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

David Michael Dow II

Has been approved by the Examining Committee for the thesis requirement for the Master of Science degree in Oral Biology at the June 2016 graduation

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NAVAL POSTGRADUATE DENTAL SCHOOL
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ABSTRACT

OUTCOME OF ENDODONTICALLY TREATED CRACKED TEETH

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D.D.S., ENDODONTICS, 2016

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A "cracked tooth" is defined as a thin surface enamel and dentin disruption of unknown depth, and is often associated with discomfort during mastication. In the presence of pulpal/apical disease, these teeth require non-surgical root canal treatment (NSRCT). However, there is limited information regarding endodontic outcomes of cracked teeth. **PURPOSE**: The primary objective of this continuing in-vivo, observational study was to determine the outcome of cracked teeth requiring initial NSRCT. A secondary objective was to determine factors that affect the outcome. **METHOD**: Subjects meeting inclusion criteria were enrolled at the Naval Postgraduate Dental School (NPDS) Endodontics Department. Standardized data collection forms were used to record subject demographics, diagnostic methods, tooth characteristics, treatment information, and clinical features of the cracked tooth. Subjects were asked to return annually for a follow-up clinical and radiographic examination a minimum of 12 months after treatment. The endodontic outcome was determined using combined clinical and radiographic data collected from the treatment and follow-up appointment. Healed was defined as the lack of clinical symptoms and radiographic lesions; functional was defined as a lack of clinical symptoms only. **RESULTS**: 15 teeth were analyzed for this interim analysis. Follow-up examination times ranged from 12 to 47 months, with a median of 16.2 months. Five teeth were radiographically verified as extracted, resulting in a survivability of 67%. For the remaining 10 teeth, 78% were healed and 90% were functional. 93% of cracked teeth requiring NSRCT were previously restored, and 60% were mandibular molars. **CONCLUSION**: An interim analysis of

this retrospective outcome study revealed cracked teeth that required non-surgical root canal therapy had a favorable outcome and may be treated predictably.

TABLE OF CONTENTS

LIST OF TABLES AND GRAPHS

LIST OF ABBREVIATIONS

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

Section I: Introduction

Cameron published the term "cracked tooth syndrome" in a landmark 1964 article and defined it as an incomplete fracture of a vital posterior tooth that may or may not involve the pulp (Cameron 1964). He also defined it as a condition associated with pain during chewing and with temperature changes. According to the American Association of Endodontists (AAE), a cracked tooth has a thin surface disruption of enamel and dentin, and possibly cementum of unknown depth or extension (AAE Glossary of Terms 2015). They typically present in a mesiodistal direction, and without separation of the two fragments. Despite a high prevalence of cracked teeth in recent years, there are few studies regarding the diagnosis, treatment, and outcomes of cracked teeth, and no outcome studies focused solely on cracked teeth.

Section II: Review of Literature

LITERATURE SEARCH

A review of the literature was conduced on 04 October 2014 in the PubMed database. The terms of the search included any articles containing "cracked tooth," "incomplete fracture," "cracked tooth syndrome," "cracked tooth treatment," "cracked tooth diagnosis," "cracked tooth outcome," and "cracked tooth survivability." No date limits were applied. An initial screening of returned abstracts was accomplished, and relevant full-length articles from peer-reviewed periodicals were obtained. Thirty four articles were ultimately selected and a preliminary bibliography was compiled. On 06 December 2014 and 01 March 2016, follow-up searches were conduced under similar parameters, and two additional studies were added.

PREVALENCE

Krell and Rivera (2007) evaluated over 8000 patients in an endodontic practice and reported a 9.7% incidence of cracked teeth.

Bader et al. (1995) assessed an adult population and reported a 5% complete tooth fracture rate. In fractured teeth group, 4.4% of the fractures occurred in posterior teeth (3.1% molars and 1.3% premolars) and 15% of these resulted in pulpal involvement or were extracted. The authors concluded that teeth more posterior in the arch exhibited a higher incidence of cracks (Bader 1995).

The incidence of cracked teeth increases with age as older populations have a greater prevalence of cracked teeth (Cameron 1964, Cameron 1976, Eakle 1986, Roh 2006). Both Cameron studies found that females had a higher incidence of cracked teeth, although a more

recent study in 2006 demonstrated an almost equal distribution between genders (Cameron 1964, Cameron 1976, Roh 2006).

ETIOLOGY

Excessive parafunctional forces, excursive interferences, facial or oral injuries, restorative procedures, and the physical properties of restorative materials (thermal expansion and contraction coefficients) have all been associated with coronal fractures (Rosen 1982, Abou-Ross 1983, Ratcliff 2001).

Teeth positioned closer to the temporomandibular joint are more likely to encounter stronger occlusal forces which may lead to higher rates of fracture (Signore 2007). Specifically, mandibular molars have been reported to be the most susceptible, however more recent studies report that maxillary molars are equally affected (Seo 2012, Roh 2006).

Cracks occur in both restored and non-restored teeth. Silvestri (1976, 1978) demonstrated restored teeth are more likely to exhibit cracks. It was stated, "teeth with larger restorations lack adequate structure." Restorative procedures weaken teeth and increase the likelihood of cracks. In restored teeth, the incidence of fracture increased with increasing size of the restoration (Silvestri 1976, 1978). More recent studies have indicated that non-restored teeth are just as likely to crack due to anatomical features such as steep cusps and deep grooves (Qian 2013, Seo 2012, Roh 2006).

A patient's occlusion may play a critical role in the development of cracked teeth. Excursive interferences create stress during normal and parafunctional tooth movement, which can lead to cracks (Silvestri 1976). A 2012 study explored the correlation between cuspal inclination and cracked tooth syndrome by reconstructing cuspal inclinations and measuring

stresses in cracked maxillary first molars. Steeper cuspal inclinations resulted in increased increments of tensile stress that localized at the center groove and cervical region of the molar model under equivalent loads. A higher, unfavorable, tensile stress was generated as horizontal component load increased on the cuspal incline (Qian 2012). Furthermore, clinical studies suggest that fractured cusps and teeth occur more frequently among patients that brux compared to non-bruxers (Pavone 1985).

Eakle et. al. (1986) examined over 200 patients with cracked teeth and reported that 48% of the teeth were mandibular molars, 28% maxillary molars, 16% maxillary premolars and 6% mandibular premolars,. Incisors and canines made up the remaining 2% of teeth (Eakle 1986).

DIAGNOSIS

Cameron (1964) described "cracked tooth" as both a diagnostic and treatment dilemma. The diagnosis is primarily based on a patient's subjective symptoms and chief complaint. These can include the presence of pain during mastication, temperature sensitivity without a clear etiology, and pain when releasing pressure on a bite stick (Cameron 1964, Ratcliff 2001, Rosen 1982). In addition to subjective symptoms, diagnostic aids are available to practitioners for cracked tooth identification. Transillumination with a fiber optic light and magnification enhance visualization of defects (Cameron 1976, Abou-Ross 1983, Ailor 2000). After placing the light source directly on the tooth, a crack penetrating into the dentin will diffuse the light and generate a shadow. Some authors suggest removing existing restorations to support crack visualization (Abou-Ross 1983, Ailor 2000). Staining a suspected crack with methylene blue can also improve visualization (Abou-Ross 1983, Ailor 2000). Roh 2006 found that 96% of patients with a

cracked tooth responded positively to the bite test. An article in which these methods were tested in a controlled clinical trial was not found during a literature search.

HISTOPATHOLOGY

Studies evaluating pulpal and microbiologic responses to the presence of a crack are limited. Only one article was noted describing the histopathology and bacteriology of cracked teeth. Ricucci et al. (2015) investigated 12 teeth with confirmed tooth fractures. In all specimens, bacteria had penetrated and colonized the dentinal tubules. This was especially evident in cracks that extended perpendicularly into dentin. Inflammatory cells accumulated in the pulp zone adjacent to the infected tubules. Patients were symptomatic in most cases in which the crack extended into the pulp. In these cases, pulpal response varied from acute inflammation to complete pulpal necrosis. Polymorphonuclear neutrophils were observed migrating from the pulp into the crack towards the enclosed bacterial biofilm. Severe pulp reactions were also observed when the crack extended to the pulp chamber floor. The authors concluded that cracks are always colonized with bacterial biofilms, and that the pulp tissue response varies according to the location, direction, and extent of the crack.

TREATMENT AND OUTCOMES

Davis and Overton (2000) observed 40 cracked teeth over a one year period following restoration with either bonded or non-bonded (mechanical retention only) cuspal coverage or conventional amalgam restorations; both treatments successfully resolved chewing sensitivity over the course of the study. Opdam et al. (2008) followed 40 patients diagnosed with cracked teeth and reversible pulpitis. These patients received either intracoronal composite restorations

or cuspal coverage composite onlays and were followed for seven years. None of the teeth were extracted due to restorative failures and were considered clinically successful, although the intracoronal group did have a mean annual failure rate of 6%. There were no restorative failures for the group with cuspal coverage. Seven and one-half percent of the subjects required root canal treatment over the course of the study, 50% of all restored teeth were still symptomatic after six months, and 25% were still symptomatic after seven years. The authors concluded that bonded composite is an effective treatment for symptomatic cracked teeth, resulting in 92.5% of the teeth maintaining pulp vitality. They also concluded that full cuspal coverage composites resulted in better outcomes than those without full coverage. In a retrospective study Signore et. al. (2007) also evaluated the clinical performance of bonded indirect resin composite onlays on symptomatic cracked teeth. After six years, 93% remained symptom free and were deemed a restorative success.

Few in vivo clinical studies report on the treatment and outcomes of cracked teeth. Even fewer studies have evaluated cracked teeth that also require endodontic treatment. The outcome of the Krell and Rivera (2007) study suggest that if a crack is identified early in teeth diagnosed with reversible pulpitis and a crown placed, root canal treatment will be necessary in about 21% of the cases. Therefore, endodontic treatment should only be performed if the pulpal and apical diagnosis requires it. They reported the outcomes of symptomatic cracked teeth that were initially diagnosed with reversible pulpitis and treated with full cuspal coverage restorations. One hundred twenty seven teeth were followed for six years following crown delivery. One hundred percent of the crowned teeth in the study survived and remained asymptomatic in both the endodontically treated and non-treated groups. A limitation of this study was it did not compare the success rate of full coverage to other restorative treatments.

One outcome study focused specifically on endodontically treated cracked teeth. Tan et.al. (2006) reported retrospective results from 49 patients who received root canal treatment for cracked teeth. The data included the presence of periodontal pocketing, sinus tract, and swelling associated with the teeth. Pretreatment data collected were number, extent and location of crack, presence of periodontal pocketing, patients' age and gender, location of cracked teeth, type of teeth and presence of terminal cracked tooth. The 2-year survival rate was 85.5%. Factors that decreased outcomes were the terminal tooth position in the arch, the presence of periodontal pocketing prior to endodontic treatment, and the presence of multiple cracks. A follow-up study completed by Sim et al. (2016) reported an overall 92% 2 to 4-year survival rate. However, they discovered that if the crack extended onto the pulp chamber floor, survivability dropped to 82%. To date, no *prospective* outcome studies have been conducted.

Section III: Objective

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 at a minimum of 12 months 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 least one year following the completion of treatment.

Section IV: Materials and Methods

[This section was referenced 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 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 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 at any point in the treatment including pre-operatively, post-operatively, or 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 endodontic registry; a database of patients maintained in the NPDS Endodontic department. The endodontic 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 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). The data were analyzed using the Fisher's Exact Chi Square and odds ratio tests. An intraclass correlation coefficient was performed to assess inter-examiner reliability.

Based on previously published literature, a healed rate of 85% with a 5% confidence interval produced a sample size of 81 subjects required for analysis.

Section V: Results

At the time of this interim analysis, fifteen retrospective and twenty prospective subjects were enrolled in the study. None of the prospective subjects met the minimum 12-month time period following treatment, and were ineligible for follow-up. The 15 retrospective teeth observed were analyzed (Table 1.). Five teeth were radiographically verified as extracted.

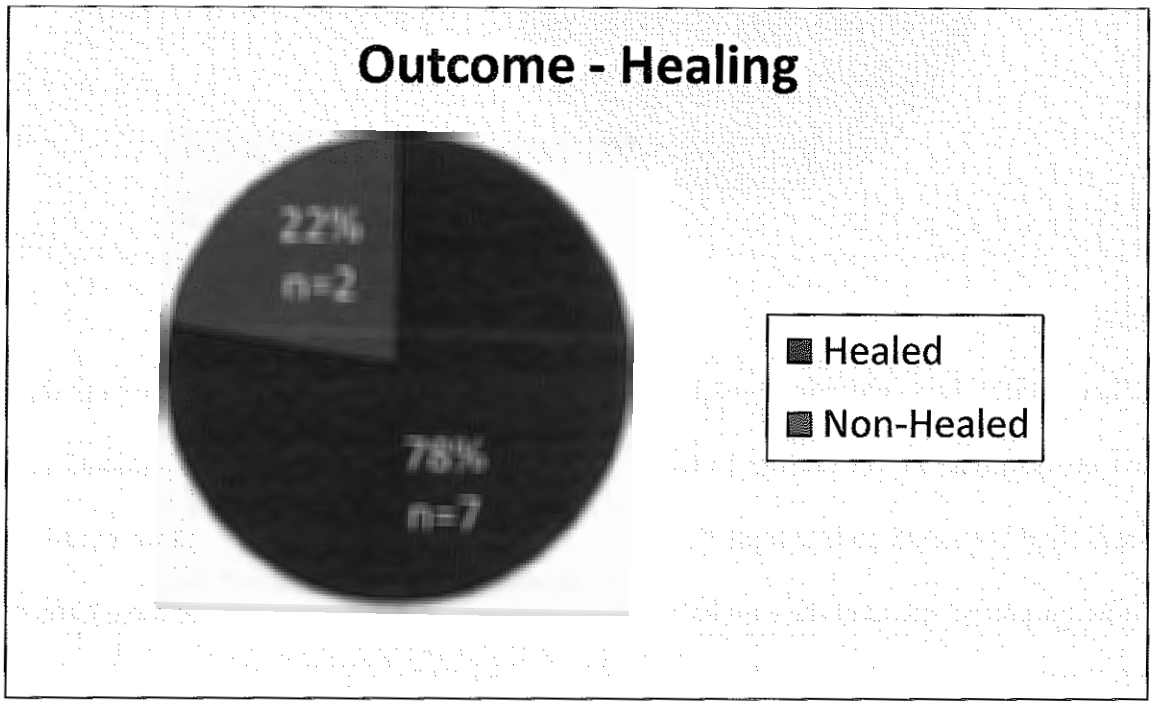
Status	# Subjects
Retrospective Enrolled	15
Prospective Enrolled	20
Prospective Eligible for Follow-up	0
Total Enrolled	35
Extracted	5
Analyzed	10
Symptomatic	1

Table 1.

The sample demographics were 53.3% male (n=8) and 46.6% female (n=7) and ranged in age from 27.2 to 57.7 years, with a median age of 46.6 years. The follow-up examination ranged from 12.5 months to 46.9 months, with a median of 16.2 months. Sixty seven point seven percent (n=10) of the cracked teeth were in a non-terminal position in the arch, and 33.3% (n=5) were in the terminal position. Sixty percent (n=9) were mandibular and 40% (n=6) were maxillary teeth. All but one tooth were molars. Regarding the frequency of cracked teeth, the mandibular first molar was the most frequency observed cracked teeth in this study (n=6), followed by the maxillary first molar

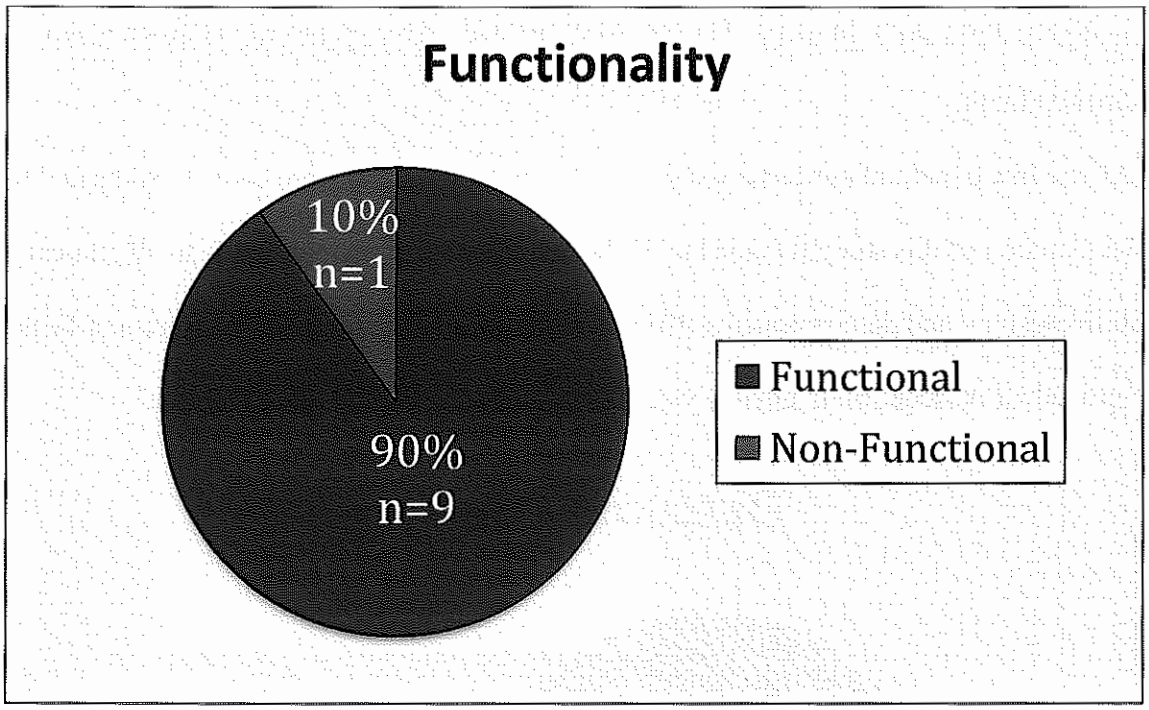
(n=4), mandibular second molar (n=3), maxillary second molar (n=1), and maxillary first premolar (n=1). Ninety three point three percent (n=14) of the teeth were previously restored when diagnosed as a cracked tooth.

After clinical and radiographic assessment, seven teeth (78%) were considered healed based on the strict criteria of this study (Graph 1). All healed teeth were asymptomatic to all clinical and sensibility testing, and demonstrated a PAI score of 1 or 2. Two teeth (22%) were non-healed; both were graded a PAI score of 4, and one was asymptomatic while the other was not.



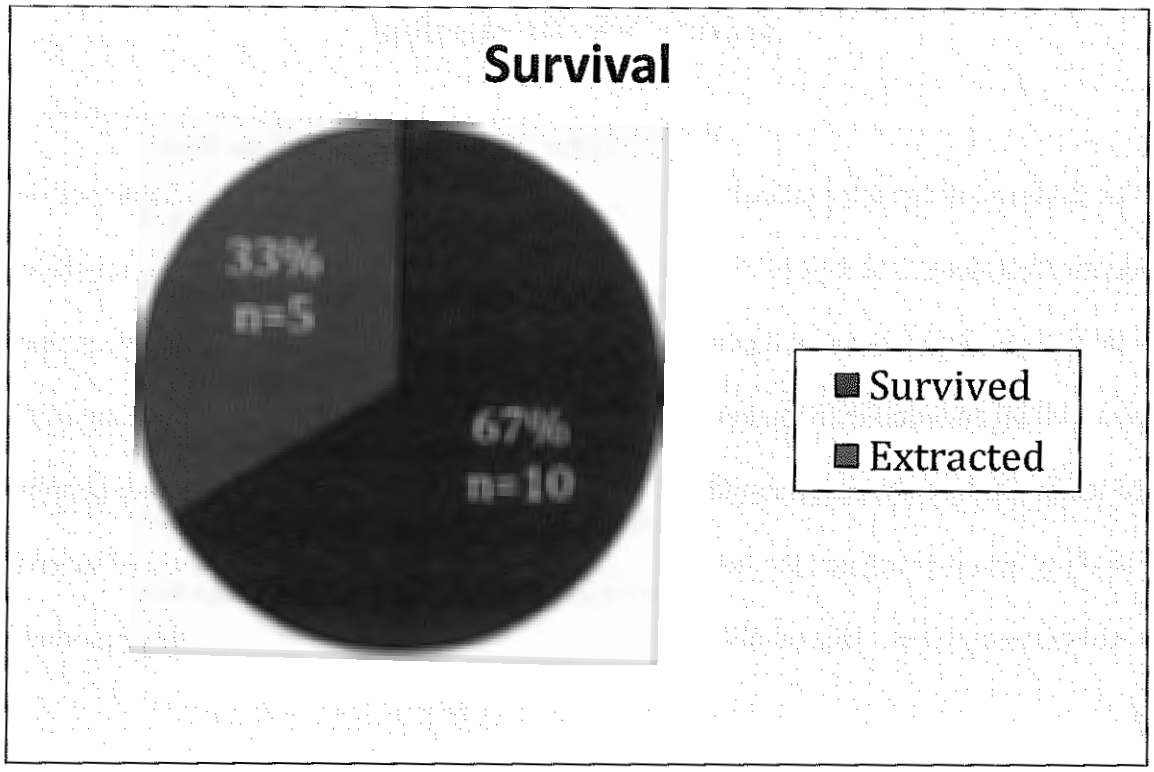
Graph 1.

After clinical and radiographic assessment, nine of ten teeth (90%) were considered functional (Graph 2). Each of these teeth demonstrated no sensitivity to percussion, palpation, tooth slooth application, cold testing, and demonstrated normal mobility or probing depths beyond 3mm. PAI score was not considered in this category. One additional tooth was assessed in this category compared to the healed category because the tooth scored a PAI of 3 and a healing outcome could not be determined.



Graph 2.

Survivability was determined solely based on the presence of the tooth in the mouth during follow-up examination. Ten of the 15 teeth were still present at the follow-up examination, whereas five teeth had been extracted (Graph 3). Two mandibular molars were extracted for treatment planning purposes; one maxillary molar was asymptomatic, but extracted due to the enlargement of a periodontal defect and mobility. The circumstances of the remaining two extracted teeth are unknown.



Graph 3.

The secondary objective of this study was to evaluate possible covariate influences on cracked tooth endodontic outcomes. The following covariate factors were analyzed: gender, age, tooth position, tooth type, depth of crack, presence of multiple cracks, pulpal and periapical diagnosis, diabetes, HTN, pain, percussion sensitivity, restorations, pocket depths, and mobility. Due to the limited number of subjects currently enrolled in this interim analysis, these factors could not be assessed at this time.

Section VI: Discussion

The findings of this interim analysis support that cracked teeth have a predictable outcome after endodontic treatment. The healed rate of 78% is comparable to other studies observing the outcome of initial non-surgical root canal therapy. Ng et.al. (2011) reported a 72% healing rate at one year following initial endodontic treatment. De Chevigny et.al (2008) reported 86% healing of initially treated teeth. Both studies used similar criteria and assessed both symptoms and radiographic data. De Chevigny also investigated the functionality of the treated teeth and found 94% of surviving teeth were without symptoms. This number also is consistent with the 90% functionality reported in this study.

Two current studies exist in the literature addressing the survivability of cracked teeth. In a retrospective study, Tan et al. (2006) reported an overall two year survival rate of 86% for initially treated cracked teeth. They identified that the presence of multiple cracks, the tooth arch position, and the presence of pre-treatment periodontal pocking all negatively impacted survival. A follow on study conducted by Sim et al (2016) also identified the depth of crack penetration as the key factor in determining prognosis. Although they reported an overall survivability of 92%, if a crack extended onto the pulp chamber floor, there was a drop to 82%. The reported survivability of 67% in this study was notably lower than both of these studies. Two of the teeth were asymptomatic and extracted for restorative reasons; it was noted in the chart that the provider felt the prognosis was better for extracting and placing implants than crowning already cracked teeth. It is not known whether those teeth would have healed, but if excluded from the analysis, the survival rate increases to 80%, which is consistent with the other studies. As study

enrollment increases, the substantial affect of individual cases on the results will become less influential.

Regarding demographics of the incidence of cracked teeth, this study was consistent with the current literature. Mandibular molars comprised of 60% of the cracked teeth in this study. This agrees with Cameron (1964), Seo et.al (2012), and Krell and Rivera (2007), all of whom reported mandibular molars had the highest incidence of cracks. The subjects were mostly middle aged or older with a median age of 46.6 years. Roh et.al. (2006), also reported similar numbers and concluded that the incidence of cracks increase with increasing age.

It was also found that 93.3% of cracked teeth were previously restored. Silvestri (1976) demonstrated that restored teeth are more likely to exhibit cracks. It was stated, teeth with larger restorations lack adequate structure. Restorative procedures weaken teeth and increase the likelihood of fracture. In restored teeth, the incidence of fracture increased with increasing size of the restoration (Silvestri 1976). Two additional studies (Seo 2012, Roh 2006) indicated that non-restored teeth are just as likely to crack. This data does not support their findings.

Limitations of the healing assessment in this study include the one-year follow-up duration and the strict healing criteria. Ng et al. (2011) determined clinical healing increased from 72% to 91% after extending the follow-up interval from one to two years. Friedman (2002) found indications of healing one year following treatment, but stated that three to four years may be necessary to observe conclusive healing. Consequently, healing rates may change as further annual follow-up examinations on current subjects are conducted. One of the non-healed teeth in this study was asymptomatic and did demonstrate a smaller periapical radiolucency (PARL) at the one-year follow-up compared to the immediate post-treatment assessment, but due to the strict healing criteria of this

study, it was considered non-healed.

Due to the limited sample size, the statistical significance of factors affecting healing outcomes could not be determined.

Section VII: Conclusions

The interim analysis of this retrospective/prospective, observational study indicates the outcome of endodontically treated cracked teeth is favorable, and supports that cracked teeth may be treated predictability. Further data collection and analysis will continue until a sufficient power 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

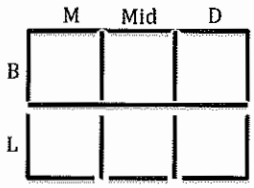
Subject#_____

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

Tooth number_____

Check the appropriate boxes/fill in blanks

Please fill in probing depths (mm)



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

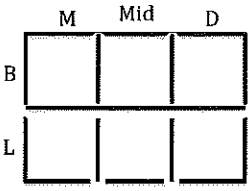
Subject#_____

Visualization upon endodontic ACCESS

Tooth number_____

Check the Appropriate boxes/Fill in blanks

Please fill in
probing depths



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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