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Interobserver Reliability in the Diagnosis of Pulpal and Periradicular Disease

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This is to certify that the thesis prepared by Todd Mellin entitled INTEROBSERVER VARIABILITY IN THE DIAGNOSIS OF PULPAL AND PERIRADICULAR DISEASE has been approved by his or her committee as satisfactory completion of the thesis or dissertation requirement for the degree of Master of Science

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INTEROBSERVER VARIABILITY IN THE DIAGNOSIS OF PULPAL AND PERIRADICULAR DISEASE

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

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Abstract

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The purpose of this study was to evaluate the interobserver variability of endodontic practitioners in the diagnosis of the presence or absence of pulpal and/or periradicular disease. The study examined 48 patients presenting to the VCU School of Dentistry for screening appointments under the rules and regulations of the Virginia Commonwealth University Institutional Review Board. The patients were examined separately by two endodontic practitioners, using a thorough patient history, clinical exam, and radiographs. The following question was then answered; does the patient have pulpal and/or periradicular disease. The answers were compared. The data was

analyzed using a Kappa score and the standard error was determined to test for statistical significance. Observers agreed 88% of the time with a Kappa score of 0.74. This was determined to represent a bona fide reliability with $p<.0001$. The results indicate that agreement among endodontists is very good when patients are evaluated for pulpal and/or periradicular disease.

Background

Pulpal and periradicular disease is a clinical diagnosis made by an examiner based on information collected in a clinical and radiographic exam. A typical endodontic exam includes the following: a thorough patient history, a visual exam of the oral and extra-oral tissues, clinical tests, and radiographs. The examiner determines the diagnosis by interpreting the information collected. A review of the medical literature demonstrates that when examiners are given the same information, be it a radiograph, CT scan, direct exam of patients, etc., the findings can vary significantly between examiners (1-5). The endodontic exam is also susceptible to variation in clinical findings. The clinician often starts an exam by noting the patient history. The quality of the history depends on the clinician's ability to listen and interpret what is being said without bias. It is also dependant on the patient's ability to accurately communicate the history of their present condition. Items omitted from the history or too much irrelevant information may cloud the clinician's view of the true symptomatology.

In a visual exam of the oral cavity, signs of disease can easily be overlooked. The clinical tests commonly used in endodontics are percussion, palpation, and vitality testing by applying cold, heat, and the electric pulp tester. Seltzer and Bender's (6) work have demonstrated that there is no correlation between vitality testing and pulpal histology. Petersson et al (7) also demonstrated that there could be false positive and

false negatives associated with vitality testing. Part of the process of clinical testing is interpreting patient's subjective response to the stimulus. This response can sometimes be vague and unclear. It can also be over-exaggerated. It is for the clinician to determine what is within normal limits and what is a sign of pathology.

Radiographic interpretation has been well studied in the endodontic literature. The research of Goldman et.al. (8) measured interobserver reliability in detecting disease on periapical radiographs. They found this agreement to be low (47%). In follow-up research Goldman et.al. (9) found that intra-examiner agreement is somewhat better (72-88%). These studies used overall agreement as a percentage and did not take into account agreement by chance alone, which would probably reduce the agreement even further. It is also important to note that there are many lesions that can mimic the radiographic appearance of periradicular disease (10). Despite these inherent errors radiographs alone are often used in the literature to determine the presence or absence of disease (11-15). With this brief review of the endodontic exam, we can clearly see that there is potential for variability in the endodontic exam based on both clinician and patient. How will this variability affect the diagnostic accuracy of an endodontic exam?

The only research found in the endodontic literature that even begins to examine this question is the work performed by Firriolo et al (16). In their research they gave examiners an invented clinical scenario of a patient's signs and symptoms. The examiners were asked to determine a diagnosis. Radiographs were not included. It was found that examiners agreed 88% of the time. This study effectively removed

many of the variables that we see in a clinical exam, and yet, we still see variability among examiners. The literature does not contain any studies that have examined the reliability of endodontic examiners when presented with a patient.

It is therefore the purpose of this study to evaluate the interobserver agreement of endodontic practitioners in diagnosing pulpal and/or periradicular disease when given a patient who may or may not have symptoms at the time of presentation.

Methods and Materials

Patients that presented to the Virginia Commonwealth University, School of Dentistry for new patient screening exams were asked to participate in this study. The first 48 patients, 18 years old and older, who agreed to participate in the study were consented. The patients then underwent two clinical exams. All rules and regulations of the VCU Institutional Review Board were followed. The examiners consisted of 4 endodontic residents with equal experience from the graduate endodontics program at the VCU School of Dentistry.

The patients were subjected to two independent oral and radiographic exams. A thorough patient history was noted. This included asking the patient if he/she had orofacial pain or swelling in the past, a history of trauma, etc. The oral cavity was examined for the presence of discoloration, inflammation, ulcerations and sinus tracts. Teeth were examined for discoloration, fractures and cracks. Transillumination was available to examine cracks and fractures. Testing of the dental pulp status was accomplished using standard tests normally used in dental schools and dental practices in the United States. Percussion and palpation were used to determine the presence of periradicular inflammation. Pulp vitality tests were conducted using cold (Endo Ice®, Coltène/Whaledent, Mahwah, NJ), heat (hot water with rubber dam isolation) and electric pulp testing (Kerr Pulp Tester, Analytic Technology, Redmond, WA) (17). Periodontal probings were used to check for any periodontal defects that might be

related to pulpal and/or periradicular pathology. Radiographic examination consisted of a panographic radiograph for all patients. Additional periapical radiographs were exposed as necessary when indicated by either a suspicious area noted on the panographic radiograph or based on the clinical examination and testing.

The examiners were calibrated to each other in two respects. First, the diagnostic terminology used was adapted from Walton and Torabinejad (18). This is presented in Table 1. Situations not specifically addressed by Walton & Torabinejad, were considered and clinical diagnoses were assigned. For example: if a patient presented with a periapical radiolucency associated with a root filled tooth without a history of symptoms

Tissue	**Diagnosis**
Pulpal	Normal or reversible pulpitis
	Irreversible pulpitis
	Necrosis
Periapical	Normal
	Acute apical periodontitis (AAP)
	Chronic apical periodontitis (CAP)
	Acute apical abscess (AAA)
	Chronic Supportive Apical Periodontitis (CSAP)

Table 1. Diagnostic categories. The pulpal and periradicular diagnosis used as adapted from Walton and Torabinejad (12).

since treatment, was asymptomatic at the time of exam, and had a clinically acceptable restoration, it was considered to be a healing lesion and not pathology. Secondly, each examiner was asked to approach the exam in the following manner to identify suspicious teeth and to ensure the completeness of the exam. All soft tissue of the oral cavity was palpated, and all of the teeth were percussed. For the purpose of this study

suspicious was defined as an area with an increased likelihood of disease. This could mean a periapical lesion was present; the patient reported a history of pain in the area; or the examiner, using his discretion, decided to examine an area further. A patient history was recorded, panograph interpreted, and all teeth were percussed. The examiner then used additional testing in areas of suspicion. Data were recorded for all suspicious teeth and at least one control tooth. After the completion of the first exam, a second examiner blinded from the previous findings, examined the patient.

To limit patient's exposure to unnecessary X-rays, an assistant held the films previously exposed. The second examiner would state what radiographs he/she intended to expose and only those that were requested were then revealed to the second examiner. Patients were instructed not to reveal the findings of the first exam to the second observer. The pairs of observers were not randomized but an effort was made to ensure that the number of observations were equal among the various combinations of observers. The teeth were given clinical diagnoses by each observer. This data was then used to answer the question: does the patient have pulpal and/or periradicular disease? In cases of disagreement the clinical and radiographic findings were presented to the entire group of investigators and an endodontist with 17 years of experience. A diagnosis was unanimously agreed upon. This was considered the "agreed" diagnosis and this diagnosis was used for further analysis.

Statistical Analysis

The agreement was measured at the level of the patient and only the presence or absence of disease was measured, not specific disease states. Interobserver reliability was determined using the techniques described by Sackett (19) and separately by Fleiss (20). An unweighted Kappa score was calculated at the study subject level. The $CI_{95\%}$ was calculated using the standard error of κ.

Results

A total of 48 patients were consented and examined for the present study. Of, this, 21 (44%) were found to have pulpal and/or periradicular disease and 27 (56%) were found to be disease free. Disagreements were found in 6 of the 48 (12%) of the diagnoses, resulting in an overall agreement of 88% and a κ of 0.74 ($p<0.0001$). Using

		Examiner 2		
		Disease	**No Disease**	Totals
Examiner 1	**Disease**	16	2	18
	No Disease	4	26	30
	Totals	20	28	48

Table 2. Paired observations. The 2x2 matrix of agreement developed from the 48 paired observations. This table was used to determine overall agreement, agreement by chance alone, and the kappa score.

the scale described by Landis and Koch this is considered to be substantial agreement (21). A score ranging from 0.81 to 1.00 is considered almost perfect. The confidence interval at 95% ($CI_{95\%}$) of κ was found to be 0.28. The κ's of the various observer pairs ranged from 0.33 to 1. The six disagreements between observers are listed in Table 4.

% Agreement	88%
% Agreement by chance alone	52%
Unweighted kappa	0.74
CI95%	0.28
p as calculated from the s.e.(k)	0.0001

Table 3. Results.

Discussion

As discussed earlier, the medical and dental literature contain many studies that show when human examiners are given the same information, be it a radiograph, CT scan, patient, etc., the resulting diagnosis will not always be the same. The diagnosis of endodontic disease is no different. The majority of studies in endodontics have considered only the differences in radiographic interpretation. It was found from these numerous studies that agreement between observers is poor. Seltzer and Bender (22) have shown that periapical pathosis is detectable on a PA radiograph when the cortical plate is involved. These observations demonstrate that radiographs are only a small part of the clinical picture.

In the present study, the examiners were given a clinically relevant scenario, a patient, and asked they were asked to determine whether or not this patient had disease. Instead of trying to analyze the variability of the individual parts of the exam process, this study's aim was to measure the combined effect of putting all of the pieces together. It was found that examiners with endodontic training would agree on the pulpal and periradicular diagnosis with a high degree of reliability. The literature contains studies that depend on the clinical diagnosis for treatment outcome. For example, a study by Nagle et al (23) required a patient population with irreversible pulpitis to test the effect of antibiotics. The effectiveness of this treatment modality is directly affected by the accuracy of the examining clinician's diagnosis. Currently there are no studies in the endodontic literature that measure the accuracy of clinical

diagnosis. This study did not directly measure the agreement for specific diseases states, but instead for the presence of a related disease group. It can be inferred from our study that another examiner would agree with the diagnosis of the patients in Nagle's study referenced above and therefore the potential error based on misdiagnosis is removed and more credence can be given to their findings.

The disagreements encountered in this study are listed in Table 4. The "agreed" diagnosis and the incorrect diagnosis are listed as well as the source of the variability. The errors found in this study can be separated into three general groups. The first group is examiner error. In these cases one examiner failed to note critical clinical findings that lead to a more accurate diagnosis. Examples include a periodontal probing consistent with a vertical root fracture and, in another, a history of sinusitis. The second group is patient variability. This group demonstrates that a patient's reaction may be different from one examiner to the next or interpreted differently by individual examiners. Only one such error was detected in this study. It was due to the patient omitting a history of pain to one of the examiners.

The final group includes test errors. In this group we find inconstancies in the actual clinical tests. There are two examples in this study. In one case, the suspicious and control teeth did not respond to cold testing and were further tested with EPT by both examiners. The response to EPT was different from one examiner to the next and therefore the resulting diagnosis was different. In the other example, a suspicious tooth responded to cold for one examiner. The other examiner found there to be no response, tested further with EPT and found that the tooth did not respond. These results do not

indicate that the cold and EPT testing modalities are not valid, it only agrees with previous research performed by Petersson et al. (7) showing an acceptable level of variability associated with vitality testing. The variations in clinical findings listed here confirm that there is not a single test that is guaranteed to determine the presence of disease of the pulp and periradicular tissue and that in order to properly determine a diagnosis a full, careful, and through clinical exam is required. Multiple clinical findings should be used to justify the diagnosis of pathology, rather then just a single finding such as no response to temperature.

Variability Group	Tissue	Agreed Diagnosis	Incorrect Diagnosis	Source of Error
Examiner Variations	Pulpal Periradicular	Previous RCT CAP	Previous TX Healing*	One observer noted a 10mm pocket Consistent with a fractured root
	Pulpal Periradicular	Previous RCT Normal	Previous RCT CAP	Observer failed to note history of sinusitis and misinterpreted radiograph
	**Pulpal Periradicular	Previous RCT AAP	Previous RCT Normal	One observer noted tenderness to palpation above the apex of the tooth
	Pulpal Periradicular	Irreversible AAP	Reversible Normal	Misinterpretation of tenderness to percussion
Pt Variation	Pulpal Periradicular	Irreversible Normal	Normal Normal	Patient reported a history of pain to one observer and not to the other. Lingering pain noted by one observer
Testing Variations	Pulpal Periradicular	Normal Normal	Necrotic Normal	Different EPT measurements
	Pulpal Periradicular	Necrotic Normal	Normal Normal	Tooth tested (+) to cold for one observer, other observer (-) to cold, 80/80 EPT

Table 4. Diagnostic variations. The diagnosis agreed to by consensus and the conflicting diagnosis. The reason for the discrepancy is also noted. The disagreements were further divided into three groups according to the source of the variation, examiner variation, patient inconsistancy, testing variations.

*Teeth with root fillings were considered normal in the absence of other signs and symptoms

**In one patient there was disagreement on two teeth. One observer did not find any disease and the other found two teeth with disease. Only one tooth was used for the calculations because analysis was performed at the patient level.

In conclusion, it was found in the present study that when presented with patients with and without signs or symptoms of disease, examiners agreed with a high

degree of reliability as defined by the Kappa score. This degree of agreement is improved from that found from radiographs alone. This indicates the importance of a clinical exam in the determination of disease. From the errors found, it can be concluded that attention to detail by the examiner in all aspects of the exam, including patient history and clinical findings, is important in obtaining the proper diagnosis.

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APPENDIX A

The following is the complete data set used in this study. The abbreviations used in the table are listed following the table.

PT #	Exam #	Tth #	EPT	Pal	Per	Cold	Warm	Sinus T	Pain	Pre RCT	PR	SA	Crack	Dx	Pulp/Peri?
1	1	30	79	0	0	1	0	0	0	0	0	0	0	Normal	0
1	2	30		0	0			0	0	0	0	0	0	Normal	0
2	3	8	52	0	1	0		0	0	0	0	0	1	Necrotic	1
2	1	8	49	0	1	0		0	0	0	0	0	1	Necrotic	1
2	1	9	49	0	1	1		0	0	0	0	0	0	normal	0
2	3	9	53	0	0	1		0	0	0	0	0	0	normal	0
3	2	20		0	0			0	0	1	2	0	0	CAP	1
3	3	20		0	0			0	0	1	2	0	0	CAP	1
4	1	19		0	0			0	0	1	2	0	1	CAP	1
4	4	19		0	0			0	0	1	2	0	0	Normal	0
5	4	31	30	0	0	0		0	0	0	0	0	0	Normal	0
5	1	31	16	0	0	0		0	0	0	0	0	0	Normal	0
5	4	30	52	0	0	1		0	0	0	0	0	0	Normal	0
5	1	30	18	0	0	0		0	0	0	0	0	0	Normal	0
6	4	3		0	1	1		0	0	0	0	0	0	Normal	0
6	1	3	9	0	0	1		0	0	0	1	0	0	RP	0
6	4	14	3	0	0	1		0	0	0	0	0	0	RP	0
6	1	14		0	1	1		0	0	0	0	0	0	Normal	0
7	4	28			0	1		0	0	0	0	0	0	Normal	0
7	2	2	18	0	0	0		0	0	0	0	0	0	normal	0
8	1	4	45	0	1	1		0	0	0	0	0	0	RP	0
8	2	4	78	0	1	0		0	0	0	0	0	0	IR	1
9	4	30		0	1	0		0	2	1	2	0	0	CAP	1
9	2	30		0	0	0		0	0	1	1	0	0	CAP	1
10	2	13		0	0			0	0	1	0	0	0	Normal	0
10	1	13		1	1	0		0	0	1	0	0	0	Normal	0
11	3	18												Normal	0
11	4	18				1		0	0		1			Normal	0
12	3	19		0	0	0		0	0	0	2	0	0	Necrotic	1
12	2	19		0	1						2	0	0	CAP	1
13	3	29												Normal	0
13	4	29			0	1		0	0	0	0			Normal	0

14	2	19		0	0	1		0	0	0	0	0	0	Normal	0
14	3	19		0	0	1		0	0	0	0	0	0	Normal	0
15	1	24	36	0	0	1		0	0	0	0	0	0	Normal	0
15	3	24		0	0	0		0	0	0	0	0	0	Normal	0
15	3	25		0	0	0		0	0	0	0	0	0	Normal	0
15	1	25	39	0	0	1		0	0	0	0	0	0	Normal	0
16	3	5									1			Necrotic	1
16	1	5		0	0	0		0	0	0	2	0	1	CAP	1
17	4	25		0	0			0	0	1	0	0	0	Normal	0
17	2	25								1	0			Normal	0
17	4	26		0	0			0	0	1	0	0	0	Normal	0
17	2	26								1	0			Normal	0
18	1	2		0	0	1		0	0	0	0	0	0	Normal	0
18	2	2												Normal	0
19	2													Normal	0
19	3													Normal	0
20	3													Normal	0
20	4	2		0	0	1		0	0	0	0	0	0	Normal	0
21	2	3			0	1				0				Normal	0
21	1	3		0	0	1		0	0	0	0	0	0	Normal	0
21	2	25			0	1				0				Necrotic	1
21	1	25		0	1	0		0	0	0	0	0	0	Necrotic	1
22	2	30		1	1	2	2		1			1		AAP	1
22	3	30		1	1	2		0	3	0	0	0	1	IR	1
23	1													Normal	0
23	4	15		0	0	1		0	0	0	0	0	0	Normal	0
24	2	13	20	0	0	0	0	0	0	0	0	0	0	Normal	0
24	1	13	59	0	0	0		0	0	0	0	0	0	Necrotic	1
24	2	31	56	0	0	1		0	0	0	1	0	0	Normal	1
24	1	31		0	0	0	0	0	0	0	0	0	1	Normal	0
25	4	18	50	0	0	0		0	0	0	0	0	0	Normal	0
25	2													Normal	0
26	4	3		1	1			0	1	1	0	0	1	AAP	1
26	2	3		0	1				0	1	0		1	Normal	0
26	2	14		0	1	1			0		0		0	Normal	0
26	4	14		0	0	1		0	0	0	0	0	0	Normal	1
26	4	13		0	1	2		0	1	0	0	0	1	IR	1
26	2	13		0	1	1			0		0		1	Normal	0
27	3	15		0	0	1			0		0	0		Normal	0
27	4	15		0	0	1		0	1	0	1	0	1	Normal	0
28	2	18		1	1	2			1				1	IR	1
28	4	18		1	1	2		0	1	0	0	0	1	IR	1
29	3													Normal	0
29	2	30		0	0	1		0	0	0	0	0	0	Normal	0
30	1	6	65	0	0	0		0	0	0	0	0	0	Necrotic	1
30	3	6		0	0	0		0	0	0	0	0	0	Necrotic	1

31	1	30		0				0	0	0	1	0	1	CAP	1
31	2	30									2			CAP	1
32	3													Normal	0
32	1													Normal	0
33	3			0	1	0		0	1	0	1	0	1	CAP	1
33	1	29		0	0	0		0	0	0	2	0	0	CAP	1
34	3														0
34	4	2		0	0	1		0	0	0	0	0	0	Normal	0
35	2	15	80	0	0	0			2	0	0			CAP	1
35	3	15		0	0	1		0	0	0	0	0	0	Normal	0
36	4	30		0	0	1		0	2		0	0	0	Normal	0
36	2	30		0	0	1			0		0	0	0	Normal	0
37	4	31		1	0	2	0	0	2	0	1	0	0	CAP	1
37	2	31		1	1				0	0	2			CAP	1
37	4	30		1	0	0	0	0	2	1	1	0	0	CAP	1
37	2	30		0	0				0	0	2			CAP	1
38	4	30		0	0	1		0	0	0	0	0	0	Normal	0
38	1	22		0	0	1		0	0	0	1	0	0	Normal	0
39	4	20		1	1	1		0	0	0		0	0	Normal	0
39	1	20		1	1	1			0		0	0	0	RP	0
39	1	21		1	1	1			0		0	0	0	RP	0
39	4	21		1	1	1		0	0	0		0	0	Normal	0
39	4	28		1	1	1		0	0	0		0	0	Normal	0
39	1	28		1	1	1			0		0	0	0	RP	0
39	4	22		1	1	1		0	0	0		0	0	Normal	0
39	1	22		1	1	1			0		0	0	0	RP	0
40	2	13		0	0	1			0					Normal	0
40	1	18		0	0	1		0	0	0	0	0	0	Normal	0
41	1	17		0	1	2		0	1	0	1	0	0	IR	1
41	2	18		0	0	1			1					IR	1
42	2	3	11	0	0	0			0				1	Normal	0
42	1	32		0	0	1		0	0	0	0	0	0	RP	0
43	2	19		0	0	0					2			Necrotic	1
43	4	19		0	0	0		0	0	0	1	0	0	Necrotic	1
44	1	13	8	1	1	1		0	0	0	1	0		AAP	1
44	4	13	15	1	1	2		0	1	0	0	0	0	IR	1
44	1	12	6	1	1	1		0	0	0	0	0	0	Normal	1
44	4	12	20	1	1	1		0	0	0	0	0	0	Normal	1
45	1	5		0	1			0	0	1	0	0	0	Normal	0
45	4	5		0	1				0	1	1	0	0	CAP	1
46	4	24		0	0			0	0	0	0	0	0	Normal	0
46	2	24		0	0	1			0					Normal	0
46	4	25		0	0			0	0	0	0	0	0	Normal	0
46	2	25		0	0	1			0					Normal	0
47	2	2		1	1	2			1		0	0	0	AAP	1
47	1	2		1	1	2		0	1	0	0	0	0	AAP	1

47	2	19	0	1	2			1			1	0	0	Necrotic	1
47	1	19	1	1	0	0	0	0	0	2	0	0	CAP	1
48	2	3	0	0	1			2					0	Normal	0
48	1	3	0	0	1	0	0	0	0	0	0	0	RP	0
48	1	4	0	0	1	0	0	0	0	0	0	0	RP	0
48	2	4	0	1	1			2					0	Normal	0

The following is a list of abbreviations used in the table:

PT #: The number assigned to the patient in order of presentation to the clinic.

Exam #: Examiner number (1-4).

EPT: Electric pulp tester on a scale from 0-80 (Kerr Pulp Tester, Analytic Technology, Redmond, WA).

Pal: Tenderness to palpation (0 = no, 1 = yes).

Per: Tenderness to Percussion (0 = no, 1 = yes).

Cold: Endo Ice® was used for cold stimulation (0 = no response, 1 = response of short duration, 2 = hypersensitive response of long duration).

Warm: Hot water and rubber dam isolation used for cold stimulation (0 = no response, 1 = response of short duration, 2 = hypersensitive response of long duration).

Sinus T: Sinus tract present (0 = no, 1 = yes).

Pain: The tooth is painful (0 = no, 1 = spontaneous, 2 = diffuse, 3 = localized).

Pre RCT: The tooth has previous root canal therapy (0 = no, 1 = yes).

PR: The tooth has a periradicular radiolucency (0 = no, 1 = widened PDL, 2 = periapical radiolucency)

SA: Swelling was present (0 = no, 1 = yes).

Crack: A crack or fracture was present (0 = no, 1 = yes).

Dx: The diagnosis of the tooth (see Table 1).

Pulp/Peri?: Was pulpal and/or periradicular disease present in the patient examined (0 = no, 1 = yes).

Yellow Highlight: indicates variation in diagnosis.

VITA

The Author was born on December 7, 1970 in Hornell, New York and raised in the Berkshires of Massachusetts. He completed his undergraduate course work at Utah State University in Logan, Utah, culminating in a Bachelor's of Science in Environmental Engineering in 1996. The author attended the College of Dental Medicine at the Medical University of South Carolina in Charleston, South Carolina and graduated in 2000. A General Practice Residency was completed at the Veteran's Affairs Medical Center in Salt Lake City, Utah in 2001. After two years in private practice in Maine, the author began the Graduate Endodontics program at Virginia Commonwealth University, School of Dentistry. After completion of the residency program the author will enter into private practice in Portland, Maine.