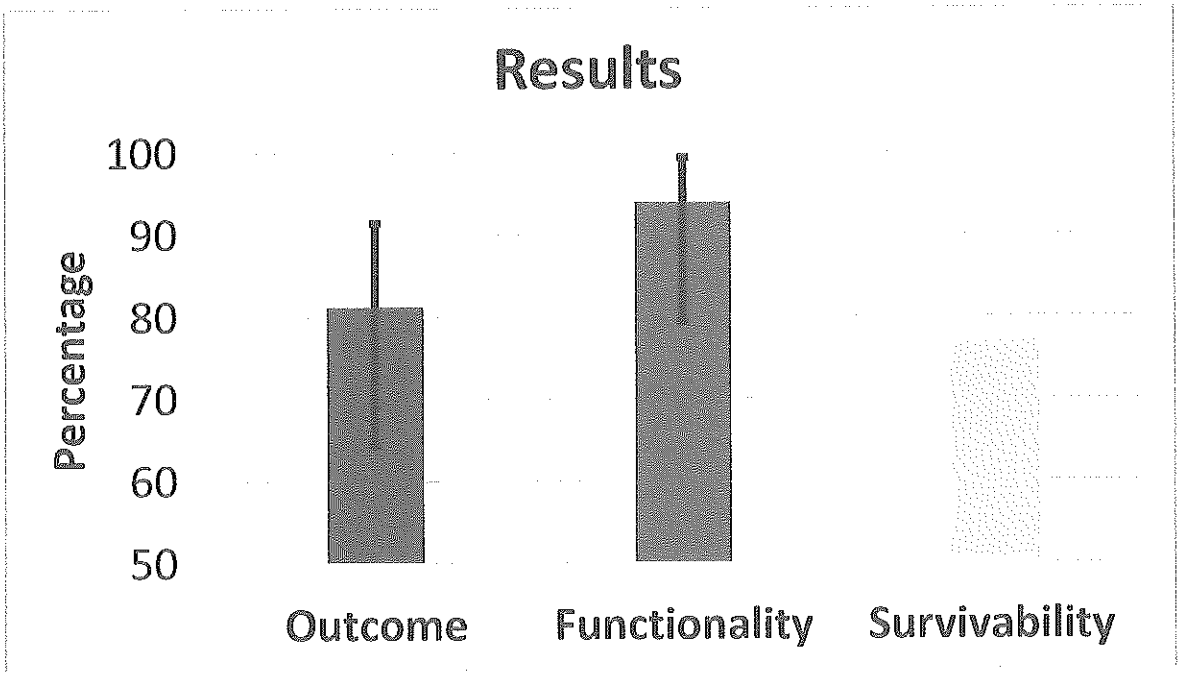
A total of 43 teeth from 42 subjects had a 12 month or greater follow up completed and were available for review for this interim analysis. Eighteen teeth were retrospectively and 25 teeth prospectively reviewed. The demographics of this cohort consisted of 69% males (n=29) and 31% females (n=13). The age range was from 27 to 80 years old with a median age of 46 years. The follow up on these subjects ranged from 12 to 68 months with a median of 13 months.

Of the 43 teeth, 10 (6 retrospective and 4 prospective) had been verified radiographically or clinically to be extracted. This left 33 teeth (12 retrospective and 21 prospective) available for PAI scoring. In this study, healed teeth were defined as clinically asymptomatic with a PAI of 1 or 2. Only 1 retrospective subject received a PAI score of 3 which left 32 teeth for outcome analysis (TABLE 1).

	Retrospective # Teeth	**Prospective # Teeth**	**Total # Teeth**
Total Analyzed	**18**	**25**	**43**
Extracted	**6**	**4**	**10**
PAI Analysis Completed	**12**	**21**	**33**
Non-PAI "3"	**11**	**21**	**32**

TABLE 1

PAI scoring resulted in a healed rate of 81% (26/32) with a 95% confidence interval of 64-91%. Teeth that were asymptomatic were defined as functional and of the teeth analyzed, 94% (31/33) were functional with a 95% confidence interval of 79-99%. The overall survival rate of the 43 teeth was 77% (33/43). This data is graphically presented in GRAPH 1.



GRAPH 1

A survivability analysis graph was created to provide an estimate of survival probability over time as represented by the red line (TABLE 2). The gray area around the red line represents a 95% confidence interval providing an estimation of uncertainty. This graph illustrates a survival estimation of approximately 88% at 1 year where a total of 36 teeth from 35 subject follow ups have been completed. Also it gives a survival estimation of approximately 65% at 2 years where a total of 13 subject follow ups have been completed.

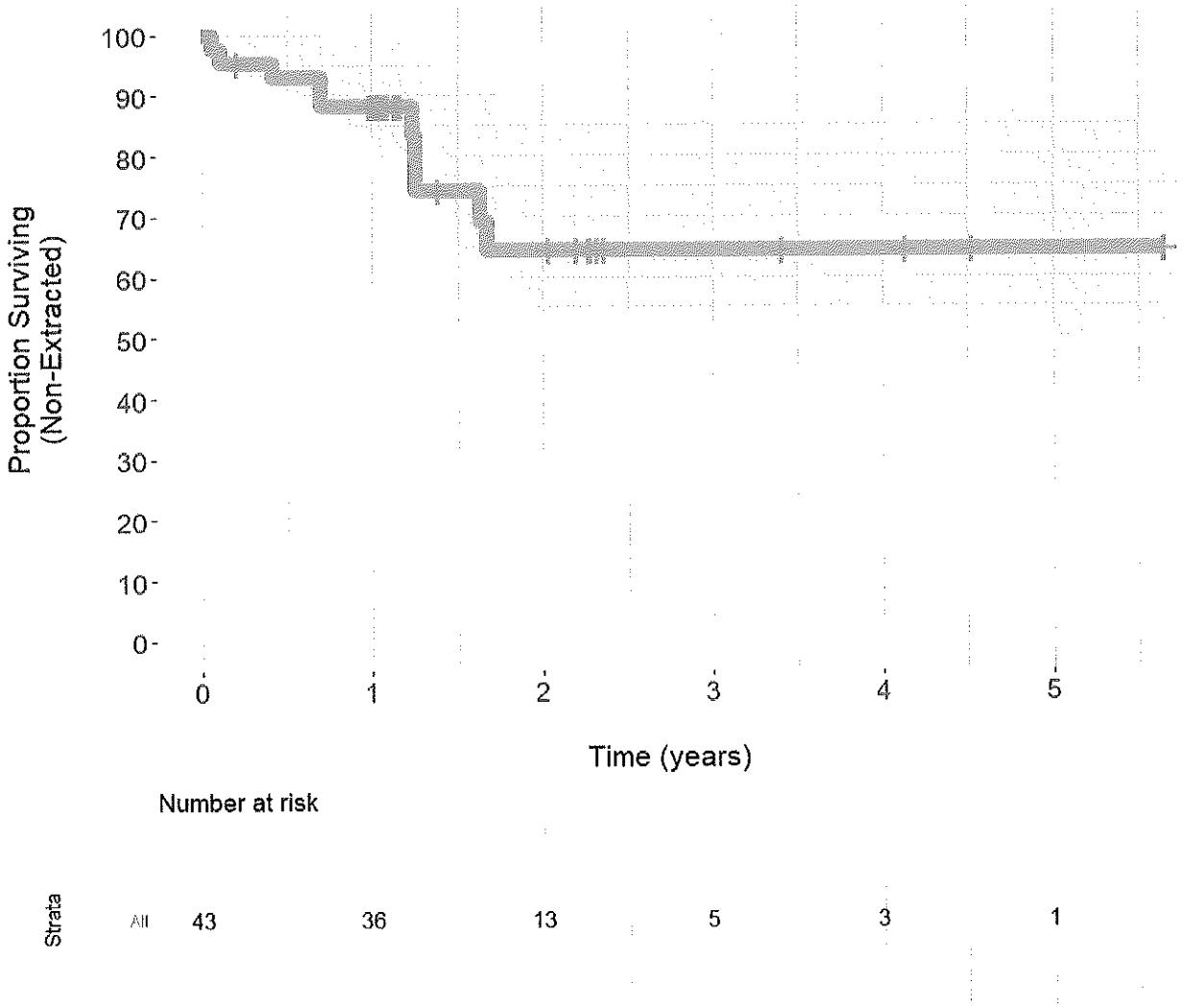

Proportion Surviving
(Non-Extracted)
100
90
80
70
60
50
40
30
20
10
0
0
1
2
3
4
5
Time (years)
Number at risk
Strata
All
43
36
13
5
3
1

TABLE 2

CHAPTER V: DISCUSSION

Following a thorough literature search, it can be concluded there are no endodontic outcome studies evaluating a cohort of only cracked teeth with which this study's results can be compared. In comparison to endodontic outcomes studies in general, the 81% healed outcome of crack teeth was nearly identical to 81% outcome of endodontic therapy overall presented by Friedman in Phase 1 of the Toronto studies (Friedman 2003). In both the Toronto studies and this study, extracted teeth were excluded from the outcome assessment. From what can be inferred thus far, should a crack tooth survive and not be extracted, it may present with a similar outcome as a cohort of teeth needing non-surgical root canal treatment (NSRCT) at large.

In regards to functional or asymptomatic, Friedman reported that 97% of root canal treated teeth could be considered functional at 4-6 years post treatment (Friedman 2003). Tan and Chen presented a survival estimation of a cohort of only cracked teeth. Of these teeth, a lower rate of only 80% were asymptomatic at review (Tan 2006). In the present study, the functional rate is 94% or 31 of the 33 survived teeth presented as asymptomatic at follow-up.

This study's overall survival rate thus far is 77%, which differs slightly from the 85.5% 2-year survival reported by Tan et al. and the 92% reported by Sim et al. Tan et.al. reported additional factors influencing survivability to include the presence of multiple cracks, if the tooth was in the terminal most position in the arch, and if a periodontal pocket was detected prior to the initial root canal treatment (Tan 2006). According to Sim and others, if the crack extended on the chamber floor, the likelihood of tooth survival was drastically reduced (Sim 2016). At this time, there is insufficient data for covariate analysis to assess factors affecting outcomes and/or survival as Tan et al. and Sim et al. have done.

When analyzing cracked tooth incidence, the cohort in this interim analysis consisted of 65% mandibular molars or 28 of the 43 teeth analyzed. This study's incidence of most frequently cracked teeth is very similar to Cameron's 1964 article that had a 56% incidence of mandibular molar cracked teeth. In this study, the mandibular 2nd molar was the most frequently cracked tooth at 42%, which again was similar to Cameron who presented mandibular 2nd molar being the most frequent at 34% (Cameron 1964). In Seo's study, which consisted of a Korean population, the maxillary first molar was the most cracked tooth, at 30%, which is different from Cameron and this study's findings. However, Seo found again that the prevalence of mandibular molars combined outweighed that of maxillary molars (Seo 2012).

The vast majority of teeth in this study had a previous restoration, 40 of the 43 teeth in the cohort. This differs from previous literature by Hiatt and Opdam in separate studies which report the restoration may not have an effect on the presence of a crack and even that unrestored teeth may crack more frequently (Hiatt 1973, Opdam 2008). Silvestri states that excessive depth of MOD restorations weakens the tooth and results in split teeth which is in line with what can be inferred from this study's cohort of cracked teeth (Silvestri 1976). The age demographic of the subjects with crack teeth in this study was similar to previously published literature. The median age of this cohort of cracked teeth was 46 years of age which agrees with Roh and Lee that stated in an analysis of 154 cracked teeth that the most prevalent cracked teeth was in those over 40 years of age (Roh 2006).

CHAPTER VI: CONCLUSIONS

Based on interim analysis of data collected in this in vivo retrospective/prospective observational study, endodontically treated crack teeth have a favorable prognosis for healing, functionality, and survival. The data available reported a healed rate of 81%, a functional rate of 94%, and a survival rate of 77%. No significant covariate factors could be identified among the limited number of samples evaluated. Further subject enrollment and data collection will continue until an adequate sample size is reached.

APPENDIX A

Subject#_____

Cracked Tooth Data Collection Form

1a. Tooth #_____

1b. Position of tooth in arch: ___Terminal
___Non-terminal

1c. Existing Restoration? Y/N
(Material and surfaces):
_____

1d. Can Crack be visualized? Y/N (cont'd pg 2)

1e. Method of crack diagnosis: ___Tooth Slooth
___Transilluminator
___Dye/Stain
_____Other: (List)

2a. Was treatment performed on day of diagnosis? Y/N

2b. Treatment performed: __ Band placed
__Occlusal adjustment
__Provisional Crown
__NSRCT
__Permanent full coverage restoration
_____Other: (List)

3a. Does the patient have a history of Cracked Tooth on another tooth? Y/N

3b. What was the treatment provided?

3c. What was the outcome of cracked tooth listed in 3a?

Date	Is tooth present?	Symptomatic Y/N	What tx has been performed since last visit?	RCT completed? (If yes, date)	Recall Method (phone, dental visit, or other)

APPENDIX B

Subject#_____

Visualization of Cracks in Tooth Pre-Treatment (at Evaluation)

Tooth number_____

Check the appropriate boxes/fill in blanks

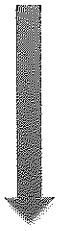
Please fill in probing depths (mm)

	M	Mid	D
B			
L			

Date:_____

Did you visualize a crack at **examination** (Circle one)?

NO YES



Location of Fracture
(check all that apply)

- ☐ Mesial Marginal ridge
- ☐ Distal Marginal ridge
- ☐ Occlusal Surface
- ☐ Buccal Groove
- ☐ Lingual Groove
- ☐ Other_____

APPENDIX C

Subject#_____

Visualization upon endodontic ACCESS

Tooth number_____

Check the Appropriate boxes/Fill in blanks

Please fill in probing depths (mm)

	M	Mid	D
B			
L			

Date:_____

Did you visualize a crack upon access (circle one)?

NO YES

Location of Fracture (check all that apply)

- ☐ Mesial Marginal ridge
- ☐ Distal Marginal ridge
- ☐ Axial Wall _____
- ☐ Floor of chamber
- ☐ Other_____

Did the crack enter a canal?

NO YES

Canal:_____
Y/N Apical Extent visualized

Canal:_____
Y/N Apical Extent visualized

Canal:_____
Y/N Apical Extent visualized

APPENDIX D

Subject #: _____

REGISTRY PREOPERATIVE

Tooth type: single root multiple root

Does patient have any of the following conditions (circle):

Hypertension: B/P_____ Smoker Coronary Heart Disease Diabetes Type: _____

Symptoms: Y/N

___Pain (0-10) (Y/N)
___Can locate pain by quadrant (Y/N)
___Can locate pain by tooth (Y/N)
___Tooth #
___/80 Electric pulp tester
___Palpation sensitivity
___Sinus tract (Y/N)
___Swelling (Y/N)
___History of Ortho tx (Y/N)
___History of external resorption (Y/N)
___Post (Y/N)
___Caries
___Cold sensitivity (R/NL; R/L; NR)
___Percussion sensitivity (S/NS)
___Mobility (Miller's Class)
___Bleeding on probing
___History of bleaching (Y/N)
___History of internal resorption (Y/N)
___Retreatment (Y/N)
___Surgical/nonsurgical treatment
___Open margin (Y/N)
___Restoration present (Y/N)
___Duration of symptoms (mos.)
___Fracture (Y/N): Type_____

PPD (mm)	Buccal	Lingual
Mesial		
Direct		
Distal		

Preoperative Radiographic findings:

Intact lamina dura (Y/N) Radiolucency (Y/N) Size____x____ mm

Preoperative Diagnosis:

Pulpal:
___Normal pulp
___Reversible pulpitis
___Symptomatic irreversible pulpitis
___Asymptomatic irreversible pulpitis
___Pulp necrosis
___Previously treated
___Previously initiated therapy

Apical:
___Normal apical tissues
___Symptomatic apical periodontitis
___Asymptomatic apical periodontitis
___Acute apical abscess
___Chronic apical abscess
___Condensing osteitis
___Lesion of non endodontic origin

History of Trauma to tooth_____

Was CBCT Taken?____

APPENDIX E

Subject #: _____

REGISTRY INTRAOPERATIVE

Working length established using electronic apex locator: Y/N

Patency Achieved:

_____Canal Y/N
_____Canal Y/N
_____Canal Y/N
_____Canal Y/N
_____Canal Y/N

Was patency maintained throughout the procedure? _____
How often?

Anesthetic used (Carpules):

2% Lidocaine w/1:100,000 epi____

.5% Marcaine w/1:200,000 epi____

4% Articaine w/1:100,000 epi ____

3% Mepivicaine ____

Procedure

Irrigants used, quantity (ml):

Method of irrigation: __ Side-vented tip __Passive ultrasonic __Neg. pressure

$Ca(OH)_2$ used as interappointment medicament: Y/N

Procedural complications: Y/N Type:

Intraorifice barrier placed: Y/N Type:

Number of treatment sessions: single multiple

Obturation:

_____ Flush (≤2 mm from apex)
_____ Overextension (beyond apex)
_____ Underextension (>2 mm short of apex)

Type of obturation material: _____
Sealer used: _____

Retreatments:

Type of obturation material removed:_____

Method of removal:_____

Post treatment Diagnosis

Pulpal:
_____ Normal pulp
_____ Reversible pulpitis
_____ Asymptomatic irreversible pulpitis
_____ Symptomatic irreversible pulpitis
_____ Pulp necrosis
_____ Previously treated
_____ Previously initated therapy

Apical:
_____ Normal apical tissues
_____ Symptomatic apical periodontitis
_____ Asymptomatic apical periodontitis
_____ Acute apical abscess
_____ Chronic apical abscess
_____ Condensing osteitis
_____ Lesion of non endodontic origin

Date of Treatment Completion: _____

EVALUATOR USE ONLY
Final treatment radiographic Periapical Index (PAI) score: 1 2 3 4 5

APPENDIX F

Subject #: _____

Registry Follow-up Data

Date of follow-up evaluation: _____

Does patient have any of the following conditions (circle):

Hypertension: B/P_____ Smoker Coronary Heart Disease Diabetes Type: _____

Symptoms: Y/N

_____ Pain (0-10)
_____ EPT
_____ Palpation sensitivity (S/NS)
_____ Sinus tract (Y/N)
_____ Swelling (Y/N)
_____ Cold sensitivity (R/NL, R/L, NR)
_____ Percussion sensitivity (S/NS)
_____ Mobility (Miller's Classification)
_____ Periodontal Screening Record (PSR)
_____ Bleeding on probing
_____ Time Elapsed Between Initial Tx and Permanent Restoration
_____ Duration of symptoms

PPD (mm)	Buccal	Lingual
Mesial		
Mid		
Distal		

Follow-up Radiographic findings:

Intact lamina dura Y/N Radiolucency (Y/N) Size____x____ mm

Follow-up diagnosis: (Apical)

_____ Normal apical tissues
_____ Symptomatic apical periodontitis
_____ Asymptomatic apical periodontitis
_____ Acute apical abscess
_____ Chronic apical abscess
_____ Condensing osteitis
_____ Lesion of non endodontic origin

Caries present? Y/N
Permanent coronal restoration present? Y/N
Intracanal post present? Y/N
Open Margin Y/N
Surgical or Nonsurgical Treatment

EVALUATOR USE ONLY

Final treatment radiographic Periapical Index (PAI) score: 1 2 3 4 5

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