Evaluation of Post-Graduate Endodontic Program Clinical Experiences: A Web-based Survey

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Evaluation of Post-Graduate Endodontic Program Clinical Experiences:

A Web-based Survey

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D.M.D., Midwestern University College of Dental Medicine, 2015

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Evaluation of Post-Graduate Endodontic Program Clinical Experiences:
A Web-based Survey

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ABSTRACT

Endodontic residency programs vary in exposure to procedures, protocols and equipment across the United States. Available resources for clarifying the clinical experiences of current endodontic residents are lacking. Following Institutional Review Board approval, a survey regarding the clinical experiences of current endodontic residents was electronically distributed to all current endodontic residents that maintained an email address listed in the 2016/2017 AAE Membership Directory. The number of endodontic procedures, techniques employed, and products utilized were evaluated and described. The results of the survey included a 30% completion rate (133/437). The majority of respondents indicated completing between: 150-250 non-surgical root canals (NS-RCT), 26-50 non-surgical root canal retreatments (NS-RCT Retx), 0-10 Apicoectomies, and 0-10 Regenerative procedures during their endodontic post-graduate programs. All respondents report using a surgical operating microscope (SOM) for all procedures performed, and 82% described using a multi-file rotary system for their non-surgical procedures. Approximately 18% stated they used both single-file reciprocation and multi-file rotary systems for NS-RCT and NS-RCT Retx procedures. Dentsply Sirona manufactured files were listed as the predominant rotary and reciprocation instruments employed during respondents endodontic training. The most commonly used obturation technique listed was warm vertical hybrid technique with apical downpack followed by backfill system (WVHT) as 92% of respondents indicated this is their preferred obturation method. Thus, the information gained from this descriptive study can provide future applicants a better understanding of the clinical experiences they should expect when matriculating into a post-graduate endodontic program while also delivering transparency amongst the various endodontic residency programs.
INTRODUCTION

The quality and experience a graduate obtains through higher education has always been at the forefront of intense scrutiny by both the media and the federal government, with the latter lending millions of dollars each year in the form of student loans\(^1\). For each individual student borrowing the average cost of higher education has escalated exponentially in the past twenty-five years\(^1,2\). Repayment of these loans often exceeds two decades for many borrowers, all the while tuition increases with little explanation on the potential impact to the experience of the student\(^2,3\). In exchange for education in the form of tuition, universities and institutions agree to deliver appropriate instruction necessary for the student to achieve training and expertise in his or her respective field.

According to the most recent data provided by the American Dental Association nearly 60,000 students applied for the 7,100 Advanced Dental Education positions available\(^3\). Each accredited post-doctoral program offers full-time clinical training, with the vast majority allowing national board eligibility\(^2,3\). Some programs mandate that in order to receive certification and graduate their respective program, residents must pass some portion of their national board certification examination\(^3\). This is usually in form of a written or oral examination. However, most programs state they strive to have all graduates become board certified and require a portion of the examination be passed in order to earn their specialty certificate. Programs believe this practice further encourages the candidate to become fully board certified\(^2,3\). While the Senate Committee on Health, Education, Labor and Pensions continues to evaluate the monetary practicality of graduates currently entering the labor-force, a more compelling inquiry is the clinical
 applicability and experience gained during post-doctoral training of these specialty graduates. Precisely, what are the protocols current residents are learning? Are current post-doctoral students being exposed to the various procedures, techniques, and products available so they are properly prepared to enter the workforce? What should an applicant expect when they matriculate into a post-graduate program?

Endodontic specialists have a responsibility to lead their colleagues in the dental community by practicing and applying comprehensive evidenced-based endodontic principles\textsuperscript{4}. These principles become “endodontic moralities” and are acquired through the educational experiences obtained during their post-graduate training. The Commission on Dental Accreditation (CODA) is the governing body responsible for maintaining and improving the quality of advanced education, which includes each endodontic program, and is recognized by the public, the endodontic profession, and the United States Department of Education as the specialized accrediting agency in dentistry\textsuperscript{5}. An endodontic specialist’s experience naturally increases as his or her career progresses, but the expertise was first acquired when he or she was an endodontic resident. The foundation of endodontic comprehension and eventual evolution into an endodontic specialist commences upon matriculation into the residency\textsuperscript{6,7}. Therefore, it would significantly aid our current educators and national professional society, the American Association of Endodontists (AAE), to understand the clinical experiences of endodontic residents in order to provide insight to prospective candidates, and to allow transparency amongst the various endodontic residency programs in the United States.
Applicant Expectations of Clinical Experiences

Applicants applying to endodontic specialty programs represent about 10% of the total number of students applying to an advanced dental specialty program. Of those that applied to an endodontic residency, approximately 5% matriculated, with the average program receiving nearly 80 applications and matriculating anywhere from three to twenty applicants. That said, it is clear that the application process is highly competitive for the specialty of endodontics. However, while applications and enrollment to endodontic specialty programs appear to be increasing between 2006 and 2017, information regarding clinical experiences of endodontic residents is deficient, if not devoid. Little evidence is also available pertaining to what those applicants can expect once they matriculate into an endodontic post-graduate program.

The AAE is the current authority responsible for conveying information relating to individual endodontic residency programs, but does not contain specifics of current residents clinical experiences. While the AAE does provide data on the average number of endodontic procedures performed, they are not broken down by specific procedure type. Applicants can expect to complete between 150 and 250 or more endodontic procedures according to the AAE. No description of the instrumentation and techniques employed among the various residency programs is displayed. Furthermore, a disclaimer is present stating: “Every attempt has been made to provide current and accurate information on each advanced endodontic program; however, because each program undergoes periodic changes, the AAE does not assume responsibility that the information provided is currently accurate.” This ultimately puts
the onus on the future endodontic resident to verify and confirm the accuracy of the data presented.

Endodontic residency program protocols can be substantially different from each other, which can ultimately lead to discrepancies in treatment modalities amongst graduates\textsuperscript{10-13}. Generalized negative perceptions of the application process for advanced endodontic residency programs, as well as recent data stating that 33\% of endodontic residents felt their post-doctoral training was inadequate, would suggest that more information is needed to depict the clinical knowledge obtained at various post-graduate endodontic specialty programs\textsuperscript{12,13}. Therefore, gaining insight into post-graduate advanced endodontic program practices associated with procedures performed, instrumentation employed, and techniques utilized will allow both evaluators and applicants alike to make informed decisions on methodological alterations and matriculation acceptance, respectively.

Forand and Applebaum have studied applicant expectations in 2011 with regard to medical school graduates applying for psychology residencies in the United States\textsuperscript{14}. However, the principles they describe can be applied to any post-doctoral applicant, as it is merely a guide to “Demystifying the Postdoctoral Experience\textsuperscript{14}.” They specifically describe the application process as, “chaotic,” because individual training goals, sites, applications, and responsibilities are heterogeneous and applicants are generally offered little formal guidance before and during the application cycle\textsuperscript{14,15}. The American Dental Association (ADA) further complicates the process by only offering a system that some,
but not all, endodontic specialty programs utilize for their formal application\textsuperscript{15}. The ADA also has a statement that tells the applicant to check with the program they are applying to, however some program sites say not to contact them if the inquiry is associated with the ADA sponsored application\textsuperscript{15,16}. This is yet another unexpected challenge that the endodontic applicant must take into consideration.

Perhaps the most integral part of an endodontic residency is development of an appropriate clinical decision making process. That said, most applicants are matriculating directly from an accredited dental school or university where they were taught a certain pattern in an effort to simplify diagnosis and treatment\textsuperscript{3,8,9}. However, this configuration needs to be reconsidered once the student begins their post-doctoral training because over-simplified diagnostic protocols can lead to improper, and often times unnecessary, treatments\textsuperscript{18,19}. Several authors have described the dental education process, which was designed to arise from practitioners who oversee clinic operations and departmental instruction\textsuperscript{7,18,19}.

Most post-graduate students rely on the expertise of their assigned clinical faculty, and model them when practicing\textsuperscript{20}. Exposure to only a handful of clinical faculty can limit the potential development of the dental student, ultimately resulting in a very regimented clinical decision tree that may omit essential, or insert needless, treatment modalities simply based on inadequate prior experiences\textsuperscript{19-21}. This dependence on a select few predominant figures during their clinical dental instruction primes the current endodontic applicant to react to their previous “authority”, as opposed to relying on the current best
available evidence\textsuperscript{18,20,21}. This seemingly insignificant influence on treatment choices may have an overwhelming effect on the applicant’s clinical standards as they enter an endodontic residency program. If they are unable to adjust to a new paradigm during their residency, it may limit the scope of their clinical experience and ultimately compromise their endodontic practice habits in the future.

Numerous reports have evaluated the influence of post-doctoral residency training on endodontic decision construction\textsuperscript{22-26}. Endodontists have the highest level of agreement on endodontic treatment modalities when compared to other specialities\textsuperscript{22,23}. In the mid-1980’s Dr. Reit examined clinical decision making concerning endodontically treated teeth and determined that most practitioners depend on “a few heuristic principles” to simplify the intricate process of estimating probabilities and determining treatment choices\textsuperscript{24}. According to Reit these “heuristic principles” equate to experimental learning, more commonly known as trial and error\textsuperscript{24}. For instance, conventional periapical radiography has been recently supplemented with cone beam computed tomography (CBCT) scans in an effort to diagnose and treatment plan endodontic cases. However, 62\% of cases previously diagnosed and treatment planed utilizing only periapical radiography were altered after CBCT was employed\textsuperscript{25}. Implementation of CBCT as an experimental modality in this case led to a clinical decision change. Thus, this can be applied to current endodontic applicants, as they will likely be reluctant to accept a modality that they are unfamiliar with. However, exposure and experience with new procedures, protocols and techniques will only enhance their education throughout their endodontic residency.
Dr. Gilbreth conducted another study in which post-graduate endodontic residents were surveyed about their clinical decision process in 2013. He showed that post-graduate endodontic residents continue to employ the clinical protocols and theories they learned in their residency more often than technology-based techniques\textsuperscript{26}. Over 50\% of the clinicians surveyed still utilize some or all facets of the procedural techniques and protocols they learned while attending their post-graduate endodontic residency\textsuperscript{26}. This report reinforced the ideology that residency training procedures, clinical experiences, and peer-reviewed evidence-based articles are the driving force behind clinical decisions pertaining to diagnosis and treatment for endodontic post-graduates. Thus, prospective endodontic residents should expect to practice endodontics in a similar fashion to how they are taught once they matriculate into a post-graduate endodontic residency program.

**Endodontic Program Transparency**

The guidelines for endodontic program assessment of post-graduate experiences were first described in 1976 at the Workshop of Advanced Endodontic Programs\textsuperscript{27}. The workshop specifically outlined the educational standards that serve as the platform for current post-graduate endodontic programs\textsuperscript{27}. These guidelines set forth over 40 years ago still represent the hallmark features of current endodontic residency programs throughout the United States. Biomedical sciences are taught to ensure an understanding of the biological principles that are associated with treating patients that are both medically compromised and healthy\textsuperscript{14,27}. Clinical endodontics is still the cornerstone of any endodontic residency and most programs agree that it should comprise over 50\% of
the resident’s time during training\(^{14,27}\). Teaching and research are also universally agreed upon as staples of all endodontic advanced education curriculums\(^{14,27}\). CODA, along with Endodontic Departments/Divisions in the United States and the AAE are now largely responsible for the education standards and practice modalities employed at endodontic specialty programs throughout the United States\(^{3,5,8,9,14}\). However, the information that is available for all programs, both educators and residents, is not uniform and extremely limited.

Currently, the AAE provides information “at the applicant’s own risk,” meaning the material offered may not be accurate for each program described\(^{14}\). While the programs are generally in agreement on the materials necessary for application and matriculation, there is no set number of procedures that must be completed to graduate. Rather a range is listed as the “number of non-surgical endodontic procedures performed\(^{14}\)” While this is helpful, it encompasses only a portion of endodontic techniques and does not include a myriad of surgical endodontic procedures that many programs teach. No standardization exists for this parameter in endodontic residency programs. Therefore, gaining insight into post-graduate advanced endodontic program practices associated with specific endodontic procedures performed, instrumentation methodologies, and techniques utilized will allow transparency of endodontic residency programs. Applicants and educators alike will then be able to make informed decisions on methodological alterations and matriculation acceptance, respectively.

Given the lack of information available about endodontic programs, a concentrated survey that evaluates post-graduate endodontic program clinical experiences may allow
future applicants, program directors, and current residents to have a better understanding of the endodontic practices being employed at other institutions across the United States. The number of endodontic procedures performed including non-surgical root canal treatment (NS-RCT), non-surgical root canal retreatment (NS-RCT Retx), surgical root canal retreatment (Apicoectomy), and regenerative endodontic procedures (Regenerative) will be described in order to provide a more specific breakdown rather than simply differentiating between non-surgical vs. surgical endodontic procedures. The precise techniques utilized and products available to endodontic post-graduate residents will be described including the use of visualization aids such as a microscope or loupes, instrumentation products such as multi-file rotary systems vs. single-file reciprocation systems, and obturation techniques such as lateral condensation, warm vertical condensation, warm vertical condensation hybrid, and single cone techniques.

**Corporate Influence on Endodontic Training**

Obtaining a sound understanding of clinically relevant endodontic procedures and techniques is a requirement for any post-graduate endodontic resident. Implementation of these clinical protocols would not be possible without the aid of essential equipment produced by manufacturers of endodontic supplies. The armamentarium distributed by these corporate entities allows procedures to be performed safely and efficiently with significant advancements being made annually. Endodontics has seen immense technological improvements in instrumentation, and while manufacturers are largely responsible for creating these enhancements for the betterment of the specialty, they also have a monetary incentive. This is especially true with respect to engine driven rotary
files, which are often introduced to the clinician after adequate training and experience, such as during endodontic residency\textsuperscript{28}.

Engine driven instrumentation, either via multi-file rotary or single-file reciprocation, has become a mainstay for cleaning and shaping root canal systems. Rotary and reciprocation endodontic files are the most prolific and utilized disposable product in endodontics, however relatively few companies produce and distribute these instruments\textsuperscript{29,30}. Currently the top endodontic file companies in the United States are Dentsply Sirona (York, PA), EdgeEndo (Albuquerque, NM), Kerr Corporation (Orange, CA), and Brasseler USA (Savannah, GA)\textsuperscript{32-34}. These companies produce more than twenty different file systems and account for nearly all market share pertaining to endodontic instrumentation in the United States\textsuperscript{32-33}. It is estimated that by 2022, manufacturers of endodontic instruments will obtain a market value worth 1.61 billion dollars globally\textsuperscript{34}.

Most endodontic corporations donate and finance a number of endodontic graduate residency programs. The University of Tennessee received a significant donation from Dentsply Sirona in 2013 that helped launch its Advanced Specialty Education Program in Endodontics\textsuperscript{35}. Dentsply Sirona also recently opened a new endodontic clinic at New York University (NYU) College of Dentistry in 2017\textsuperscript{36}. All of the leading file companies mentioned earlier offer significant discounts to universities and health centers in an effort to implement their endodontic brands into pre-clinical and post-graduate endodontic curriculums. Thus, the corporate sphere that encompasses these institutions is likely to
influence residents’ thoughts towards file systems and brands he or she chooses to employ during clinical endodontic procedures.

**Research Questions**

What are the demographics of current endodontic residents as it pertains to endodontic program duration, previous education prior to matriculating into an endodontic residency program, and degree(s) sought upon completing endodontic residency? What are the average number of endodontic procedures current endodontic residents are completing as it relates to NS-RCT, NS-RCT Retx, Apicoectomy, and Regenerative procedures? What are the techniques being employed by current endodontic residents regarding visualization, instrumentation, and obturation? How can the data obtained help provide transparency amongst the endodontic residency programs and allow new applicants a better understanding of the clinical experience they should expect when matriculating into a post-graduate endodontic program.

**Goals**

This study aims to describe the clinical experiences of current endodontic residents in the United States in three areas:

1) Demographics of current endodontic residents: program duration, prior education before matriculation, and degree(s) sought upon endodontic residency completion.

2) Average number of endodontic procedures completed during residency, broken down by procedure type: NS-RCT, NS-RCT Retx, Apicoectomy, and
Regeneration.

3) Preferred methods and techniques utilized during endodontic residency training: Visualization, instrumentation and obturation.

The study also aims to allow transparency among the current endodontic residency programs while providing information to future applicants regarding their expectations when entering an endodontic post-graduate program.

MATERIALS AND METHODS

Approval for this study was obtained from the Institutional Review Board (IRB) at the University of Connecticut Health Center School of Dental Medicine, Farmington, CT. Final IRB approval of “exemption” was conferred on October 25th, 2017. A 14-question survey pertaining to the clinical and demographic background of post-graduate endodontic residents was administered using a web service, SurveyMonkey.com (San Mateo, CA). Email invitations were sent to endodontic residents who maintained a current and active university administered, or forwarding, email address used for correspondence listed in the 2016/2017 AAE Membership Directory (n=437). No personal information was collected. The content of the survey questions as well as the respondents’ data were maintained on SurveyMonkey’s servers during the duration of the study. The software vendor, SurveyMonkey, provides a method to track participants that have responded in order to prevent sending that same individual a follow-up email for a study that he or she has already completed.
All correspondence with the endodontic residents included a cover letter bearing the stamp of IRB approval as well as an explanation of the survey’s purpose. The cover letter also stated that the subject’s completion of the survey implied consent to participate in the study. In an attempt to encourage honesty in the residents’ responses, it was emphasized in the cover letter that the survey was anonymous, and not to be perceived as an intrusion into how the endodontic residents choose to practice\textsuperscript{40}. The survey questions were primarily in multiple-choice format (n=12). Limited open-ended responses (n=1) and checkbox style (n=1) questions were also included. Pre-determined responses accurately described the majority of potential responses, with the exception of the file systems utilized for instrumentation\textsuperscript{41}. Over thirty rotary and reciprocation systems are available and listing all possible responses would make the survey apparatus very cumbersome; likely leading to respondents skipping the question altogether\textsuperscript{42-44}.

Below is an example of the email invitation that was sent to the current residents:

Subject: Endodontic Residency Clinical Experiences Survey

Dear Dr. ______________,

For my Master’s research I am surveying current Endodontic Residents. I am interested in learning more about your clinical experiences and protocols during your post-doctoral endodontic training. Since I am collecting data from a limited number of current endodontic residents, every response counts. Your participation is appreciated.

Here is a link to the survey: (Survey Link)

This link is uniquely tied to this survey and your email address. Please do not forward this message.

Thanks for your participation!

Sincerely,

Jonathan Blacher
In January 2018, a link to the survey along with a cover letter stating the purpose of this study was sent via e-mail to 473 endodontic residents who are AAE members. The e-mail list was compiled using the 2016/2017 AAE member online directory. The complete survey, when tested at the University of Connecticut, took approximately 3-minutes to complete. Descriptive analyses of demographics and factors associated with endodontic residents’ clinical experiences were obtained. The invitation e-mail was sent on two separate occasions at 2-week intervals. The survey was resent to only those participants who had not yet completed the survey after the initial invitation received no response.

Below is an example of the cover letter that accompanied the initial email invitation:

Dear colleague,

My name is Jonathan Blacher and I am a third year endodontic resident at the University of Connecticut School of Dental Medicine doing research as part of a project required for my Master of Dental Science degree. The principal investigator for this study is Dr. Blythe Kaufman.

The title of this study is “Evaluation of Post-Graduate Endodontic Program Clinical Experiences: A Web-based Survey.” This survey will be sent to over 390 post-graduate endodontic residents who maintain registered and active email and post mail address within the 2016/2017 AAE Membership Directory. The purpose of this survey is to gain insight into current practices applied at endodontic specialty training programs associated with procedures performed, instrumentation employed, and techniques utilized that would allow both evaluators and applicants alike to make informed decisions on methodological alterations and matriculation acceptance, respectively.

You are invited to participate in this study. Your participation is voluntary. If you choose to participate, please complete the survey that will be emailed to you in the following week. Please **DO NOT PUT YOUR NAME** on the survey. The survey is anonymous, and not to be perceived as an intrusion into how you perform endodontics. While complete surveys will provide better data, you may skip questions that you do not feel comfortable answering. Your response to these questions should take approximately 5 minutes to complete. **COMPLETION AND RETURN OF THE SURVEY IMPLIES YOUR CONSENT TO PARTICIPATE IN THIS STUDY.**
I appreciate your participation in this research study. For any questions regarding the study, please feel free to e-mail me at blacher@uchc.edu, or call me at (860)-679-2719, or call the Principal Investigator at (860)-679-2719.

Thank you.

Sincerely,

Dr. Jonathan Blacher

Dr. Blythe Kaufman

Demographic data regarding the duration of the resident’s program, education prior to matriculation, and degree(s) sought upon endodontic residency completion were collected. More complex data regarding the average number of endodontic procedures completed during residency, as well as preferred methods and techniques utilized during endodontic residency training, were also collected. To view the complete survey, see Appendix 1.

At the point of data collection, no identifying tags were linked to the subjects’ individual responses. There were no timed responses or required login screens and the respondent could not access the survey after they had completed it. This ensured only one survey was recorded for each respondent. No response was mandatory, thus the user could advance to the next screen, even if a question was left unanswered. Complete and partially completed responses were recorded and utilized. Each individual was sent an initial electronic invitation to complete the survey. If no response was obtained, a second email was sent two weeks later as a follow-up to the primary email invitation.
Data Analysis

A summary of raw data, and a frequency analysis, was performed by the software vendor (SurveyMonkey).

RESULTS

DEMOGRAPHIC DATA

Of the 437 surveys sent, 108 were fully completed and 25 were partially completed. This produced an overall electronic response rate, encompassing both fully and partially completed surveys, of 30% (n=133). Five questions pertaining to demographics were used to ascertain the residents endodontic program duration, current year of attendance, prior education to matriculation, and degree sought upon completion of their endodontic training program.

The majority of those surveyed indicated in the initial demographic question that they were attending a two-year endodontic program (81%), while only 18% were attending a three-year program. Less than 1% of those surveyed were attending a program of greater than three-years in duration.

Question 2 dealt with the respondent’s current year in endodontic residency. This question was skipped by 24% of those who went on to complete the remainder of the survey (n=32). Of the remaining 101 respondents, the majority indicated they were in their second year of endodontic residency (74%). Eight percent of residents indicated they were in their first year of endodontic training and this represented the second
smallest group to respond. Those who identified they were in their third year of endodontic residency represented 11%. Only 7% of respondents indicated they were in a fellowship or Ph.D. program that was greater than three years in duration.

The third demographic question wished to assess the subjects’ dental education prior to their matriculation and enrollment into their respective endodontic residency program. The majority of respondents identified that they attended a U.S. Dental School prior to matriculation (82%), while 18% reported attending a Foreign Dental School or a Foreign Dental School plus a two-year U.S. Dental Degree, respectively. This question was skipped by approximately 17% of those surveyed.
Q3 Where did you receive your dental education prior to attending an Endodontic residency?

![Graph showing percentages of dental education routes]

Question 4 further developed into the subjects’ pre-endodontic residency experiences and sought to identify the practice setting attended by those surveyed. General dentistry was the most popular route selected by residents prior to attending a post-graduate endodontic program, as 44% identified with this pre-residency track. The next common pathway was directly from dental school, which was reported by 32% of respondents. Attending a General Practice Residency (GPR) or Advanced Education in General Dentistry (AEGD) program prior to endodontic post-graduate training was the least commonly chosen path. Less than 20% reported entering endodontic specialty training via this route.

Q4 What was your experience in dentistry that immediately preceded attending your Endodontic program?

![Graph showing percentages of previous experiences]

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At this point in the survey it was noted that a consistent number of respondents skipped
the remainder the of the questions. At least 22 subjects in each of the questions
remaining chose to not answer. However, the remaining questions gained recordable
answers from virtually 80% of those surveyed who issued a response in the first
demographic question.

The final demographic inquiry, question 5, pertained to the degree being sought by the
current endodontic residents. Not surprisingly, nearly all of those surveyed indicated
they wish to earn a Certificate in Endodontics (42%), or a combined Certificate in
Endodontics and Masters Degree (57%), respectively.

Q5 What degree are you pursuing in your post-graduate Endodontic residency?

AVERAGE NUMBER OF PROCEDURES COMPLETED DATA

Questions 6 through 9 related to the average number of commonly performed non-
surgical and surgical endodontic procedures completed during a residents’ training. This
section of the survey saw a decrease in the response rate as only 25% entered answers. However, of those who initially responded (n=133), 81% went on to complete the survey in its entirety. The procedures surveyed included non-surgical root canal treatment (NS-RCT), non-surgical root canal retreatment (NS-RCT Retx), surgical root canal retreatment (Apicoectomy), and regenerative endodontic procedures (Regenerative).

It is important to note that each resident’s answer is correlated to the year they were in attendance during residency when responding. Thus, it should be established that a first year resident completes less procedures than a second year resident, and that a third year or greater resident completes more procedures than either first and second year residents. It should also be taken into account that the longer a residents program duration, the more experience they are expected to gain with the various endodontic procedures. However, this is not necessarily true when comparing total procedures completed within a certain category. That is, if all the groupings are taken separately, a first year resident A may have completed more Regenerative procedures than second year resident B. So, it would be prudent to accept each procedure as a resident’s own experience, regardless of the year of attendance.

Question 6 compared completed NS-RCT procedures and was divided into four groups: 0-50, 51-150, 151-250, and greater than 250. However, the latter two groups were combined for simplicity in interpreting the results as most programs report their endodontic residents complete somewhere between 150 and 250 NS-RCT procedures during their post-doctoral training\textsuperscript{14}. In this survey, 70% of residents reported completing
between 151 and 250 NS-RCT procedures. Only 26 respondents stated they have completed between 50-150 NS-RCT procedures (24%). The 50-150 NS-RCT group were comprised of those residents who identified as “first year residents” in question 2.

**Q6 NS-RCT?**

![Chart](chart1.png)

Question 7 pertained to completed NS-RCT Retx procedures and was divided into three groups: 0-25, 26-50, and greater than 50. It was apparent that NS-RCT Retx procedures are performed in much smaller capacity compared to NS-RCT. The majority of those who responded were in the completion range of 26-50 NS-RCT Retx, and this comprised 44%. However, the next largest group was the greater than 50 NS-RCT Retx procedures.

**Q7 NS-RCT Retreatment?**

![Chart](chart2.png)
completed, containing 33%. The remaining 23% of respondents reported completing between 0 and 25 NS-RCT Retx procedures.

It is interesting to note that almost a quarter (22%) of subjects who identified as second year residents reported completing between 0 and 25 NS-RCT Retx procedures. Third year respondents accounted for all NS-RCT Retx cases completed in the greater than 50 group.

**Q7 NS-RCT Retreatment?**

Question 8 concerned the surgical aspect of endodontics and investigated residents experience performing Apicoectomies. Three groups were obtained: 0-10, 11-20, and 20 or greater Apicoectomies completed. It was apparent that this procedure was one that was performed with far less frequency during residents’ training than the non-surgical procedures, NS-RCT and NS-RCT Retx, respectively. The majority of those who responded were in the completion range of 0-10 Apicoectomies, containing 46% of the total responses. This procedure saw a decline in the number performed as the categories
increased in quantity. For instance, the 11-20 group included 31% of the response, and the 20 or greater group contained 23%.

This dropoff in completion rate was also independent of the year of attendance the subject was currently in at the time his or her response was recorded. Much like their first year counterparts, second and third residents or greater were also found to have identified completing between 0-10 Apicoectomies during their post-graduate training. Even more remarkable is that if first year responses are excluded, the results indicated that over 90% of second year residents are completing between 0-10 Apicoectomies.

The graph below shows a decline in the number of Apicoectomy treatments for all second year residents, represented by the green line. However, third year residents and greater than third year residents displayed a slight increase in the number of Apicoectomy treatments, indicated by the blue and yellow lines.
Question 9 pertained to completed Regeneration procedures and was divided into three groups: 0-10, 11-20, and greater than 20. Similar to Apicoectomies, Regeneration procedures are performed in limited quantities as the results overwhelmingly indicate. Subjects reported that 94% are completing between 0-10 Regeneration procedures and none identified as completing over twenty Regeneration treatments. The remaining 6% reported completing between 11-20 Regeneration procedures.
SURGICAL PROTOCOL DATA

Question 10 dealt exclusively with an endodontic residents permission to perform surgical treatments during their first year. Over 50% of respondents established that their respective programs did not allow them to perform surgical procedures during their first year of residency. Not surprisingly, the majority of responses were from those who also reported performing Apicoectomies in question 8, likely because they represented second and third year respondents who were not permitted to perform surgery as first year residents, but now had gained surgical experience as they progress through their respective endodontic training programs.

Q10 Were you allowed to do surgical endodontic procedures in your 1st year?
PREFERRED METHOD AND TECHNIQUE DATA

Visualization

Question 11 confirmed that all current residents utilize the aid of a surgical operating microscope (SOM) while performing the majority of their endodontic treatment. It also seems to be standard for respondents to employ the SOM during their first year of residency. This trend continued as each resident gained more experience utilizing the SOM.

Q11 Do you use a microscope for the majority of the procedures you perform?

Instrumentation

Questions 12 and 13 inquired about the type of file system utilized by the current endodontic residents for non-surgical endodontic procedures. Specifically, these questions wished to establish the instrumentation techniques employed by residents. The predominant file systems utilized by residents during their endodontic residency was also determined using a write-in format which was later broken down into categories based on manufacturer and file type.
Prior to gaining insight into the specific file brands, the type of system utilized was investigated in question 12. The instrumentation most commonly reported by subjects was a multi-file rotary system, which 82% said they employed exclusively. The remaining 18% of respondents stated they use both a multi-file rotary and a single-file reciprocation system.

Q12 Do you use a multi-file rotary system or a single file reciprocation system, or both?

![Pie chart showing 82% use multi-file rotary, 18% use both systems.]

Respondents listed a wide variety of file systems they have had exposure to during their endodontic training. The most widely utilized manufacturer of multi-file rotary and single-file reciprocation files was Dentsply Sirona (York, PA). Other manufacturers included: Brasseler USA (Savannah, GA), Coltène/Whaledent Incorporated (Altstätten, Switzerland), EdgeEndo LLC (Albuquerque, NM), Kerr Corporation (Orange, CA), and SS White Dental (Lakewood, NJ). All instrumentation data including manufacturer, file types listed, and respondents utilization percentages are available in Appendix 2.
Dentsply Sirona was the most commonly used manufacturer. Their brand, ProTaper, comprised 78% of the responses and included several types of ProTaper files. ProTaper Gold (PTG), ProTaper Next (PTN) and ProTaper Universal are all multi-file rotaries and were listed as file brands utilized by the residents surveyed. Dentsply Sirona also produced the second most employed file brand by those surveyed, Vortex Blue. Over 70% of residents indicated they utilize this multi-file rotary system as well. Two other multi-file rotary brands produced by Dentsply Sirona are Vortex and TRUShape. The Vortex file is the predecessor to the commonly used Vortex Blue file, and it represented 11.5% utilization by those surveyed. TRUShape was the least used Dentsply Sirona file with an application rate slightly below 10%.

Dentsply Sirona also manufactures single-file reciprocation systems, WaveOne (WO) and its newer version, WaveOne Gold (WO Gold). WO and WO Gold were the most commonly recorded single-file reciprocation products employed and the fourth most utilized file among multi-file rotaries and single-file reciprocation brands. Nearly 26% of those surveyed indicated utilizing either WO or WO Gold during residency.

<table>
<thead>
<tr>
<th>Manufacturer</th>
<th>File Brand</th>
<th>Utilization Reported by Residents (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dentsply Sirona (York, PA)</td>
<td>PTG, PTN, PTU¹</td>
<td>77.88</td>
</tr>
<tr>
<td>Dentsply Sirona (York, PA)</td>
<td>Vortex Blue</td>
<td>73.08</td>
</tr>
<tr>
<td>Dentsply Sirona (York, PA)</td>
<td>WO and WO Gold²</td>
<td>25.96</td>
</tr>
<tr>
<td>Dentsply Sirona (York, PA)</td>
<td>Vortex</td>
<td>11.54</td>
</tr>
<tr>
<td>Dentsply Sirona (York, PA)</td>
<td>TRUShape</td>
<td>9.62</td>
</tr>
</tbody>
</table>

¹: PTG=ProTaper Gold, PTN=ProTaper Next, PTU=ProTaper Universal
²: WO=WaveOne, WO Gold=WaveOne Gold
Brasseler USA had the second most file brands listed by those surveyed. Their multi-file rotary brands described by residents included EndoSequence, XP-Endo, BioRaCe, ESX, and KontrolFlex. However, EndoSequence was used by 24% of the respondents and was by far the most popular file brand from Brasseler USA according to the residents’ responses. Compared to all other file brands, EndoSequence ranked as the fifth most popular file listed by the endodontic residents surveyed. XP-Endo, BioRaCe, ESX, and KontrolFlex multi-file rotary brands were utilized by less than 6% of respondents.

<table>
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<th>Manufacturer</th>
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<th>Utilization Reported by Residents (%)</th>
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</thead>
<tbody>
<tr>
<td>Brasseler USA (Savannah, GA)</td>
<td>EndoSequence</td>
<td>24.04</td>
</tr>
<tr>
<td>Brasseler USA (Savannah, GA)</td>
<td>XP-Endo</td>
<td>5.77</td>
</tr>
<tr>
<td>Brasseler USA (Savannah, GA)</td>
<td>BioRaCe</td>
<td>3.85</td>
</tr>
<tr>
<td>Brasseler USA (Savannah, GA)</td>
<td>ESX</td>
<td>2.88</td>
</tr>
<tr>
<td>Brasseler USA (Savannah, GA)</td>
<td>KontrolFlex</td>
<td>0.96</td>
</tr>
</tbody>
</table>

Kerr Corporation contained the third most often mentioned file brands including both multi-file rotaries and a single-file reciprocation product. Kerr’s file systems did not crack the top five according to popularity, but several brands were identified in the response data. K3XF and its precursor, K3, were utilized just under 11% of the time according to the survey responses listed. The other files registered were Twisted File, and Kerr’s reciprocation brand, TF-Adaptive. Twisted File and TF-Adaptive were both recorded at less than 6% utilization by the residents surveyed.

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<th>Utilization Reported by Residents (%)</th>
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</thead>
<tbody>
<tr>
<td>Kerr Corp. (Orange, CA)</td>
<td>K3/K3XF</td>
<td>10.58</td>
</tr>
<tr>
<td>Kerr Corp. (Orange, CA)</td>
<td>Twisted File</td>
<td>5.77</td>
</tr>
<tr>
<td>Kerr Corp. (Orange, CA)</td>
<td>TF-Adaptive</td>
<td>4.81</td>
</tr>
</tbody>
</table>
The third most utilized manufacturer listed was EdgeEndo LLC. A myriad of file systems and brands were listed by those surveyed, however they were all combined when the data was tabulated. This included both multi-file rotaries and single-file reciprocation systems produced by EdgeEndo. Over 30% of residents reported using EdgeEndo file brands.

The remaining two file companies listed were SS White Dental and Coltène/Whaledent Incorporated. SS White Dental is the manufacturer of multi-file rotary brands V-Taper and V-Taper2. The latter is the newest version of the V-Taper file system. SS White Dental files were utilized by 12.5% of the responding residents. Hyflex file systems are produced by Coltène/Whaledent Incorporated, and while several types of Hyflex files were listed, the data was categorized under the manufacturer of the main Hyflex file brand. Less than 6% of residents stated they employ Hyflex file brands during endodontic treatment.

Perhaps the most interesting response that was recorded in this section was that residents could use “any system they desired.” While this response accounted for less than 2% of those surveyed, it was a peculiar answer to an open ended question about instrumentation. This answer was coded as “Residents Choice” and though it did not convey any specific file system utilized, it did leave the assumption that these respondents have likely employed a variety of endodontic instrumentation systems and did not wish to list all of them. Therefore, this response was appropriated as: “any file system was made available for operation and use by the resident.”
Obturation

Question 14 was the final question of the survey and its purpose was to identify which obturation techniques residents have experienced during their post-graduate training. This was the only question that subjects were able to choose all applicable answers. The choices for obturation contained current methods for filling a root canal space including: Lateral Condensation (LC), Warm Vertical Condensation (WVC), Warm Vertical Hybrid Technique with Apical Downpack and Backfill (WVHT), Single Cone Technique with Bioceramic Sealer (SCBS), and Carrier-based obturation such as Thermafil and Guttacore. WVHT was overwhelmingly selected by 92% of the endodontic residents as their preferred obturation method. LC, WVC, and SCBS were selected by over half of the respondents, indicating that these obturation techniques are also utilized during residency. Carrier-based obturation techniques comprised only 10% of the residents surveyed.

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<th>Manufacturer</th>
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<th>Utilization Reported by Residents (%)</th>
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</thead>
<tbody>
<tr>
<td>EdgeEndo LLC (Albuquerque, NM)</td>
<td>EdgeEndo</td>
<td>30.77</td>
</tr>
<tr>
<td>SS White Dental (Lakewood, NJ)</td>
<td>V-Taper/V-Taper2</td>
<td>12.5</td>
</tr>
<tr>
<td>Coltèn/Whaledent Inc. (Altstätten, Switzerland)</td>
<td>Hyflex</td>
<td>5.77</td>
</tr>
<tr>
<td>N/A</td>
<td>Residents Choice*</td>
<td>1.92</td>
</tr>
</tbody>
</table>

Residents Choice* = Any file system is available to the resident

Q14 Which obturation technique(s) do you or have you used: (select all that apply)
OTHER DATA

The average time to complete the survey was 3.6 minutes, with the minimum time being 2 minutes, while the maximum time was over 15 minutes. Of the email invitations that were opened (n=306), almost 33% were “clicked-through” and not completed in full. Partially completed surveys comprised 19% of the total responses. Most partially completed surveys were terminated at question 6, which is the section that began inquiring about residents’ average number of endodontic procedures completed during their training.

SUMMARY

Results indicated that current endodontic residents have a wide range of experiences during their post-graduate training. According to 81% of surveyed subjects, most endodontic residency programs are two years in duration and 74% of residents who completed the survey indicated they were in their second year of post-graduate training. The majority of respondents indicated completing between: 151-250 NS-RCT, 26-50 NS-RCT Retx, 0-10 Apicoectomies, and 0-10 Regenerative procedures during their endodontic post-graduate programs. Over 50% of those surveyed indicated they were not allowed to perform surgical endodontic procedures during their first year of training. All respondents report using a SOM to aid in visualization for all procedures performed, and 82% described using a multi-file rotary system for their non-surgical procedures. Approximately 18% stated they used both single-file reciprocation and multi-file rotary systems for NS-RCT and NS-RCT Retx procedures. Dentsply Sirona manufactured file systems were listed as the predominant rotary and reciprocation instruments employed
during respondents post-graduate endodontic training. Nearly 80% of those surveyed listed ProTaper Gold, ProTaper Next, ProTaper Universal and Vortex Blue rotary files as the most frequently employed file brands while attending residency. The most commonly used obturation technique listed was WVHT with 92% of respondents indicating this is their preferred obturation method. LC, WVC and SCBS were utilized by over 50% of those surveyed. Carrier-based obturation techniques were performed by only 10% of subjects.

DISCUSSION

DEMOGRAPHICS

All those surveyed were attending at least a two-year endodontic residency program with the majority indicating they were in their second year of attendance. This corresponds to CODA requirements for endodontic advanced specialty programs, as they must be a minimum of 24 months\(^45\). All respondents reported attending a dental school within the U.S. in some capacity before matriculating into an endodontic residency program. This may be due to the fact that there are limited endodontic resident positions available. Some programs also have a predilection to take previous dental school attendees\(^8,9\). However, this also relates to the fact that many foreign trained dentists who wish to practice initially as general dentists in the U.S. must receive a U.S. dental degree and pass subsequent national board examinations. That said, foreign trained dentists may proceed directly into an advanced specialty training program if they desire, but in order to receive licensure and practice in the U.S. they must first pass required national board examinations\(^5,45\).
Residents surveyed indicated that they enter into an endodontic residency directly from practicing general dentistry or dental school. Only 4% of subjects answered that they matriculated from another specialty program signifying that dual specialization is uncommon, nor the norm in dentistry. It was evident that those surveyed were motivated to receive a Masters Degree, as over 50% identified that they were anticipating earning both a Certificate in Endodontics and a Masters Degree upon completion of their program. Only 1% reported they were enrolled in a Certificate in Endodontics and Ph.D. track, perhaps because of the long time required for such an endeavor to be achieved. Also, this study was conducted on “Clinical Experiences,” and those enrolled in combined Certificate in Endodontics and Ph.D. programs were likely geared more towards academia rather than clinical practice. Thus, they may be less likely to complete a survey that does not pertain to their career objectives.

**CLINICAL EXPERIENCE: AVERAGE PROCEDURES PERFORMED**

The most commonly performed procedure was NS-RCT with most respondents reporting they perform between 151 and 250 NS-RCTs during their endodontic residency. This is in agreement with the information provided on the AAE website which has the average number of non-surgical procedures listed under each program by state between 150-250 NS-RCTs\(^4\).

NS-RCT Retx procedures are being performed far less than primary endodontic therapy. The majority of residents indicated they are only completing between 26 and 50 NS-RCT

34
Retx procedures. The increase in implant placement over the past two decades has likely had a direct impact on patients’ decision to extract rather than attempt to save their natural tooth. This is despite recommendations from Zitzmann et al. which state that good long-term success rates and greater flexibility in clinical management indicate that NS-RCT and NS-RCT Retx should be performed first in most instances, rather than making a rash decision to extract and replace with an implant. Another possible reason for substantially lower numbers of NS-RCT Retx procedures compared to NS-RCT could be due to the financial strain on the patient as most state dental insurance programs do not cover NS-RCT Retx. These patients are more likely to have the tooth extracted and not replace it with an implant. Rather fixed and removable partial dentures are the treatment modality of choice in this group of patients based on the coverage of their state dental insurance.

Surgical retreatment of failing endodontically treated teeth is the procedure that most residents are unfamiliar with when entering their residency program. Regardless of the year the resident was in attendance at the time the survey was completed, the majority described completing less than 20 apicoectomies during their post-graduate training. This also corresponded to the fact that over 50% of respondents stated they could not perform surgical procedures during their first year. This is likely because surgical endodontics requires significant experience in order to be competent, especially for multi-rooted molars. However, it is a no-win situation, as experience can only be gained by performing the procedure. While it is clear that residents are not mastering this procedure, it may be attributed to the lack of cases being seen by the residents. This may
be due in part to a rise in implants throughout dentistry\textsuperscript{46}. Patients believe that if they are to undertake a surgical procedure they might as well go with the reported higher “survival” rate of implants, versus taking a chance they may require another surgery if the apicoectomy is unsuccessful\textsuperscript{46}.

Over 90\% of respondents indicated they are performing between 0 and 10 Regeneration procedures during their post-graduate training. This makes Regeneration the least experienced procedure by those surveyed. While this procedure is no more invasive as the most commonly performed procedure by residents, NS-RCT, its outcomes and protocols have not been fully elucidated\textsuperscript{48}. Furthermore, alternative procedures and variations in treatment modalities contribute to the lack of familiarity with Regeneration in endodontics\textsuperscript{49}. Case selection is also another factor that can be attributed to the inconsistency in performing this procedure as most Regeneration cases in the literature are done on children less than 16 years of age. Endodontic residents may not have the opportunity to see as many of these cases as a result because pediatric residents are commonly managing these young patients. Furthermore, referring practitioners and other dental specialists may not be aware of Regenerative endodontic protocols, which may lead them to explore other treatment modalities in lieu of endodontic intervention\textsuperscript{49,50}.

**VISUALIZATION TECHNIQUES**

All residents indicated they use magnification in the form of a surgical operating microscope (SOM), which is the standard of care in providing endodontic treatment\textsuperscript{5,45,51}.
It was also evident that as residents gain more exposure and experience with techniques each year they attend their respective residency training programs, they will continue to utilize the SOM during implementation of clinical endodontics. The SOM has seen a dramatic increase in utilization over the past 25 years in the field of endodontics\textsuperscript{51,52}. A survey study comparing access and usage of a SOM in daily clinical practice among endodontists in 1999 and 2007 showed that in 1999 only 52\% incorporated a SOM\textsuperscript{52,53}. This increased substantially in 2007 as nearly 90\% stated they employ a SOM for clinical endodontic procedures\textsuperscript{52,53}.

In 2012 the AAE published a Position Statement on the Use of Microscopes and Other Magnification Techniques and they stated that, “the microscope is an integral and important part of the performance of modern endodontic techniques.” Specifically, the position statement describes procedures that benefit from the use of the microscope\textsuperscript{52-54}. Locating canals obstructed by mineralization and/or reduced in size, removing materials such as solid obturation constituents including: silver points, carrier-based materials, and posts or separated files are areas listed that are improved with the enhanced visualization the SOM affords\textsuperscript{52-54}. The SOM also aids the endodontist in removing canal obstructions, assisting in access preparation to avoid unnecessary destruction of structural dentin, repairing perforations, locating cracks and fractures that are not clinically visible or palpable with an endodontic explorer, and facilitating all aspects of endodontic surgery, particularly in root-end resection and placement of retrofilling materials\textsuperscript{52-54}.
Use of the SOM also permits superior photographic documentation and enhanced ergonomics for the clinician. This is especially true for surgical endodontic procedures, which have significantly evolved from earlier conventional techniques. The modern approach to endodontic surgery is through magnification, illumination and microsurgery. The improved outcomes seen when employing the SOM are well documented. Other magnification aids, such as loupes, that are adequate for coronal restorative procedures, may prove inadequate for apical surgery or even conventional coronal endodontics when compared to performing these complex procedures under microscopic visualization. Microscopy provides a more detailed examination of the root apex and anatomic features such as isthmuses, missed canals, accessory canals, fractures and crazing. The SOM also helps the endodontist in proper placement of apical sealing materials during surgical endodontic procedures.

**INSTRUMENTATION TECHNIQUES**

It is apparent that current endodontic residents are exposed to variety of rotary and reciprocation endodontic file instrumentation systems. The majority utilizes multi-file rotary instrumentation systems as 82% of those surveyed indicated. It was interesting to note that the top three leading brands according to sales were also the manufacturer of the most commonly used file brands according to respondents. Dentsply Sirona’s ProTaper and Vortex Blue brands were employed by over 70% of those surveyed and represented the leading file manufacturer by almost a 45% margin. The next leading file manufacturer was EdgeEndo LLC with nearly 31% identifying they instrument, clean and shape with their file systems. Brasseler USA’s EndoSequence file system came in as the
third manufacturer and file brand at 24% utilization by endodontic residents. What is perhaps most interesting is that the second leading file manufacturer in the U.S., EdgeEndo LLC, happens to be the newest company to hit the endodontic market. The increased usage of their file brands is in direct relation to their marketing and pricing strategies. EdgeEndo LLC sells their files for nearly half of what Dentsply Sirona and Brasseler USA file brands retail for in the U.S. Moreover, EdgeEndo LLC files claim to be identical in terms of usage protocols to those of Dentsply Sirona’s and Brasseler USA’s most popular file systems, ProTaper and EndoSequence, respectively.

Litigation from Dentsply Sirona against EdgeEndo LLC for patent infringement and fabrication of copycat replacement files is on-going.

The increased use of multi-file rotary and single-file reciprocation systems is likely a reflection of the case complexity experienced by an endodontic resident. Typically, they are treating multi-canaled teeth with significant anatomical complexities. Additionally, the difficult teeth that are referred to endodontic residents represent the majority of their cases because the referring dentist will often complete the perceived “simpler” cases, which include single canaled incisors, canines, and some premolars.

Dentsply Sirona has established a monopoly on several universities being the sole supplier to their dental departments for endodontic rotary and reciprocation files. These products are being supplied to dental students and residents who have had no prior exposure to engine driven files during their pre-doctoral dental training and post-doctoral residency. It would be prudent to teach dental students and incoming endodontic
residents alike multi-file rotary instrumentation before mandating the use of a single-file reciprocation system. This is especially true given the findings of the current study, which showed that over 82% of resident respondents use a multi-file instrumentation technique. Exposure to multi-file systems can ingrain the sense that “one file will not always get the job done.” Too often the single-file reciprocation systems are a fall back for students with little experience, and mistakes commonly occur during this trial and error period. Also, multi-file rotary systems are usually interchangeable with obturation techniques, while single-file reciprocation methods often require different sizes of gutta-percha for obturation that may not be readily available.

**OBTURATION TECHNIQUES**

It appears that residents are gaining experience utilizing a variety of obturation techniques, which aids in their experience, especially when complex cases arise. Over 90% are exposed to WVHT. This technique employs the use of an apical downpack followed by a backfill system that injects thermopalasticized gutta-percha to fill the entire canal space. While technique-sensitive, WVHT has been utilized for over 20 years and has shown favorable outcomes when mastered.

Many residents report utilizing the relatively new bioceramic sealers with single cone obturation technique. This technique uses a bolus of bioceramic sealer that is then injected into the canal space. Next, a single gutta-percha mastercone is coated with the bioceramic sealer and placed into the canal space. Lastly, the gutta-percha mastercone is seared off at the canal orifice. The single-cone technique, sometimes referred to as
“hydraulic condensation,” permits the sealing of the canal spaces with only one application of gutta-percha via the mastercone. While WVC and WVHT employ a second method of gutta-percha application, single-cone techniques do not require this extra step. Thus, it can be postulated that the ease of application is one reason for its increased utilization. An advantage to using the bioceramic sealer and single-cone technique is that the bioceramic sealer has a larger particle size than its conventional sealer counterparts. Thus, bioceramic sealers are less likely to be extruded during obturation. The main disadvantage that is discussed in the literature is the difficulty in retreating such cases because the bioceramic sealer is not dissolved by commonly used endodontic retreatment chemicals chloroform and eucalyptol. Rather, the bioceramic sealer has to be removed by mechanical means, which in turn may compromise the remaining root structure during retreatment. The bioceramic sealer may also block the apical foramen and apical patency may be difficult to regain.

Carrier-based obturation techniques were not as popular amongst residents. Only 10% of those surveyed reported using this obturation protocol. Proponents of this obturation method claim it can better negotiate curvatures and seal complex root canal anatomy compared to the conventional warm vertical techniques. However, it is perhaps more technique sensitive as the placement of the sealer can lead to excessive extrusion, or even voids, if the proper amount is not precise and accurate. Another possible reason for its limited use during residency training is the reported difficulties encountered during its retreatment, as the carrier cannot always be predictably removed.
STUDY LIMITATIONS AND FUTURE DIRECTIONS

One limitation of the study is the lack of evidence concerning the outcomes of the clinical procedures performed by endodontic residents. While valuable information was obtained regarding the quantity of endodontic treatment experienced, the quality of these cases could not be assessed. Another limitation of the present report is that there are no prior research studies regarding endodontic residency clinical experiences. This made comparisons impossible to perform. With that said, future studies can be prepared and analyzed with regard to the present evaluation. Future research in this area can also aim to compare endodontic resident procedural outcomes to previous studies pertaining to success rates. Data is available regarding NS-RCT, NS-RCT Retx, Apicoectomy, and Regeneration treatment outcomes and it can be utilized to see if post-graduates are performing at an acceptable level. Even more transparency could be attained if institutions were held accountable for tracking the number of procedures their endodontic residents complete during training. Thus, there exists an opportunity for universities to make this information available. Ultimately, the more data that is gained will benefit future research aimed at describing clinical experiences during post-graduate endodontic residency.

CONCLUSION

The results of the survey included a 30% completion rate (133/437). Only 18% of subjects stated they were attending a three-year endodontic residency program, while
81% indicated their program duration was two-years. Nearly 75% of residents reported they were in their second year of post-graduate training and 82% matriculated from a U.S. Dental School prior to beginning their endodontic residency. One-third of respondents identified they matriculated directly from dental school while 44% gained clinical experience as practicing general dentists prior to matriculation. Almost all of those surveyed indicated they wish to earn a Certificate in Endodontics (42%), or a combined Certificate in Endodontics and Masters Degree (57%), respectively. The majority of respondents indicated completing between: 151-250 NS-RCT, 26-50 NS-RCT Retx, 0-10 Apicoectomies, and 0-10 Regenerative procedures during their endodontic post-graduate programs. All respondents report using a SOM for all procedures performed, and 82% described using a multi-file rotary system for their non-surgical endodontic treatments. Approximately 18% stated they used both single-file reciprocation and multi-file rotary systems for NS-RCT and NS-RCT Retx procedures. Dentsply Sirona manufactured files were listed as the predominant rotary and reciprocation instruments employed during respondents’ endodontic training. The most commonly used obturation technique listed was WVHT as 92% of respondents indicated this is their preferred obturation method. Thus, the information gained from this descriptive study can provide future applicants a better understanding of the clinical experiences they should expect when matriculating into a post-graduate endodontic residency while also delivering transparency amongst the various endodontic residency programs.
APPENDIX 1

DEMOGRAPHICS:
Q1. What is the duration of your Endodontic program?
   a. 2-years
   b. 3-year
   c. Greater than 3 years

Q2. Which year of residency are you currently in?
   a. 1st year
   b. 2nd year
   c. 3rd year
   d. Greater than 3rd year resident (Fellow or Ph.D)

Q3. Where did you receive your dental education prior to attending an Endodontic residency?
   a. U.S. Dental School
   b. Foreign Dental School
   c. Foreign Dental School and a 2-year U.S. Dental Degree yielding DDS or DMD.

Q4. What was your experience in dentistry that immediately preceded attending your Endodontic program?
   a. Dental School straight into endodontic specialty training program.
   b. GPR or AEGD
   c. General dentist
   d. Another specialty program

Q5. What degree are you pursuing in your post-graduate Endodontic residency?
   a. Certificate in Endodontics
   b. Certificate in Endodontics and Masters
   c. Certificate in Endodontics and Ph.D.

PROCEDURES:
Approximately how many cases of the following procedures have you completed during your endodontic residency…
Q6. NS-RCT?
   a. <50
   b. 50-150
   c. 151-250
   d. >250
Q7. NS-RCT Retreatment?
   a. 0-25
   b. 26-50
   c. >50

Q8. Apicoectomy?
   a. 0-10
   b. 11-20
   c. >20

Q9. Regeneration?
   a. 0-10
   b. 11-20
   c. >20

Q10. Were you allowed to do surgical endodontic procedures in your 1st year?
   a. Yes
   b. No

**PREFERRED METHOD/TECHNIQUE**
Q11. Do you use a microscope for the majority of the procedures you perform?
   a. Yes
   b. No

Q12. Do you use a multi-file rotary system or a single file reciprocation system, or both?
   a. Multi-file rotary system
   b. Single file reciprocation system
   c. Both

Q13. What are the predominant file systems you have had exposure too at your program? (List all).

Q14. Which obturation technique(s) do you or have you used: (select all that apply)
   a. Lateral condensation
   b. Warm vertical
   c. Warm vertical hybrid with apical down-pack followed by backfill system.
   d. Single cone technique with bioceramic sealer.
   e. Carrier based obturation (Thermafil, Guttacore, or similar)
# APPENDIX 2

## Q13: INSTRUMENTATION DATA TABLE

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1: PTG=ProTaper Gold, PTN=ProTaper Next, PTU=ProTaper Universal  
2: WO=WaveOne, WO Gold=WaveOne Gold  
Residents Choice*=Any file system is available to the resident
REFERENCES


23. L. K. McCaul, S. McHugh, W. P. Saunders. The influence of specialty training and experience on decision making in endodontic diagnosis and


