OUTCOME OF ENDODONTICALLY TREATED CRACKED TEETH

by

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2019

ABSTRACT

OUTCOME OF ENDODONTICALLY TREATED CRACKED TEETH

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Introduction: Cracked tooth, one of the five categories of longitudinal tooth fractures, was defined as "an incomplete fracture initiated from the crown and extending subgingivally, usually directed mesiodistally" by the American Association of Endodontists. Patient's experiencing symptoms of a cracked tooth most commonly report pain with biting and with temperature changes. When a crack extension compromises the pulp and results in a pulpal and/or periapical pathosis, non-surgical root canal treatment (NSRCT) is required to alleviate the patient's symptoms. Although reports of cracked teeth have been published since the 1950s, there are no long-term, prospective outcomes studies of endodontically treated cracked teeth. **Objectives**: To determine the outcome of teeth diagnosed with cracked tooth requiring initial NSRCT with one-year to 5-year recall data and identify co-variant factors associated with functional outcomes. **Method**: Research is conducted at the Naval Postgraduate Dental School Endodontics Department where consenting patients with a cracked tooth diagnosis requiring initial NSRCT are enrolled. Data is collected on standardized forms at each annual appointment up to 5-years. 250 teeth is the N required to power this study to determine healed, non-healed, survival, and functional outcomes from the analysis of clinical and radiographic data. **Results**: 62 teeth were analyzed for this interim analysis, 11 had verification of extraction and 1 was excluded due to a PAI score of 3 (unsure). Of the 50 subjects with one-year data, the healed rate was determined to be 54% (*n=27*) and the functional rate was

80% (*n=40*). Co-variant analysis could not be performed due to insufficient data at this point in this study. **Conclusion:** A 54% healed rate, an 80% functional rate, and a two-year survival rate of 81% is the current reporting of this interim analysis.

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LIST OF ABBREVIATIONS

AAE	American Association of Endodontists
mm	millimeters
NPDS	Naval Postgraduate Dental School
NSRCT	non-surgical root canal treatment
PAI	periapical index
PARL	periapical radiolucency
SPSS	Statistical Package for the Social Sciences (IBM, inc.)

Chapter I: Introduction

In 1964, Cameron[7] first coined the term "cracked tooth syndrome." He evaluated 50 cracked teeth and reported the 'predominant symptom is discomfort to pressure and thermal changes.' [7] Although symptoms reported by patients may be vague, many diagnostic aids are available as awareness of a potential crack and making an early diagnosis are critical in preventing the cracks progression. His observations concurred with the earlier works of Gibbs, Mellion, Thoma, and Ritchie. [7]

Since varying terminology had been used to describe a cracked tooth such as 'incomplete fracture of posterior teeth,' 'green-stick fracture' or 'split tooth syndrome'[7], the American Association of Endodontists published "Cracking the Cracked Tooth Code: Detection and Treatment of Various Longitudinal Tooth Fractures." This guide provided clarification on tooth fractures so providers could communicate more clearly with each other in diagnosis and treatment planning. Cracked tooth, one of the five categories of longitudinal tooth fractures, was defined as "an incomplete fracture initiated from the crown and extending subgingivally, usually directed mesiodistally." [2]

Providers must determine the pulpal and periapical diagnosis to establish an appropriate treatment plan. [2] If these diagnoses are normal and the crack does not extend into the pulp, conservative treatment of an onlay or crown is recommended. [8] However, if the pulpal diagnosis is irreversible pulpitis or pulp necrosis, the cracked tooth will require a root canal prior to crown placement. [15] Research on the outcomes of cracked teeth requiring root canal treatment is lacking; [15] thus, the purpose of this in-vivo retrospective/prospective observational study.

Chapter II: Review of the Literature

LITERATURE SEARCH

A review of the literature was conducted on 17 October 2017 in three biomedical literature databases: MEDLINE (via PubMed), Embase (via Elsevier), and Dentistry and Oral Sciences Source (via EBSCO). Literature search strategies in these databases included a combination of subject headings and keywords related to cracked teeth. As an example, this search strategy was used in PubMed: ("Cracked Tooth Syndrome"[Mesh] OR "cracked tooth"[Text Word] OR "cracked teeth"[Text Word] OR "split tooth"[Text Word] OR "split teeth"[Text Word] OR ("incomplete fracture"[Text Word] AND (tooth[Text Word] OR teeth[Text Word]))). Similar searches were conducted in Embase and DOSS. No date limits were applied. Five hundred and sixty-one unique citations were retrieved at this time. An initial screening of returned abstracts was performed and compared against the last literature search for this research project. Two additional, relevant full-length articles from peer-reviewed periodicals were obtained and included in this updated literature review. An additional search was conducted on 01 December 2018 resulting in one additional article to be added to the bibliography.

PREVALENCE

In 2007, Krell and Rivera reported a 9.7% incidence of cracked teeth after evaluation of 8,175 patients in a private endodontic practice.[16] Kang et al had a similar finding in 2016 of 8.9% cracked tooth incidence of the 1977 teeth they assessed in a dental hospital.[15] Cracks were more prevalent with increasing age,[8,15,22] with 80% being 40 and older. [8] When evaluating cracked tooth incidence by gender, there was a variation in findings. Females were reported more likely to experience a cracked tooth[14] to include

Cameron's report of females being two times more likely. [8] This was the opposite of Kang et al with 61.1% diagnosis of cracked tooth with males. [15] In addition, Roh and Lee suggested no difference between genders.[22]

ETIOLOGY

Enamel, the thin outer portion of the crown of a tooth, helps protect teeth from daily use such as chewing, biting, crunching, and grinding. Although enamel is the hardest tissue in the body, it is still susceptible to irreversible damage of being chipped or cracked. [27] When the crown of the tooth is cracked, contact of teeth during eating or parafunctional activity can cause irritation to the pulp which may lead to pulpal injury or to an odontogenic infection. When the pulp has been compromised, treatment of the cracked tooth usually requires a root canal to alleviate the pain by removal of the damaged pulp and nerve tissue. In addition of providing relief of symptoms, root canal treatment may prevent or slow down the crack propagation; thus, extending the survival of the tooth. [1]

Masticatory or accidental trauma have been cited as the most common cause for an incomplete fracture. [11] The instigation of cracked teeth may be attributed to localized excessive biting load, decrease in stability of a tooth due to deep or unsupported cavity preparations, removal of coronal tooth structure during endodontic access, deep occlusal grooves, lingual inclination of mandibular molar cusps, and acidogenic extensive loss of enamel and dentin. [11] Additionally, Ratcliff and colleagues reported that teeth with intracoronal restorations were 29 times more likely to experience fracture than unrestored teeth.[20]

Multiple studies identified the mandibular second molar as the most common tooth diagnosed as cracked tooth. [7,12,15,17] On the other hand, Roh and Lee found the maxillary

first molar to be the most common. [22] They also evaluated restorations of cracked teeth and found 77.9% had no restorations and occluded natural teeth. Hiatt reported 35% of cracks where identified in teeth with no restoration and 26% with Class I restorations. [13] Therefore, it is important not to rule out potential cracked teeth when patients present with no or minimally restored dentition.

DIAGNOSIS

Cracked teeth may present with vertical lines on the surface of the tooth. [26] Direct visualization of a crack would be helpful in diagnosis for the practitioner; however, the evidence of an external crack is not often apparent. This makes diagnosis of cracked teeth a challenge along with the diverse symptoms in which patients present. [15] The most frequent symptom of cracked teeth is the discomfort associated with chewing as well as unexplained sensitivity to cold. [8] Due to the complexity of identifying a cracked tooth, several diagnostic methods are available to identify and confirm the presence of cracks. These diagnostic techniques include bite test, dye staining, magnification, transillumination, and isolated deep periodontal probing depth. [23]

According to Seo et al, sensitivity in the bite test was the chief complaint of most patients suspected to have longitudinal fractured teeth and was found a reliable diagnostic indicator. [23] Krell and Rivera found cracked teeth exhibited pain to biting on either a Burlew wheel or Tooth Slooth with at least 1 cusp. [16]

Abou-Rass suggested removal of existing restorations and highlighted the use of crack visualization aids such as magnification, dye staining, and transillumination. [4] Krell and Rivera utilized transillumination to diagnosis a cracked tooth when light was placed

on both the buccal and lingual surfaces of the crown and light transmission was blocked. [16] This created a shadow in the tooth and confirmed the crack.

Periodontal probing depth may also assist in diagnosis of a cracked tooth. Krell and Caplan assessed mesial and distal interproximal spaces as well as the furcal region and found deepest probing of the crack was located apical to the marginal ridge crack. [17]

Along with the difficulty in identification of cracked teeth, so is the difficulty to know how advanced the crack is and determine a prognosis. [23] Therefore, utilizing the above aids may assist providers in early detection of cracked teeth and the ability to offer more conservative treatment plans.

HISTOPATHOLOGY

Although limited research on the histopathology of cracked teeth exists, one study by Ricucci et al investigated 12 cracked teeth. [21] They found regardless of the crack's location, direction, or its extent, bacterial biofilms were present. [21] These bacterial biofilms were colonized in the dentinal tubules along with the accumulation of inflammatory cells in the pulp zone adjacent to the infected tubules. [21] Pulpal response ranged from acute inflammation to pulpal necrosis with most patients reporting symptoms when the crack extended into the pulp. [21]

TREATMENT

According to the AAE College of Excellence, treatment of cracked teeth must take into consideration the 'location and extend of the crack' along with the pulpal and periapical diagnosis. [2] The aim of cracked tooth restoration is to stabilize the tooth to prevent movement during occlusal forces thereby eliminating symptoms and preventing the extension of the crack. [6] If pulpal and periapical pathology is diagnosed, a root canal

must be done prior to final crown restoration. Extraction may be required if symptoms do not resolve after root canal treatment. [15]

Four categories for the treatment of cracked teeth are as follows: 1) immediate (occlusal adjustment, bands, temporary crown), 2) direct restorations placed intra-coronally without cuspal coverage, 3) direct restorations which provide cuspal coverage, and 4) indirect restorations placed intra-coronally without any cuspal support and indirect restorations which provide cuspal coverage (onlays and full coverage restorations). [6]

Immediate treatments of cracked teeth can provide quick relief of symptoms. Caution should be used with occlusal adjustments as the process itself may cause the crack to continue to propagate. Reduction of the occlusion eliminates contact between teeth but does not stop the occlusal forces when chewing food; thus, return of symptoms. Temporary crowns can be a good adjunct but take time and preparation significantly reduces the coronal structure. Direct composite splint is another option which is non-invasive and requires little chair time. [6]

Bonded restoration had success in treatment of symptomatic, cracked teeth. Opdam et al had a 97% follow-up rate in his 7-year investigation on the success of direct composite restoration treatment to alleviate symptomatic cracked teeth. [18] Half of the cracked teeth had cuspal coverage while the other half did not. 40 teeth were evaluated at 7 years and identified that root canal treatements had been done for 3 teeth without full cuspal coverage. Furthermore, at the end of the study, the group with cuspal coverage had no failures. However, the non-cuspal coverage group, saw a 6% average annual failure rate. [18] In Signore et. al. 4-6 year retrospective study, the treatment of 43 posterior cracked teeth

included the removal of existing materials, placement of a direct composite build-up, and a bonded indirect resin composite onlay. The 6-year survival rate was 93% where 40 teeth remained asymptomatic. [24]

The recommended treatment of cracked teeth is a full-coverage crown or onlay. [7,13] Guthrie and DiFiore treated 28 vital cracked teeth initially with a temporary crown with 25 becoming asymptomatic. [12] These 25 teeth were restored with a permanent full cast crown and at one year remained asymptomatic resulting in an 89% success rate. [12] Abbott and Leow crowned 100 cracked teeth with reversible pulpitis resulting in an 80% success rate at the 5-year recall. [3] Krell and Rivera treated 127 teeth diagnosed with reversible pulpitis with a full cuspal coverage crown. By 6 months, 21% of cases required root canal treatment. At 6-years, all 127 teeth, with or without root canal treated, continued to be asymptomatic. [16]

PROGNOSIS

Krell reported in 2018 that root canal treated cracked teeth did not have long-term studies available. [17] Current studies report survival rates with most being retrospective. In the retrospective study by Tan et.al., they reported a 2-year survival rate of 85.5% with significant negative prognostic factors being multiple cracks, terminal teeth, and pretreatment probing depth. [26] A 90% survival rate among 88 root canal treated cracked teeth was reported by Kang et al. [15] They found that vertical root fracture or split tooth was the primary cause of extraction. In this study, a significant negative prognostic factor was probing depths greater than 6mm. A 96.8% 2-year survival rate was reported for probing depths of less than 6mm and significantly less at 74.1% when probing depth was greater than 6mm. [15] Sim et al reported a 92% survival rate in their retrospective study. They

followed 84 root canal treated cracked teeth for 5-years and identified an 11-fold increase in tooth loss when cracks extended onto the pulpal floor. [25]

Krell and Caplan evaluated the outcome of 363 cracked teeth with a pulpal diagnosis of irreversible pulpitis, necrosis, or previously treated. They found an 82% success rate at 1-year with negative prognostic factors being marginal ridge cracks, mesial or distal probing depths of 5mm or more, and a diagnosis of chronic apical periodontitis, suppurative apical periodontitis, or acute apical abscess. [17]

More research is needed on endodontically treated crack teeth outcomes.

Chapter III: Objective

**This study, WRNMMC IRB #410603, "Outcome of Endodontically Treated Cracked Teeth", is ongoing. The Objective section for this paper was taken from the approved protocol.*

The purpose is to determine the outcome of teeth diagnosed with cracked tooth requiring initial NSRCT at a minimum of 12 months after receiving treatment using clinical and radiographic data.

This study will assess the outcome of teeth diagnosed with cracked tooth that require initial NSRCT. Radiographic PAI scoring and the presence or absence of clinical symptoms will be collected at a minimum of 12 months following treatment to establish proportions of healed and not healed teeth. Healed teeth will have a PAI score of 1 or 2 AND are asymptomatic at recall. Teeth will be classified as not healed if they are symptomatic OR have a PAI score of 3, 4, or 5.

A secondary analysis using only the presence or absence of clinical symptoms will be used to establish the proportion of teeth that are functional.

Chapter IV: Materials and Methods*

**This study, WRNMMC IRB #410603, "Outcome of Endodontically Treated Cracked Teeth", is ongoing. The Material and Methods section for this paper was taken from the approved protocol.*

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 to aid 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, and Tooth Slooth® bite test. 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 one periapical radiograph at a minimum. 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).[19] 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 perform power analysis giving a target sample size of 250 subjects.

Chapter V: Results

In this interim analysis, a total of 62 teeth had a follow-up of a minimum of 12 months and were used in the descriptive analysis. Although eleven teeth had been extracted, there were three cases of at least one-year recall data available prior to the extraction. Therefore, 54 teeth had PAI scoring completed by three calibrated Board Certified Endodontists. One retrospective subject had a PAI score of three which indicated an unsure assessment and was excluded per research protocol resulting in 53 subjects in the outcome analysis. The subjects could be further separated by enrollment type of retrospective or prospective as seen in Table 1.

Table 1: Data Available by Retrospective and Prospective Enrollment

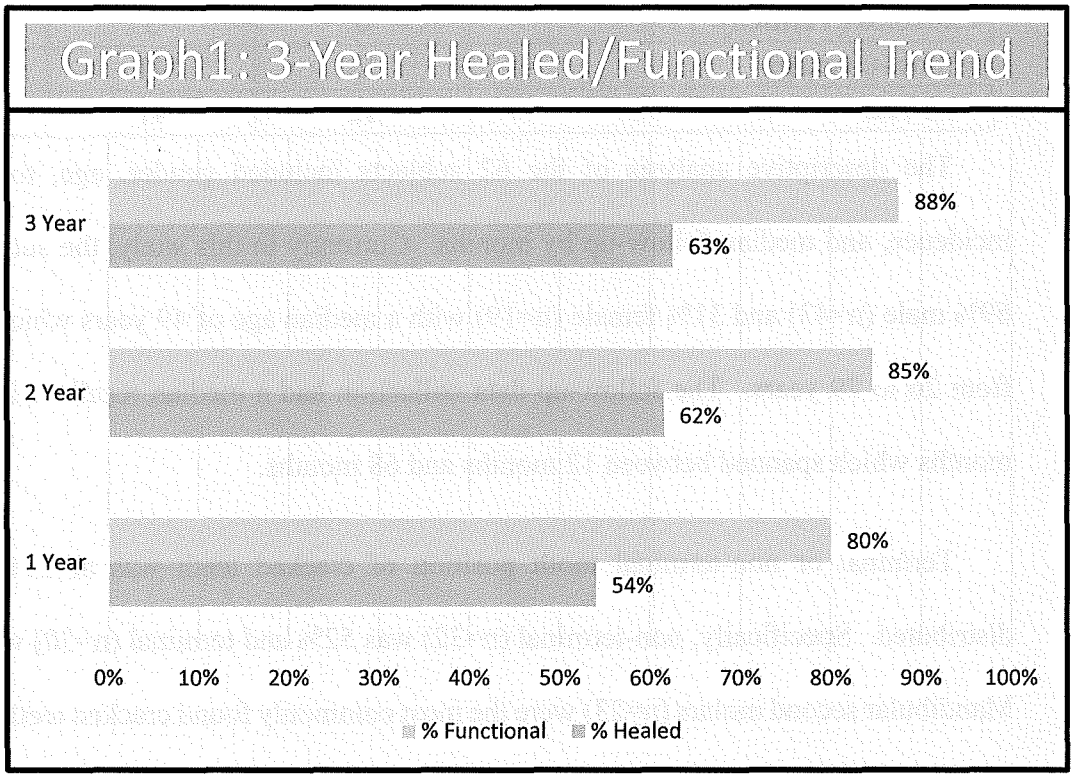
Status	# Teeth Retrospective	# Teeth Prospective	# Teeth Total
Total analyzed	18	44	62
Extracted (Verified)	6	5	11
Follow-up exam	13	41	54
Non-PAI "3"	12	41	53

The descriptive analysis of the 62 subjects included gender, age, tooth type incidence, and median follow-up by months. Currently in this study, the subjects are 69% male (n=43) and 31% female (n=19) with a median age of 49 years which ranged from 26 to 79 years. The follow-up data collection had a median recall period of 19 months which spanned between 12 months and 68 months.

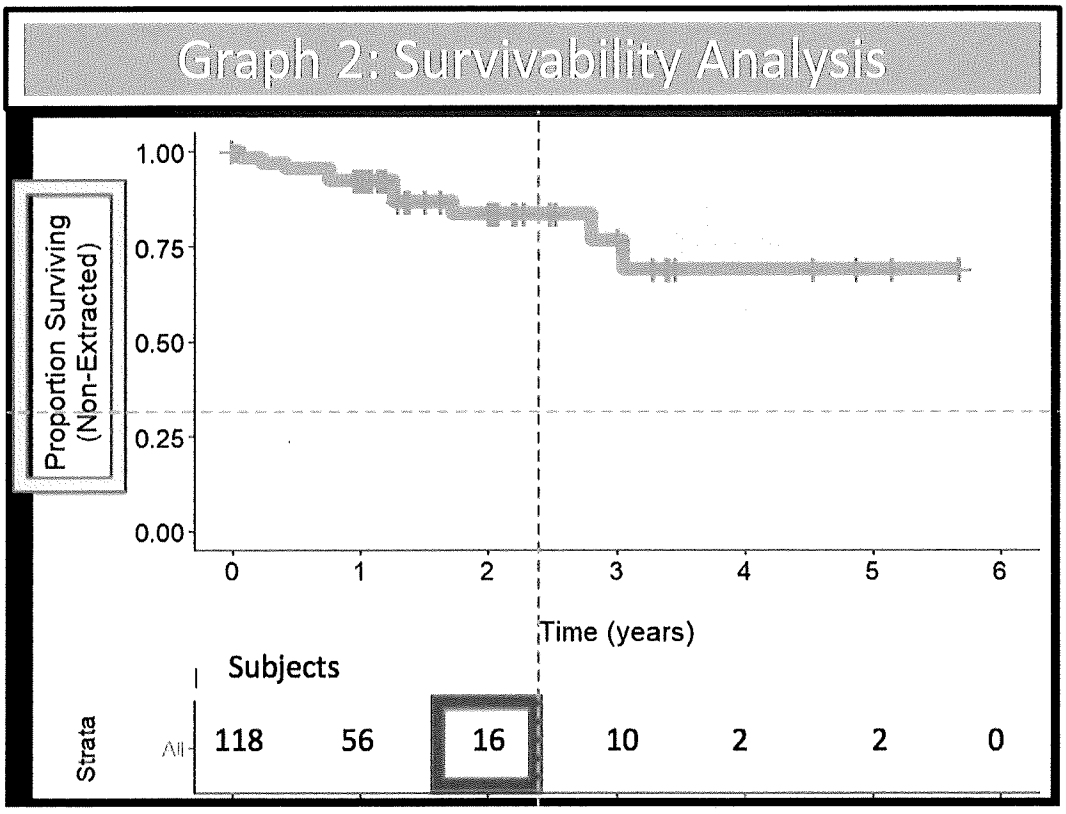
Terminal or non-terminal tooth position of cracked teeth was almost equally distributed. Specifically, non-terminal (n=32) was 52% and terminal (n=30) was 48%. Mandibular second molars (n=23) were the most commonly found cracked teeth at 37%. Cracked teeth reported by incidence of tooth type is provided in Table 2.

Table 2: Tooth Type Incidence		
Tooth Type	N	%
Mandibular 2nd molar	23	37
Mandibular 1st molar	15	24
Maxillary 1st molar	13	21
Maxillary 2nd molar	4	6
Maxillary 1st premolar	1	2
Maxillary 2nd premolar	4	6
Mandibular 2nd premolar	2	3

In this interim analysis, the one-year functional rate, meaning teeth are asymptomatic, is 80%, and a healed rate which adheres to a strict criterion for a completely asymptomatic tooth with a PAI score of 1 or 2, is 54%. Although the N is small, the current two-year functional rate is 85% with a 62% healed rate for 13 subjects. The three-year data closely resembles the two-year data with a functional rate of 88% and a healed rate of 63% (Graph 1).



Survivability has been assessed by multiple studies and is equally important to evaluate with the previously discussed functional and healed outcomes. In this survival graph, all enrollees are included, even those that have not had a 1-year recall as demonstrated by data points between 0 and 1 year. The Y-axis represents the survival probability and the X-axis represents time. Below the time are numbers representing the total subjects that have been followed up at each year point. For example, 16 subjects have a two-year follow up with an estimated survival rate of 81 percent. As more subjects are followed up for longer time periods, this graph will be a valuable representation of annual survival of cracked teeth (Graph 2).



At this time, there is insufficient data in this study for co-variate analysis to assess factors, such as gender, age, tooth type, tooth position, or presence of restorations, affecting outcomes of endodontically treated cracked teeth.

Chapter VI: Discussion

This study followed the strict criteria as defined by Friedman where 'healed' is 'when follow-up reveals a combined clinical and radiographic normalcy and 'functional' is 'when follow-up reveals a residual radiolucency combined with clinical normalcy.' [10]

There were no prospective endodontic outcome studies identified specifically evaluating cracked teeth with which to compare the current study's one-year healed rate of 54%. However, in 2018, Krell and Caplan published a retrospective cracked tooth study analyzing 363 cracked teeth. Treatment was completed by a single endodontist over 25-years in private practice and yielded an 82% success (healed) rate at 1-year. They defined success 'as the absence of signs or symptoms plus resolution of any previous radiographic pathosis.' [17]

The one-year functional rate for this interim analysis is 80%. This is less than DeChevigny et al. who reported 94% functional rate at 12 months for his evaluation of 510 teeth with initial NSRCT. [9]

This interim analysis had an 81% two-year survival rate which aligns with Tan et al[26] two-year survival rate of 85.5% for 50 root filled cracked teeth but short of the 90% two-year survival rate reported by Kang et al. [15]

After demographic data analysis, this study found the mandibular 2nd molar to have the highest incidence of cracked diagnosis at 36%. This is common throughout the literature as supported by Cameron[7] at 34%, Kang[15] at 44%, and Krell and Caplan[17] at 36%. As for age, our subjects had an age range from 26 to 79 years with a median age of

49 years. Roh et al evaluated a Korean population and found subjects in their 40s and 50s were more common to have a cracked tooth which is similar to our findings. [22] As for gender, our study had 69% males and 31% females which is similar to Kang et al finding of 61.1% males. [15] This differed from Hilton et al who found more prominence with females at 64%.[14]

At this time, there is insufficient data in this study for co-variate analysis.

Chapter VII: Conclusions

This in-vivo retrospective/prospective observational study's interim analysis reports a favorable prognosis for survival, functionality, and healing of endodontically treated cracked teeth. Current one-year healed rate is 54%, functional rate is 80%, and the two-year survival rate is 81%. Insufficient data to identify possible covariate factors. Continued subject enrollments to obtain the projects N will provide better data pool for analysis.

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

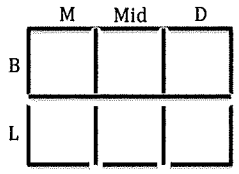
Subject#_____

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

Tooth number_____

Check the appropriate boxes/fill in blanks

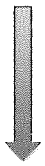
Please fill in probing depths (mm)



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 <u>ACCESS</u>

Tooth number_____

Check the Appropriate boxes/Fill in blanks

Please fill in
probing depths

	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 visualize

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:l _____
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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