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Treatment Decisions Involving Teeth with Intrapulpal Cracks: A Survey of Endodontists

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Dentistry at Virginia Commonwealth University.

by

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## Abstract

### TREATMENT DECISIONS INVOLVING TEETH WITH INTRAPULPAL CRACKS: A SURVEY OF ENDODONTISTS

By Sheldon M. Sealey, DMD

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in Dentistry at Virginia Commonwealth University.

Virginia Commonwealth University, 2015

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There is no universal protocol for diagnosing, treating and managing cracked teeth. The purpose of this survey was to investigate the use of traditional methods of crack detection and to explore how treatment decisions were made using an intrapulpal crack classification. The electronic survey was sent to 1115 active members of the American Association of Endodontists (AAE) and The Digital Office (TDO™) community. Comparisons were assessed using logistic or repeated-measures regression. The most often used diagnostic method was probing. When the crack involved one wall, 85% of respondents would complete root canal therapy > 50% of the time or always. For two or more walls, the percentage dropped to 44%. When the crack involved the floor or orifices, 60% would not complete treatment. For necrotic teeth, 36% of respondents preferred extraction as opposed to 3% if vital. This survey illustrated the anecdotal nature of detection, diagnosis and management of cracked teeth.

## Introduction

The cracked tooth continues to pose significant problems for patients and for the clinician. Epidemiologic studies have shown that cracked teeth are one of the leading causes of tooth loss in industrialized countries (1). Clinicians often find it challenging to diagnose cracked teeth, assess their prognosis and decide on a predictable management strategy. As evidence of the importance of the issue of cracked teeth, the American Association of Endodontists (AAE) President, Robert S. Roda stated “The AAE has instituted the Cracked Tooth Initiative to facilitate research and help eliminate fractured teeth as a major cause of tooth loss in the future” in the January 2015 Communique (2). The uncertain prognosis and the unpredictable management strategies associated with cracked teeth have lead to a wide variability in how practitioners approach treatment.

Most treatment recommendations utilized today are based on anecdotal information rather than high levels of clinical evidence. At present there is no universal protocol for treating and managing cracked teeth but it is recommended that clinicians use the pulpal and periapical diagnoses to guide their decisions (3, 4). However, what should the protocol be for initiating root canal therapy, completing root canal therapy and deciding when a tooth should be extracted? Some authors have tried to present flow charts to aid clinicians in their decision making process. In one such study, the author suggested root canal treatment and provisional crown on cracked teeth if symptoms were suggestive of irreversible pulpitis. If symptoms continued, then the recommendation was to extract the tooth (5). Another study, recommended initiation of root

canal therapy followed by temporary restoration and stainless steel band. Only if symptoms resolved after a follow up period of 6-8 weeks did the author recommend that the root canal treatment be completed. If symptoms continued then the recommendation was extraction (4). Differences between both protocols involved when or if root canal therapy should be completed, how teeth should be managed from a restorative aspect and what the follow up period should be before deciding on extraction. These differences in the literature make it difficult for the clinician to decide which is the most predictable strategy.

Each of the protocols above, also recommended extraction if symptoms did not resolve. Other studies have recommended extraction of cracked teeth upon confirmation of the fracture in the pulp chamber (3) . Some authors have recommended extraction in cracked cases of necrotic teeth with minimal to no restoration due to their poorer prognosis (6). Most recently, a case report was published describing a novel approach to treat fractures in teeth with prior endodontic treatment and related symptoms (7). Most of these teeth might have been extracted ordinarily. The author recommended re-accessing, removal of the fracture with a round bur, followed by repair of the iatrogenic perforation with MTA. The cases showed success in terms of alleviation of patient symptoms and periodontal healing seen radiographically (7).

Quite often clinicians are presented with cases in which a crack is detected in the pulp chamber during root canal treatment. The first decision to be made is if the crack is to be eliminated or left in-situ? Sometimes, after root canal treatment the patient's symptoms are not alleviated or the symptoms return after a brief period of resolution. Should these teeth be extracted or are there other options that may allow patients to retain their natural dentition?

Crack classification and detection are two other areas where there has been confusion in the literature. The "Cracked Tooth Syndrome" or CTS was popularized by Cameron in 1964 and,

in fact, is still quoted in the literature today (8). CTS was used to describe symptoms of pain when chewing, temperature sensitivity, especially cold sensitivity and pain on release of pressure (8, 9). The term syndrome implies that a diagnosis of “Cracked tooth” must include one or more of these symptoms. However, other authors believe that a cracked tooth is simply a clinical finding and may be associated with a variety of symptoms depending on the status of the pulp and the periradicular tissues (4, 10).

At the moment there is no universal classification system for cracked teeth. The AAE has its own classification system and each category is associated with a specific prognosis and treatment recommendation (11). The five types of longitudinal fractures in their classification are craze lines, fractured cusp, cracked tooth, split tooth and vertical root fracture. With the growing popularity of microscopes, Clark et al proposed another classification system based on visual observation at (x16) magnification (12). In 2013, VCU created the Intrapulpal Crack Classification system based on microscopic findings after access (13). The classification system combined both pulpal wall and pulpal floor involvement. For clinicians, these different classification systems have made it hard to decide on the best management strategy because each one is usually associated with different treatment recommendations.

Regardless of the etiology, cracked teeth can be sometimes hard to recognize clinically due to the variability and inconsistency that can present with patient symptoms (3, 4, 10). Hence, various methods of detection have been proposed in the literature. Traditional methods of crack detection include: bite test, cold test, transillumination and staining (10). The bite test and cold test were utilized for the reproduction of a patient’s chief complaint of cold sensitivity and pain on biting or release (10). The other two methods were designed to utilize visualization as a means of detection. Probing depths can also be helpful in the determination of a cracked tooth.

The literature suggests that an isolated narrow defect may be prognostic for an adjacent crack (3, 10). With the limitations of each modality, which ones are being most utilized by practitioners? Some authors even suggest that traditional methods of crack detection may not be necessary due to use of the microscope (12).

Some questions that arose from the review of the literature include: Are traditional diagnostic modalities still being utilized today by endodontists? How do endodontists make treatment decisions? If introduced to the Intrapulpal Crack Classification system (13), would endodontists find it of value when making treatment decisions?

Hence, the purpose of this survey was to investigate the utilization of specific methods of crack detection and to explore how decisions about treatment are being made based upon an Intrapulpal Crack Classification system.



## Materials and Methods

An invitation to the electronic survey was sent to members of the AAE (American Association of Endodontics) and members belonging to a forum in which the members utilize TDO™ endodontic software via REDCap. A cover letter accompanied the email invitation to complete the survey. The invitation was sent to 1115 endodontists. The questionnaire included eight questions on demographics, nine questions on detection, and thirteen questions on treatment decisions. The questions related to treatment decisions included three photos taken with a digital camera (Canon Rebel T4i) under magnification provided by a surgical operating microscope (Carl Zeiss Meditec, Jena, Germany). To ensure anonymity, no personal information was requested. Emails were not saved as part of the study. Submitting the survey was accepted as voluntary consent to participate in the study. The study was conducted with VCU IRB approval (#HM20002041).

Data were summarized using percentages, means, and standard deviations as appropriate. All analyses were performed using SAS software (JMP version 10, SAS Institute Inc., Cary, NC). Comparisons across questions on the survey were assessed using repeated-measures regression or logistic regression, as appropriate. Significance was declared at  $\alpha < 0.05$ .

## Results

Invitations were sent via email to 1115 endodontists. Of these, 72 were returned as spam, and 30 were blocked as not deliverable. Not eligible for the study were 15 retired AAE members and 7 not in active practice. Of those remaining as potentially eligible to respond to the survey (n=991), 28.4% responded (n=281). The results are summarized in the following sections. Note that not all of the participants responded to every question therefore, the totals will not always add to 281. Percentages are based on the non-missing responses to each question.

### Part 1: Demographics

The characteristics of the respondents (n=281) who participated in this survey are summarized in Table 1. Forty one percent (41%) of respondents had greater than 20 years of private practice experience, 27% from 11 to 20 years and 32% from 1 to 10 years. Thirty two percent (32%) of the respondents were certified through the American Board of Endodontics (ABE); 68% were not. Seventy nine percent (79%) of all respondents were in private practice full time. Forty four percent (44%) of the respondents were in solo practice while the remaining 57% belonged to a type of group practice. Ninety three percent (93%) of respondents did not place implants in their practice. There was an even distribution of respondents by region as seen in Table 3. Information on the characteristics of the patients treated by the respondents was summarized in Table 2. The majority of patients seen by the respondents were either middle income (48%) or middle to upper income (42%). Eighty eight percent (88%) of the patients had private insurance.

**Table 1. Description of Respondents**

Characteristic	N	Percent
Years in practice as an endodontist:		
1-10 yrs.	89	31.9
11-20 yrs	75	26.9
21-30 yrs	60	21.5
more than 30 yrs	55	19.7
Are you a board certified endodontist?		
No	190	67.9
Yes	90	32.1
Practice type:		
Full -time Private Practice	219	78.5
Part -time Private Practice	21	7.5
Academics only	7	2.5
Part -time Faculty/ Part-time Private Practice	11	3.9
Practice environment:		
Solo practice	121	43.5
Group practice with < 4 endodontists	103	37.1
Group practice > 4 endodontists	31	11.2
Group practice with both general dentists and endodontists	16	5.8
Group practice with other specialists	7	2.5
In your practice do you place implants?		
No	260	93.2
Yes	19	6.8

**Table 2. Patient Characteristics**

Characteristic	N	Percent
Which income level represents the majority of your patients?		
Low to middle income	14	5.1
Middle income	132	47.8
Middle to upper income	117	42.4
Upper income	13	4.7
Which one applies to the majority of your patients?		
Private Insurance	245	88.4
Self Pay	31	11.2
Medicaid	1	0.4

**Table 3. Survey of Participants' Location**

Where do you currently practice?	N	Percent
District I (Delaware, District of Columbia, Maine, Maryland, Massachusetts, New Hampshire, Pennsylvania, Vermont and Virginia)	61	22.3
District II (Connecticut, New Jersey, New York and Rhode Island)	18	6.6
District III (Florida, Georgia, North Carolina, South Carolina and Tennessee)	37	13.5
District IV (Illinois, Indiana, Kentucky, Michigan, Ohio, West Virginia and Wisconsin)	37	13.5
District V (Alabama, Arizona, Arkansas, Louisiana, Mississippi, New Mexico, Oklahoma, Public Health, Puerto Rico, Texas, U.S. Air Force, U.S. Army, U.S. Navy and the Veterans Administration)	45	16.4
District VI (Alaska, Colorado, Guam, Hawaii, Idaho, Iowa, Kansas, Minnesota, Missouri, Montana, Nebraska, Nevada, North Dakota, Oregon, South Dakota, Utah, Washington and Wyoming)	56	20.4
District VII (California)	20	7.3

## Part 2: Detection Methods

Nine questions were asked about detection methods and each is summarized in Table 4.

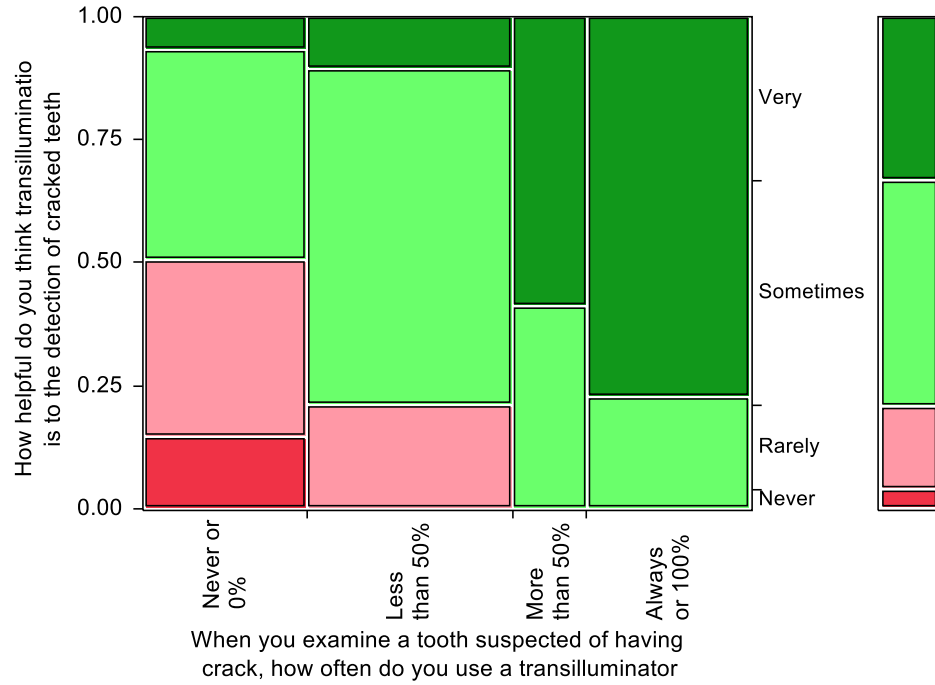
For each detection method, there is a range of opinions in practice. There is a relationship between how often a detection method is used and how helpful it is perceived to be. For example, Figure 1 shows the relationship between how often transillumination is used and its perceived helpfulness. The figure is a stacked bar chart where the size of a bar is proportional to the number of practitioners choosing both options. For instance, the large green bar on the top right side represents the 21% of practitioners who chose “When you examine a tooth suspected of having a crack, how often do you use a transilluminator? =Always or 100” and “How helpful do you think transillumination is to the detection of cracked teeth? =Very”. The colors correspond to the value of the helpfulness question. As shown in Figure 1, going from right to left there is a decreasing proportion of green. Moving from “Always” to “Never” (ie, from right to left), the helpfulness decreases (from “Very” to “Never”). Likewise, the red bar corresponds to the 4% of practitioners who chose “When you examine a tooth suspected of having a crack, how

often do you use a transilluminator? =Never or 0%" and "How helpful do you think transillumination is to the detection of cracked teeth? =Never".

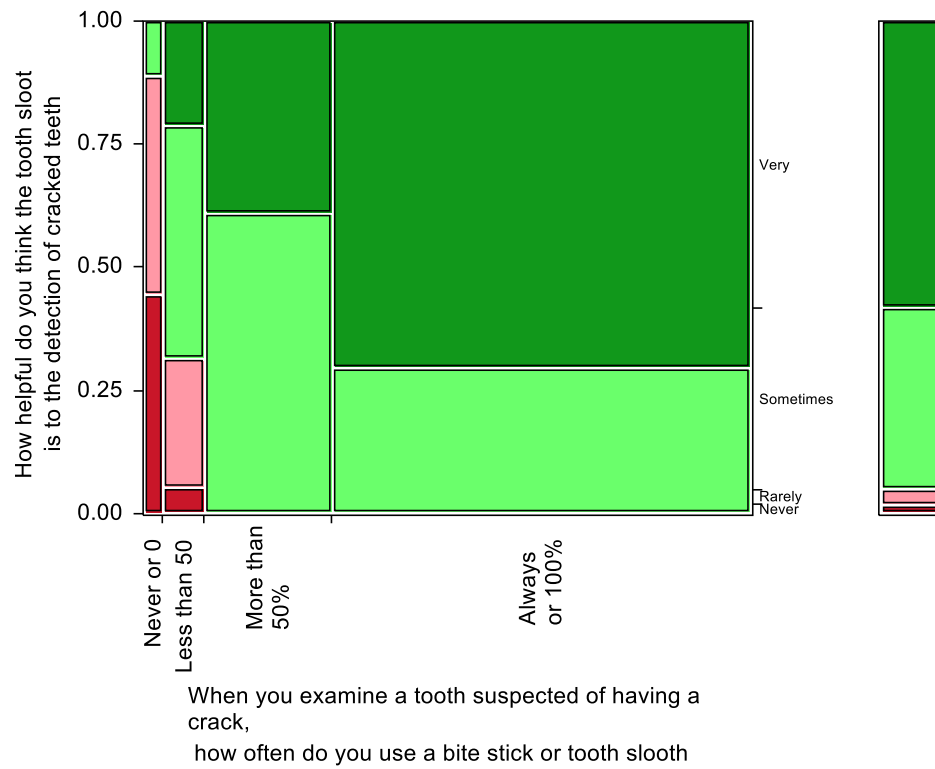
With regards to transillumination, while 62% of the respondents reported a frequency of < 50% or never, a significant number (79%) felt that this modality was "Sometimes" or "Very" helpful. This relationship was depicted in Figure 1. For the Tooth Slooth<sup>®</sup>, 90% of the respondents reported a frequency of > 50% or always and 95% felt that this modality was "Sometimes" or "Very" helpful. This relationship was depicted in Figure 2. Periodontal probing was used > 50% of the time or always by 98% of respondents and 98% of respondents felt that it was "Sometimes" or "Very" helpful. This relationship was depicted in Figure 3. Staining was used by 79% of the respondents <50 % of the time or never while 70% found it to be "Sometimes" or "Very" helpful. This relationship was illustrated in Figure 4. When queried about when they used staining the most, 63% of respondents reported use after access, while only 12% used it before and after access.

**Table 4. Detection Methods**

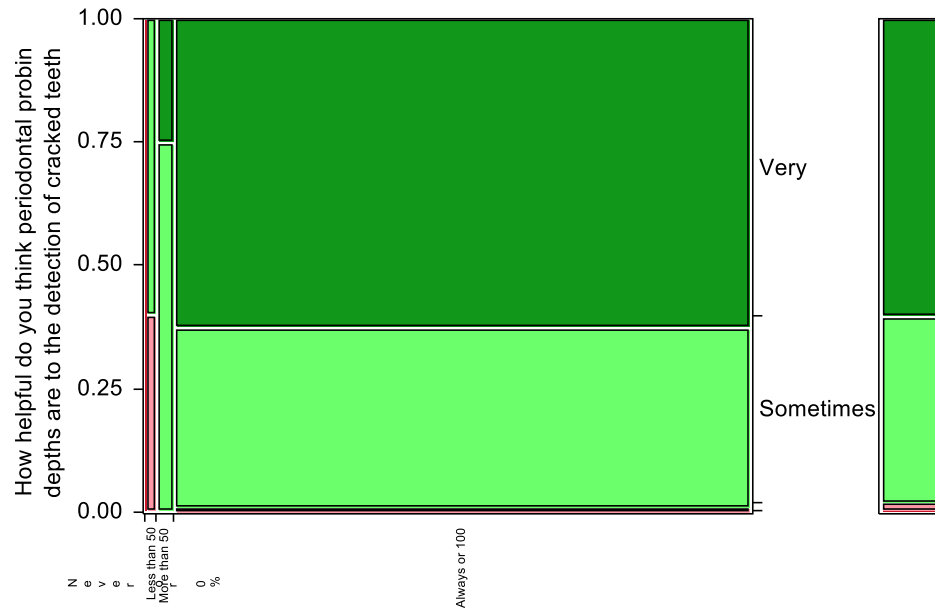
Percentage				N
When you examine a tooth suspected of having a crack, how often do you use a transilluminator?				
Never or 0%	Less than 50%	More than 50%	Always or 100%	281
27.8	33.5	12.1	26.7	
How helpful do you think transillumination is to the detection of cracked teeth?				
Never	Rarely	Sometimes	Very	277
4.0	17.0	45.8	33.2	
When you examine a tooth suspected of having a crack, how often do you use a bite stick or Tooth Slooth®?				
Never or 0%	Less than 50%	More than 50%	Always or 100%	280
3.2	6.8	21.1	68.9	
How helpful do you think the Tooth Slooth® is to the detection of cracked teeth?				
Never	Rarely	Sometimes	Very	281
1.8	3.2	37.0	58.0	
When you examine a tooth suspected of having a crack, how often do you measure periodontal probing depths?				
Never or 0%	Less than 50%	More than 50%	Always or 100%	280
0.4	1.8	2.9	95.0	
How helpful do you think periodontal probing depths are to the detection of cracked teeth?				
Never	Rarely	Sometimes	Very	280
0.4	1.4	37.9	60.4	
When you examine a tooth suspected of having a crack, how often do you stain the suspected teeth?				
Never or 0%	Less than 50%	More than 50%	Always or 100%	279
32.6	46.2	14.0	7.2	
How helpful do you think staining is to the detection of cracked teeth?				
Never	Rarely	Sometimes	Very	277
5.4	24.9	52.7	17.0	
When are you most likely to use staining?				
Never	Before access	After access	Before and after access	279
21.9	3.6	62.7	11.8	



**Figure 1. Relationship Between Helpfulness and Frequency of Use: Transillumination**



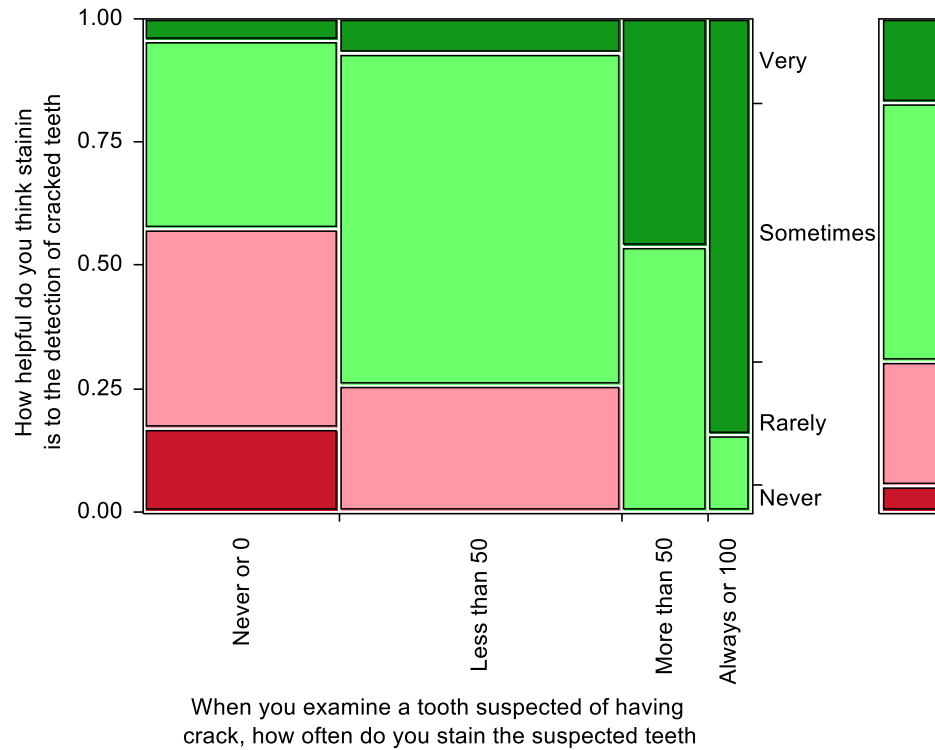
**Figure 2. Relationship Between Helpfulness and Frequency of Use: Tooth Slooth®**



When you examine a tooth suspected of having a crack,  
 how often do you measure periodontal probing depths

**Figure 3. Relationship Between Helpfulness and Frequency of Use: Periodontal Probing**





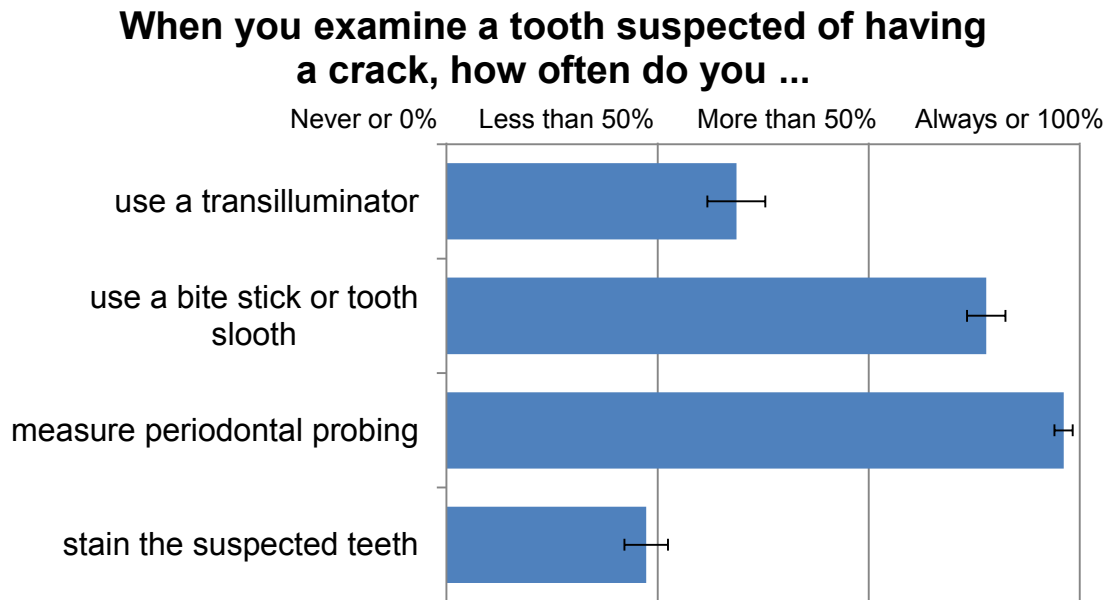
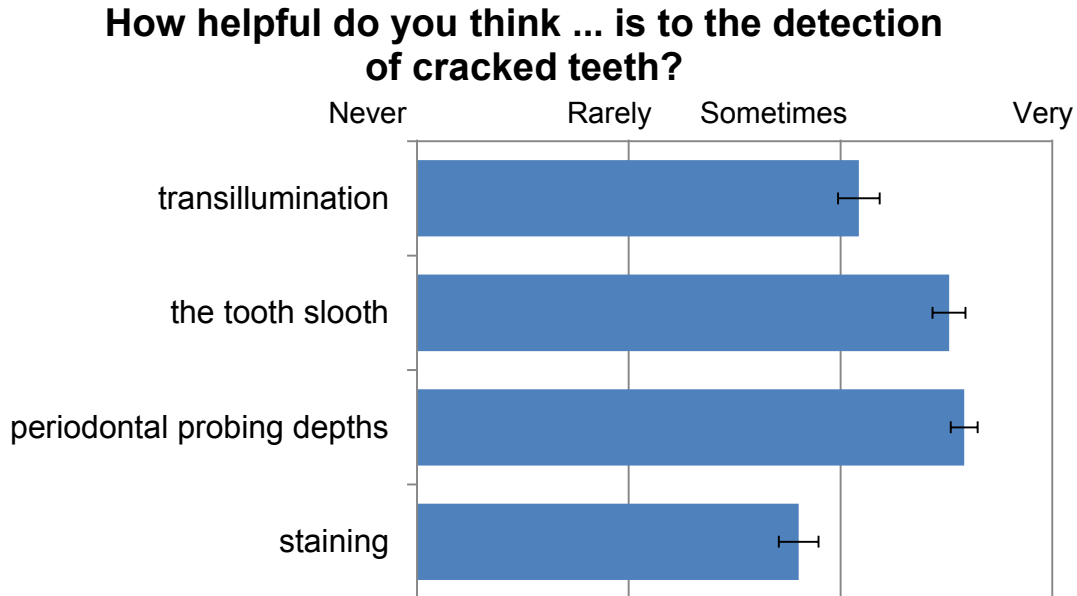
**Figure 4. Relationship Between Helpfulness and Frequency of Use: Staining**

A repeated-measures ANOVA was used to compare how often each of the detection methods were used and how helpful they were. Using a scoring system where 0=never or 0%, 1=less than 50%, 2=more than 50%, and 3=always or 100% for the “how often” questions and 0=never, 1=rarely, 2=sometimes, and 3=very for the “how helpful” questions, the averages are shown in **Table 5** and Figure 5. Considering how helpful each of the four methods were, there was a significant difference ( $P < .0001$ ) with the tooth slooth and periodontal probing being not significantly different and the highest helpfulness. Next in helpfulness was transillumination, followed by staining. Considering how often each of the four methods were used, there was a significant difference between each of the four ( $P < .0001$ ). In order from most used to least used was: probing, Tooth Slooth<sup>®</sup>, transillumination, and staining.

**Table 5. Detection Methods: How Often and How Helpful**

Detection	Mean*	SE	95% CI	
How helpful do you think ... is to the detection of cracked teeth?				
transillumination	2.09	0.050	1.99	2.18
the Tooth Slooth®	2.51	0.040	2.43	2.59
periodontal probing depths	2.58	0.033	2.52	2.65
staining	1.80	0.048	1.71	1.90
When you examine a tooth suspected of having a crack, how often do you ...?				
How helpful do you think ... is to the detection of cracked teeth?				
How helpful do you think ... is to the detection of cracked teeth?				
use a transilluminator	1.37	0.070	1.24	1.51
use a bite stick or Tooth Slooth®	2.56	0.046	2.47	2.65
measure periodontal probing	2.92	0.022	2.88	2.97
stain the suspected teeth	0.95	0.053	0.84	1.05

\* Means calculated using the scoring system where 0=never or 0%, 1=less than 50%, 2=more than 50%, and 3=always or 100% for the “how often” questions and 0=never, 1=rarely, 2=sometimes, and 3=very for the “how helpful” questions.



**Figure 5. Detection Methods: How Often and How Helpful**

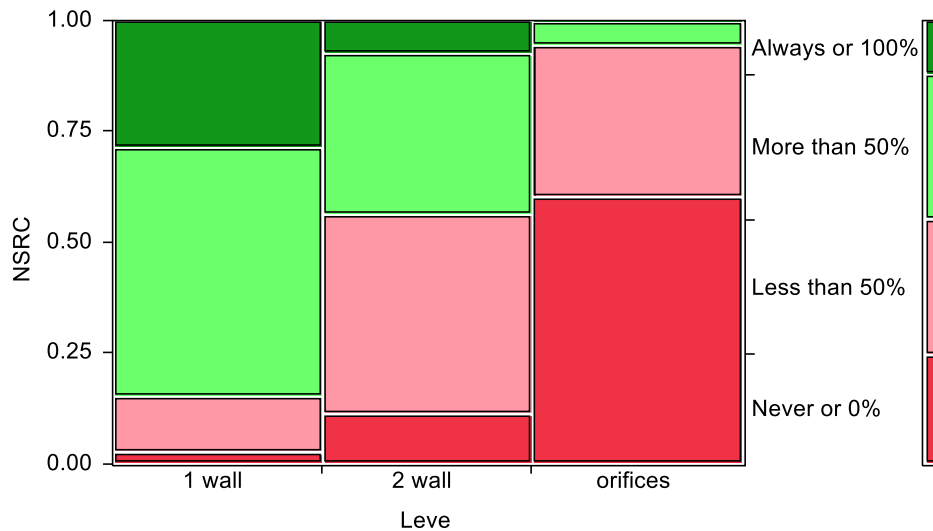
These orderings did not vary by years in practice ( $P>0.15$ ), patient income ( $P>0.9$ ), insurance ( $P>0.6$ ), implants ( $P>0.9$ ) or district ( $P>0.18$ ).

### Part 3: Treatment Decisions

For treatment decision questions, responses are presented in Table 6. These responses did not vary by years in practice ( $P>0.2$ ). Eighty nine percent (89%) of respondents felt that the extent of a crack into the pulp chamber impacted their decision to perform endodontic therapy while 11% said “No”. Of the respondents queried, 85% responded that they would complete root canal therapy  $> 50\%$  of the time or always in cases where the intrapulpal crack was limited to one wall. For cracks involving two or more walls, the percentage of respondents completing the root canal  $>50\%$  of the time or always dropped to 44%. In cases where the crack involved the floor of the pulp chamber or the orifices, only 6% of respondents reported that they would complete the root canal  $>50\%$  of the time or always. Sixty percent (60%) of respondents reported that in this case they would never complete the root canal therapy. As Figure 6 shows, there is a significantly different preference for each of the three levels of involvement ( $P < .0001$ ). For cracks involving only one wall, the preference was completing the root canal  $>50\%$  of the time. For cracks involving two or more walls, the preference was completing the root canal  $< 50\%$  of the time. For cracks involving the floor or orifice the preference was never completing the root canal.

**Table 6. Treatment Decisions**

Percentage				N
If a crack extends into the pulp chamber (i.e. an intrapulpal crack), does the extent of the crack impact your decision to perform endodontic therapy?				
No	Yes			
11.1	88.9			279
How often do you complete a root canal when the crack extends into the pulp chamber and is limited to only 1 wall?				
Never or 0%	Less than 50%	More than 50%	Always or 100%	
2.5	12.6	56.1	28.8	278
How often do you complete a root canal when the crack extends into the pulp chamber and involves 2 or more walls?				
Never or 0%	Less than 50%	More than 50%	Always or 100%	
11.2	45.0	36.3	7.6	278
How often do you complete a root canal when the crack extends into the pulp chamber and includes the floor of the chamber or the orifices?				
Never or 0%	Less than 50%	More than 50%	Always or 100%	
60.2	34.1	5.4	0.4	279



**Figure 6. Treatment Decisions: Extent of Crack Involvement**

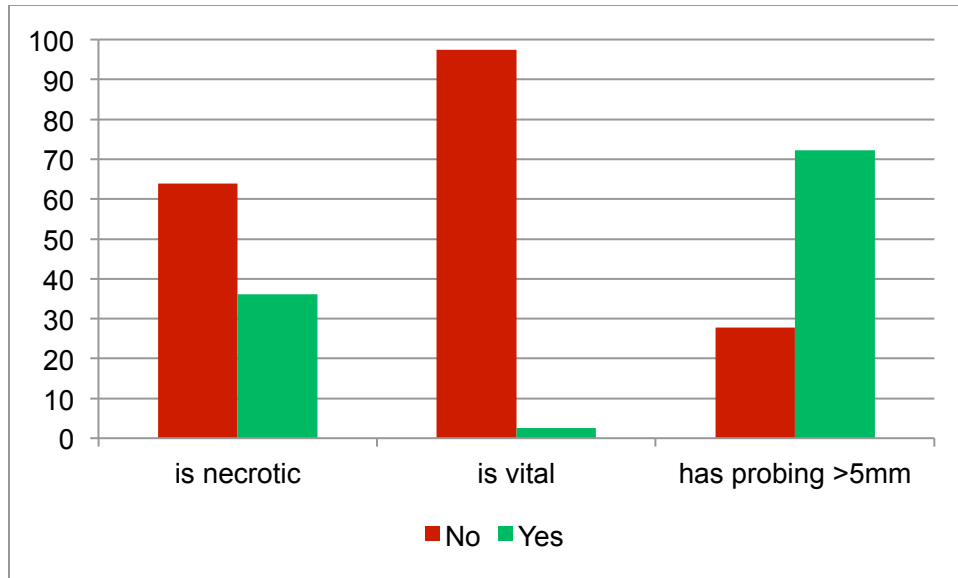
When asked “For teeth with intrapulpal cracks, do you alter your normal routine for cleaning, shaping and obturation?” 86% said No (239/277).

#### Part 4: Extraction Recommendations

For extraction recommendation questions, responses are presented in Table 6 and Figure 7. In each of the cases, the percentage “Yes” was significantly different than the other two cases ( $P < 0.0001$ ). When respondents were queried about extraction recommendations, 36% were more likely to recommend extraction if a cracked tooth was necrotic as opposed to only 3% that would recommend extraction if a tooth were vital. Seventy-two percent (72%) of respondents were more likely to recommend extraction in cases where isolated probing depths were greater than 5mm.

**Table 7. Extraction Recommendations**

Percentage		N
Are you more likely to recommend extraction if a cracked tooth is necrotic?		
No	Yes	
63.9	36.1	277
Are you more likely to recommend extraction if a cracked tooth is vital?		
No	Yes	
97.5	2.5	277
Do you recommend extraction over endodontic therapy if a cracked tooth has an isolated probing depths of >5mm?		
No	Yes	
27.7	72.3	274



**Figure 7. Extraction Recommendations**

When asked “Would you welcome the introduction of an Intrapulpal Crack classification system designated for classifying teeth with intrapulpal cracks?” 69% said “Yes” (193/278).

Questions 19-23 were summarized in Table 8. Seventy three percent (73%) of respondents saw between 1 to 4 cases of cracks extending into the pulp chamber per week, 22% saw between 5 and 10 and 4% saw > 10 cases. Most respondents (80%) felt that intrapulpal cracks were mostly present in mandibular molars. With regards to cracked teeth and restoration size, 68% of all respondents felt that cracked teeth largely presented with restorations between 1/3 and 2/3 width of the occlusal table or greater than 2/3 width. Only 5% felt like they were more commonly associated with teeth with no restorations, while 14% reported a larger occurrence in teeth with crowns. In teeth with intrapulpal cracks, after root canal treatment 47% of respondents recommended a permanent core and permanent crown immediately while 38% recommended a permanent core and temporary crown until symptoms resolved.

**Table 8. Restorative Analysis**

	Percentage
Approximately how many root canal cases do you see per week where the crack extends into the chamber?	
0	1.8
1-4	73.0
5-10	21.7
more than 10	3.6
Total N=	(281)
Intrapulpal cracks present most often in:	
Maxillary premolars	6.9
Maxillary molars	11.2
Mandibular premolars	1.4
Mandibular molars	80.4
Total N=	(276)
In cracked teeth, which restoration size do you most commonly observe?	
No restoration	5.3
Restoration size < 1/3 of MD or BL width of the occlusal table	12.5
Restoration size between 1/3 and 2/3 width of the occlusal table	44.7
Restoration size > 2/3 width	23.1
Crown	14.4
Total N=	(264)
What is your impression of the teeth that most often present with intrapulpal cracks?	
Doesnt matter	51.1
Minimally restored	11.4
Heavily restored	37.5
Total N=	(280)
In teeth with intrapulpal cracks what do you recommend after treatment? Choose one.	
Permanent core, temporary crown until symptoms resolve	37.5
Permanent core, permanent crown immediately	46.8
Only permanent core until symptoms resolve	3.6
I let the general dentist decide	4.3
Other (state recommendation)	7.9
Total N=	(280)



## Discussion

The respondent's almost universal use of the periodontal probe depths and the Tooth Slooth<sup>®</sup> was not surprising and showed consistency among the various demographic groups. These modalities have traditionally been taught as detection methods in dental school and endodontic residencies. Literature supports pre-treatment pocketing as a significant prognostic factor (14). However, it should be noted that a probing defect is not a requirement for the diagnosis of a crack (15). Studies recommend performing the bite test with a Tooth Slooth<sup>®</sup> in order to determine pain on release or biting and identify any specific cusps associated with the crack (3, 4, 5, 10). Despite being a strong indicator for the presence of a crack, clinicians must be aware that cracked teeth may present symptomatic or asymptomatic (10). The results of this survey, however, implied that respondents still see value in both of these modalities for crack detection.

The limited use of transillumination and staining was surprising. A few respondents mentioned their use of the microscope under high magnification in lieu of transillumination and staining. These methods have potential drawbacks that possibly contributed to their lack of popularity. Both transillumination and staining are reliant on the coronal tooth structure being visible and accessible. In some instances a crack may be too small to permit penetration of the dye resulting in false negatives. Staining is considered by many to be subjective and relies heavily on the clinician's ability to discern a true crack from normal anatomical grooves. Transillumination as a detection modality is most reliable in natural dentition and lacks the

ability to detect cracks below crestal bone (16). However, in clinical studies conducted at VCU by endodontic residents, transillumination has shown to be predictive of a crack (13). Does transillumination still have value as a predictor of the extent of the crack? The answer to this question was beyond the scope of this survey.

Are newer detection modalities such as the microscope and CBCT replacing traditional methods such as staining and transillumination? Studies have shown possible value in using CBCT to detect VRF of various sizes (17, 18). In 2015, a meta analysis suggested that CBCT has value in being used clinically for crack detection (19). It would be interesting in a revised survey to compare the use of more traditional detection modalities with newer modalities.

This survey specifically asked about intrapulpal cracks and used the Intrapulpal Crack Classification System(13). Respondents had no difficulty using the classification system. The finding that endodontists were more likely not to complete NSRCT when the intrapulpal crack included more pulpal walls or involved the floor and orifices, illustrates their use of the decision making paradigm that crack extension affects prognosis. Unfortunately, little evidence based literature exists to support this paradigm. In fact one study that looked at the survival of cracked teeth after NSRCT found that the radicular extension of the crack was not a significant prognostic factor (14).

Regardless of whether vital or necrotic, the majority of respondents preferred to attempt NSRCT rather than extract. However, a significant number recommended extraction when the tooth was necrotic as opposed to vital. Case reports and a single study of the macroscopic and micro-CT analysis of necrotic teeth make up the body of evidence to date related to the prognosis of necrotic teeth (6, 20). Randomized prospective clinical trials are necessary to shift decision making from sound clinical judgment to evidence based decision making.

There were several limitations to this current survey. The response rate of 28.4% was low but not atypical for a survey. Quantifying frequency of use is subjective and could have been under or over reported. All 8 subcategories of the Intrapulpal Crack Classification System (13) were not presented. This could have been more useful in analyzing how effective or valuable this classification system would be to clinical decision making. Also, questions about microscopes, radiographs or CBCT were not included so no comparisons could be made between these newer modalities and more traditional modalities. As a result, the inference that the increased use of the newer detection modalities resulted in a decrease of utilization of transillumination and staining is beyond the scope of this survey.

Regardless of the etiology or the detection modality used, the cracked tooth continues to pose a dilemma for the clinician. Many respondents rightfully stated that the job of the clinician is to inform the patient of their options and ultimately the decision is dependent on the patient. This rationale is the new decision making paradigm but as we go forward more studies evaluating outcome will be valuable in helping clinicians make more evidence based decisions and also help patients to make more informed decisions about their treatment.

## Conclusion

The survey revealed that most respondents relied on pre-treatment pocketing and extension of the crack to include the floor or orifices as the major prognostic factors for recommending extraction over root canal therapy. The Intrapulpal Crack Classification System would be welcomed by practicing endodontists as a diagnostic and treatment tool. The survey also highlighted the fact that there is variability in treatment philosophy among respondents and that much of the decision-making process regarding cracks is anecdotal in nature.

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Appendix A  
Cracked Tooth Survey

Please answer each of the questions below based on your current practice patterns. For the purposes of this survey an “Intrapulpal Crack” is defined as a crack propagating into the pulp chamber. The term “intrapulpal” refers to the location of the crack in reference to the walls and floor of the pulp chamber.

Section 1- Detection

1. When you examine a tooth suspected of having a crack, how often do you use a transilluminator?  
 Never or 0%    Less than 50%    More than 50%    Always or 100%
2. How helpful do you think transillumination is to the detection of cracked teeth?  
 Never    Rarely    Sometimes    Very
3. When you examine a tooth suspected of having a crack, how often do you use a bite stick or Tooth Slooth<sup>®</sup>?  
 Never or 0%    Less than 50%    More than 50%    Always or 100%
4. How helpful do you think the Tooth Slooth<sup>®</sup> is to the detection of cracked teeth?  
 Never    Rarely    Sometimes    Very
5. When you examine a tooth suspected of having a crack, how often do you measure periodontal probing depths?

\_\_\_ Never or 0% \_\_\_ Less than 50% \_\_\_ More than 50% \_\_\_ Always or 100%

6. How helpful do you think periodontal probing depths are to the detection of cracked teeth?

\_\_\_ Never \_\_\_ Rarely \_\_\_ Sometimes \_\_\_ Very

7. When you examine a tooth suspected of having a crack, how often do you stain the suspected teeth?

\_\_\_ Never or 0% \_\_\_ Less than 50% \_\_\_ More than 50% \_\_\_ Always or 100%

8. How helpful do you think staining is to the detection of cracked teeth?

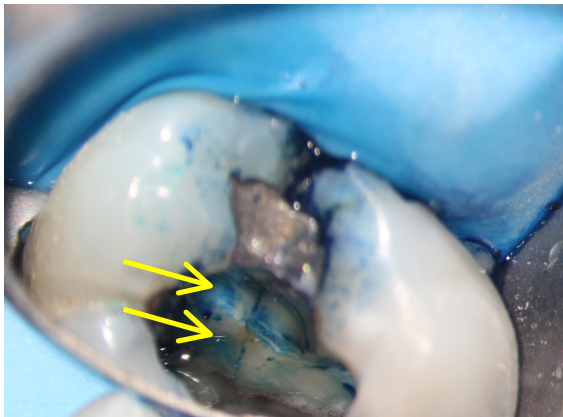
\_\_\_ Never \_\_\_ Rarely \_\_\_ Sometimes \_\_\_ Very

9. When are you most likely to use staining?

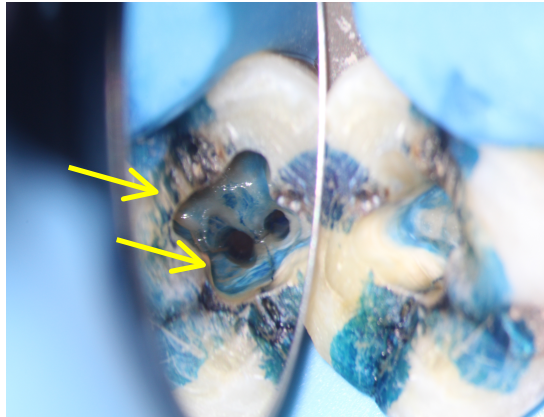
\_\_\_ Before access \_\_\_ After access \_\_\_ Before and after access \_\_\_ Never

### Section 2- Treatment Decisions

For the purposes of this study, below are some representations of “Intrapulpal Cracks.”

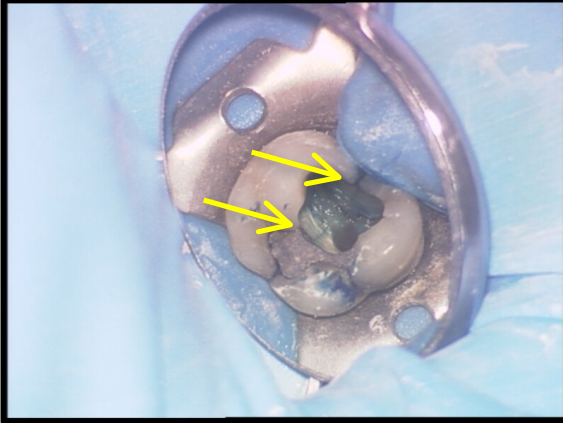


One Wall Involvement



Floor and Wall Involvement





### Two Wall Involvement

10. If a crack extends into the pulp chamber (i.e. an intrapulpal crack), does the extent of the crack impact your decision to perform endodontic therapy?

Yes  No

11. How often do you complete a root canal when the crack extends into the pulp chamber and is limited to only 1 wall?

Never or 0%  Less than 50%  More than 50%  Always or 100%

12. How often do you complete a root canal when the crack extends into the pulp chamber and involves 2 or more walls?

Never or 0%  Less than 50%  More than 50%  Always or 100%

13. How often do you complete a root canal when the crack extends into the pulp chamber and includes the floor of the chamber or the orifices?

Never or 0%  Less than 50%  More than 50%  Always or 100%

14. For teeth with intrapulpal cracks, do you alter your normal routine for cleaning, shaping and obturation?

Yes  No

15. Are you more likely to recommend extraction if a cracked tooth is necrotic?

Yes  No

16. Are you more likely to recommend extraction if a cracked tooth is vital?

Yes  No

17. Do you recommend extraction over endodontic therapy if a cracked tooth has an isolated probing depth of >5mm?

Yes  No

18. Would you welcome the introduction of an “Intrapulpal Crack” classification system designated for classifying teeth with intrapulpal cracks?

Yes  No

19. Approximately how many root canal cases do you see per week where the crack extends into the chamber?

0

1-4

5-10

>10

20. Intrapulpal cracks present most often in:

Choose one.

Maxillary Premolars

Maxillary Molars

Mandibular Premolars

Mandibular Molars

Maxillary and Mandibular Anteriors

21. In cracked teeth, which restoration size do you most commonly observe?

No restoration

Restoration size < 1/3 of MD or BL width of the occlusal table

Restoration size between 1/3 and 2/3 width of the occlusal table

Restoration size > 2/3 width

Crown

22. What is your impression of the teeth that most often present with intrapulpal cracks?

Heavily restored  Minimally restored  Doesn't matter

23. In teeth with intrapulpal cracks what do you recommend after treatment? Choose one.

Permanent core, temporary crown until symptoms resolve

Permanent core, permanent crown immediately

Only permanent core until symptoms resolve

I let the general dentist decide

Other (state recommendation)

### Section 3- Demographics

24. Years in practice as an endodontist:

1-10 yrs.

11-20 yrs.

21-30 yrs.

> 30 yrs.

25. Are you a board certified endodontist?

Yes

No

26. Please check one:

Full-time Private Practice

Part-time Private Practice

Academics only

Part-time Faculty/ Part-time Private Practice

Part-time Faculty/ Full-time Private Practice

27. You work in:

Solo practice

Group practice with < 4 endodontists

Group practice > 4 endodontists

Group practice with both general dentists and endodontists

Group practice with other specialists

28. Which income level represents the majority of your patients?

Low to middle income

Middle income

Middle to upper income

Upper income

29. Which one applies to the majority of your patients?

Private Insurance

Self Pay

Medicaid

30. In your practice do you place implants?

Yes

No

31. Where do you currently practice?

District I (Delaware, District of Columbia, Maine, Maryland, Massachusetts, New Hampshire, Pennsylvania, Vermont and Virginia)

District II (Connecticut, New Jersey, New York and Rhode Island)

District III (Florida, Georgia, North Carolina, South Carolina and Tennessee)

District IV (Illinois, Indiana, Kentucky, Michigan, Ohio, West Virginia and Wisconsin)

District V (Alabama, Arizona, Arkansas, Louisiana, Mississippi, New Mexico, Oklahoma, Public Health, Puerto Rico, Texas, U.S. Air Force, U.S. Army, U.S. Navy and the Veterans Administration)

District VI (Alaska, Colorado, Guam, Hawaii, Idaho, Iowa, Kansas, Minnesota,

Missouri, Montana, Nebraska, Nevada, North Dakota, Oregon, South Dakota, Utah,  
Washington and Wyoming)

\_\_\_District VII (California)

Comments-

## Vita

Dr. Sheldon Michael Sealey was born on September 29, 1982 in Trinidad and Tobago and is a citizen of Trinidad and Tobago. Dr. Sealey received his Bachelor of Science in Biology from South Carolina State University in 2006 and Doctor of Dental Medicine from the University of Connecticut School of Dental Medicine in 2010. He subsequently received a Certificate in Advanced Education in General Dentistry from the University of Rochester in New York in 2011. Dr. Sealey then entered private practice in Oswego, NY and completed two years in general dental practice. In 2013, he enrolled in the Advanced Specialty Program in Endodontics at Virginia Commonwealth University School of Dentistry. Dr. Sealey is a member of the AAE, ADA, and NYSDA and will enter private practice in upstate NY. He will graduate with a Master of Science in Dentistry and a Certificate in Endodontics.