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THESIS APPROVAL PAGE FOR MASTER OF SCIENCE IN ORAL BIOLOGY

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DISLAIMER:

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ABSTRACT:

The purpose of this study was to investigate the current trends in obturation techniques and compare them between general dentists and endodontists. An e-mail invitation was sent to 81,091 members of the American Dental Association (ADA) and 4,985 members of the American Association of Endodontists (AAE). Each participant was asked between 12-16 questions based on their individual responses. Questions investigated types of materials, techniques utilized to obturate, and desirable properties when selecting materials and techniques. When considering only the opened emails, 11.1% responded (n=3281; AAE=819; ADA= 2462). Chi-squared tests of homogeneity were run with post hoc pairwise comparisons using multiple z-tests of two proportions with Bonferroni correction. Statistical significance was accepted at $p<.001$. Significant differences were found between ADA and AAE members regarding the use of the following types of sealers: ZOE, $Ca(OH)_2$, bioceramic, and "unknown." Significant differences were also found for the following obturation techniques: lateral compaction, warm vertical compaction, continuous wave, carrier-based, and hybrid. Significantly more ADA members utilize $Ca(OH)_2$ and "unknown" sealers and perform obturation with lateral compaction and carrier-based techniques while significantly more AAE members utilize ZOE & bioceramic sealers and perform obturation with warm vertical compaction, continuous wave, and hybrid techniques. The research was entirely funded by the United States Army.

BACKGROUND:

The goal of endodontic therapy has been geared towards the prevention, or elimination of periapical disease. ([1]) All steps taken throughout endodontic therapy attempt to maintain asepsis in vital cases, or to provide decontamination of non-vital teeth.([2,3]) Some of these key steps include; placement of a rubber dam, utilization of pre-sterilized armamentarium, choice of irrigation solutions and aseptic techniques. Even with advancements in chemo-mechanical preparation techniques, there are multiple studies which indicate that the complete cleaning and disinfection of the root canal system is unable to be achieved. ([4–7]) With this known shortcoming, a well-sealed canal system to reduce leakage into the tooth from coronal contamination as well as out of the tooth by remaining bacteria and/or their byproducts from the apex has a tremendous impact on the success of treatment. ([8])

The properties of the ideal canal filling material have been described by Grossman.([9]) He stated the material should be easy to introduce into the root canal, it should seal the canal laterally as well as apically, it should not shrink after being inserted, it should be impervious to moisture, it should be bacteriostatic or at least not encourage bacterial growth, it should be radiopaque, it should not stain tooth structure, it should not irritate periradicular tissues, it should be sterile, or easily and quickly sterilized, immediately before insertion, and if necessary it should be removed easily from the root canal. ([9])

As of yet, there has been no material which has been able to satisfy all of these suggested properties. However, there are many that approximate the list and still provide for excellent clinical results and good overall outcome. Gutta-percha is by far the most popular and commonly utilized root canal filling material, which is generally placed with some type of sealer. ([10], [11]) The major difference in how dental practitioners fill a root canal system arises with the chosen technique to place the gutta-percha into the canal system, as well as which type of root canal system sealer is utilized.

There are a myriad of different obturation techniques and materials, with newer protocols and materials being added frequently. There is little research looking into to the currently utilized methods and materials among members of the AAE. Additionally, most root canal therapy procedures are performed by general practitioners ([12]) but there is even less evidence as to the current methods/materials utilized by GP in comparison with AAE members. The purpose of this study was to investigate the current trends in obturation techniques and compare between ADA Members and AAE Members within the United States and Canada.

METHODS AND MATERIALS:

Membership lists were obtained from the ADA and AAE and e-mail invitations were sent out to participate in an online survey (Survey Monkey) about the currently practiced obturation techniques utilized during endodontic procedures. In total, invitations were sent out to 81091 members of the American Dental Association, and to 4985 members of the American Association of Endodontists. Each participant was asked between 12-16 questions based on their individual responses. Questions included types of material utilized to obturate, types of sealers used to obturate, techniques utilized to obturate, ranking of ideal properties they look for when choosing materials/techniques etc. The survey questions were compiled of multiple choice, ordinal ranking, and write-in answers based on their practice paradigm. The survey for the ADA members was also selective in removing those practitioners who stated they didn't perform root canal therapy. (Sample questions can be found in figures 1&2) Following the initial electronic invitation, one additional e-mail reminder was sent after 2-weeks, and the survey window was closed after a total of 4 weeks. Survey Monkey system was utilized to collect the responses from which the raw data was extracted, and SPSS software was utilized to analyze the received data.

Do you currently practice in the US or Canada?

- Y/N

Do you perform non-surgical root canal therapy (NSRCT) in your practice?

- Y/N

Which Technique to you primarily use? (what is your "Go-To" technique?)

- Lateral Condensation
- Plasticized technique
- Warm Vertical Compaction
- Sealer Based
- Carrier Based System
- Single Cone Hydraulic
- Hybrid
- Continuous Wave
- Other: Please Specify

Which factors play a role in your choice of obturation technique? (select all that apply)

- Previous Training
- Pulpal diagnosis (vital vs necrotic, vs previously treated etc.)
- Restorative needs (need for post placement etc.)
- Canal morphology (curved vs straight vs round vs oval etc)
- Speed
- Periapical diagnosis (PARL vs No vs sinus tract etc)
- Cost
- Size of apical constriction
- Other(please specify)

Which type of sealer do you primarily use? (i.e. What's your "GO-TO" sealer?)

- Calcium Hydroxide Based(Ca(OH)2) (i.e. Sealapex, Apexit, Vitapex)
- Zinc Oxide Eugenol (ZOE)(i.e. Roth's Grossman's)
- Epoxy/Resin Based (i.e. AH Plus, Endo REZ, Epiphany)
- Bioceramic Based (i.e. MTA Fillapex, BC Sealer)
- Unknown
- Other (Please specify)

Which factors play a role in your sealer selection? (select all that apply)

- Previous Training
- Pulpal diagnosis (vital vs necrotic, vs previously treated etc.)
- Restorative needs (need for post placement etc.)
- Canal morphology (curved vs straight vs round vs oval etc)
- Speed
- Periapical diagnosis (PARL vs No vs sinus tract etc)
- Cost
- Availability in practice setting. (i.e. someone else chooses available materials)
- Size of apical constriction
- Method of placement (mix vs injection)
- Other(please specify)

Please arrange the following sealer traits from most to least important (with 1 the most important and 9 the least)

- Biocompatibility
- Ability/ease to retreat canal system
- Setting time
- Ability to set in presence of moisture
- Dimensional stability (i.e. expansion vs shrinkage
- Ability to seal canal
- Handling characteristics (viscosity, stickiness
- Method of application (mix and apply vs injection
- Radiopacity

How many years ago did you graduate dental school?

- <5yrs
- 5-10yrs
- 11-20yrs
- 21-30yrs
- >30yrs
-

Did you complete any post-graduate training? (AEGD,GPR, Fellowship etc)

- Y/N

Figure 1: Sample ADA Survey Questions

Do you currently practice in the US or Canada?

- Y/N

Which Technique to you primarily use? (what is your "Go-To" technique?)

- Lateral Condensation
- Plasticized technique
- Warm Vertical Compaction
- Sealer Based
- Carrier Based System
- Single Cone Hydraulic
- Hybrid
- Continuous Wave
- Other: Please Specify

Which factors play a role in your choice of obturation technique? (select all that apply)

- Previous Training
- Pulpal diagnosis (vital vs necrotic, vs previously treated etc.)
- Restorative needs (need for post placement etc.)
- Canal morphology (curved vs straight vs round vs oval etc)
- Size of apical constriction
- Speed
- Periapical diagnosis (PARL vs No vs sinus tract etc)
- Cost
- Other(please specify)

Which type of sealer do you primarily use? (i.e. What's your "GO-TO" sealer?)

- Calcium Hydroxide Based(Ca(OH)2) (i.e. Sealapex, Apexit, Vitapex)
- Zinc Oxide Eugenol (ZOE)(i.e. Roth's Grossman's)
- Epoxy/Resin Based (i.e. AH Plus, Endo REZ, Epiphany)
- Bioceramic Based (i.e. MTA Fillapex, BC Sealer)
- Unknown
- Other (Please specify)

Which factors play a role in your sealer selection? (select all that apply)

- Previous Training
- Pulpal diagnosis (vital vs nectotic, vs previously treated etc.)
- Restorative needs (need for post placement etc.)
- Canal morphology (curved vs straight vs round vs oval etc)
- Speed
- Periapical diagnosis (PARL vs No vs sinus tract etc)
- Cost
- Availability in practice setting. (i.e. someone else chooses available materials)
- Size of apical constriction
- Method of placement (mix vs injection)
- Other(please specify)

Please arrange the following sealer traits from most to least important (with 1 the most important and 9 the least)

- Biocompatibility
- Ability/ease to retreat canal system
- Setting time
- Ability to set in presence of moisture
- Dimensional stability (i.e. expansion vs shrinkage
- Ability to seal canal
- Handling characteristics (viscosity, stickiness
- Method of application (mix and apply vs injection
- Radiopacity

How long ago did you complete Endodontic specialty training?

- Still in training
- <5yrs; 5-10yrs
- 11-20yrs
- 21-30yrs
- >30yrs

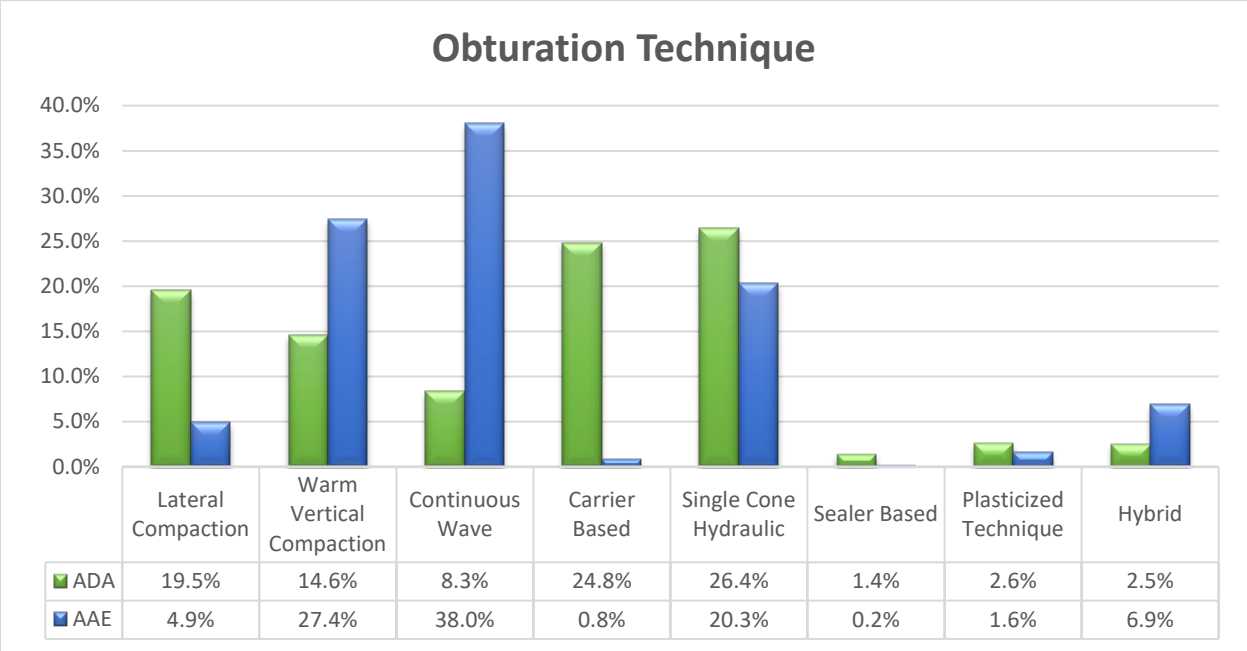
Are you a Diplomate of the American Board of Endodontics?

- Y/N

Figure 2: Sample AAE Survey Questions

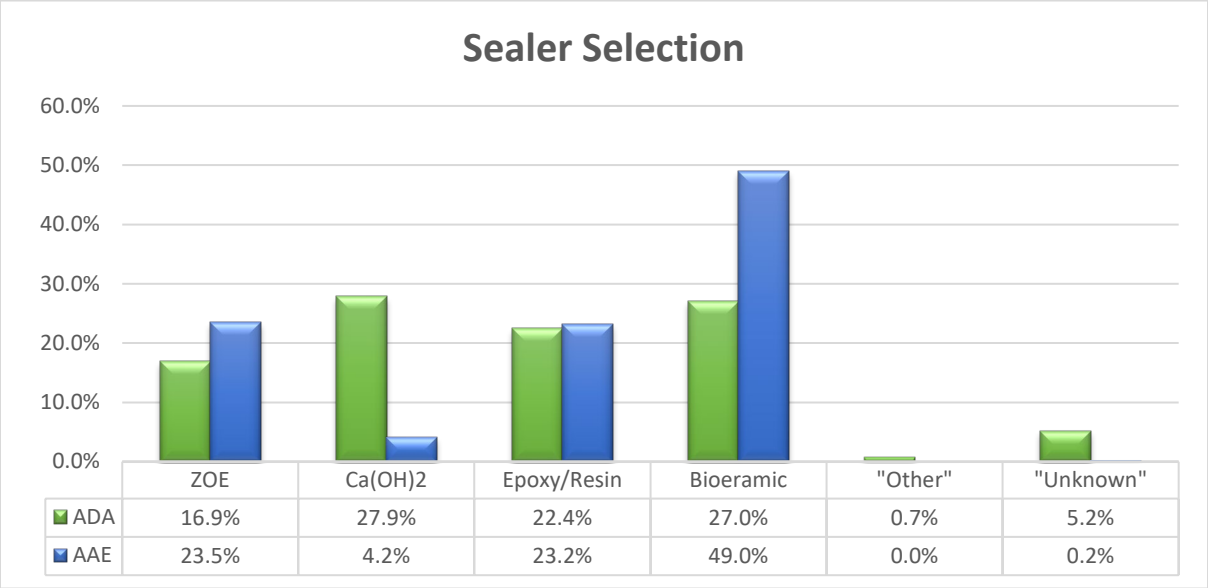
RESULTS:

Of 26498 ADA member recipients who opened the emails, 9.3% responded (n=2462), and the 2898 AAE members who opened the emails, 28.3% responded (n=819) (See Table 1&2 for the reported obturation techniques and sealer types.)



	Lateral Compaction	Warm Vertical Compaction	Continuous Wave	Carrier Based	Single Cone Hydraulic	Sealer Based	Plasticized Technique	Hybrid
ADA	19.5%	14.6%	8.3%	24.8%	26.4%	1.4%	2.6%	2.5%
AAE	4.9%	27.4%	38.0%	0.8%	20.3%	0.2%	1.6%	6.9%

Table 1: Reported obturation technique based on practitioner type.



	ZOE	Ca(OH)2	Epoxy/Resin	Bioeramic	"Other"	"Unknown"
ADA	16.9%	27.9%	22.4%	27.0%	0.7%	5.2%
AAE	23.5%	4.2%	23.2%	49.0%	0.0%	0.2%

Table 2: Reported sealer type based on practitioner type.

For comparing between ADA and AAE members, Chi-squared tests of homogeneity were run with respect to the types of sealers and obturation techniques utilized. The distributions were not equal between the two groups with sealer $X^2(5) = 240.104$, $p = .001$ (sealer selection) and $X^2(7) = 565.499$, $p = .001$(obturation technique)

Post hoc analysis with pairwise comparisons using multiple z-tests of two proportions with Bonferroni correction were performed. Statistical significance was accepted at $p<.001$. There was a statistically significant difference in the reported usage the following obturation techniques by ADA members vs. AAE members: Cold Lateral (n = 369, 19.5% vs. n = 31, 4.9%); Carrier Based (n = 468, 24.8% vs n = 5, 0.8%) each respectively. Whereas there was a statistically significant difference in the reported usage of the following obturation techniques by AAE members vs. ADA Members: Warm Vertical (n = 175, 27.4% vs. n= 275, 14.6%); Continuous Wave (n = 243, 38.0% vs. n = 156, 8.3%); Hybrid (n = 44, 6.9% vs. n = 47, 2.5%) each respectively. No significant difference was found between ADA and AAE members for the following obturation techniques: Single Cone Hydraulic (n = 498, 26.4% vs. n = 130, 20.3%); Sealer Based (n = 26, 1.4% vs. n = 1, 0.2%); and Plasticized Technique (n = 49, 2.6% vs. n = 10, 1.6%) each respectively.

As for sealer selection, there was a statistically significant difference in the reported usage the following sealer types by ADA members vs. AAE Members: $Ca(OH)_2$ (n=527, 27.9% vs. n = 27, 4.2%); "Unknown" (n = 99, 5.2% vs n = 1, 0.2%) each respectively. Whereas there was a statistically significant difference in the reported usage of the following sealer types by AAE members vs. ADA members: ZOE (n = 150, 23.5% vs. n= 230, 16.9%); Bioceramic (n = 313, 49.0% vs. n = 509, 27.0%) each respectively. No significant difference was found between ADA and AAE members for the following sealer types: Epoxy/resin (n = 420, 22.4% vs. n = 148, 23.2%); "Other" (n = 13, 0.7% vs. n = 0, 0.0%) each respectively.

DISCUSSION:

Initially the aim of the investigators was to try and compare the obturation trends between general dentists and endodontists.

Overall, the results indicated that ADA members utilized what could be considered simpler techniques for obturating the root canal systems with carrier based and cold lateral obturation techniques being used significantly more. These types of techniques also require less armamentarium to complete compared with a warm vertical, continuous wave and hybrid technique, which were found to be used significantly more by AAE members. The differences between the lateral condensation and warm vertical techniques have been reviewed in multiple studies to try and determine which provides a better overall seal of the root canal system. ([13–18]) Additionally, studies have looked at variations of a warm vertical compaction vs continuous wave ([19,20]) Although there have been differences found in the in vitro ability to seal a canal, they haven't necessarily translated into higher clinical success from one type of technique to another. ([21,22])

The differences noted between the two groups for sealer choice could be seen as a function of previous experience and training. The members of the ADA were found to use $Ca(OH)_2$ and unknown sealers significantly more, while the AAE members used ZOE and Bioceramic based sealers significantly more. Both $Ca(OH)_2$ and ZOE based sealers have been used for a long time. The advent of epoxy/resin based

sealers is more recent and has been adapted by both groups almost equally, based on the findings of the present study. (ADA=22.4%, AAE=23.2%) When dental practitioners find a material which works well and provides good results, they are not as likely to switch to something else. Examples of reasons why a practitioner would modify their technique or material selection include; economical incentives, improved clinical results, greater ease of use, more time efficient etc. These could be some of the reasons for the significantly greater amount of AAE members using a bioceramic based sealer with 49% reporting it as their "go-to" sealer.

Some of the advantages of a bioceramic based sealer include it's high hydrophilicity, antibacterial properties during the setting reaction, expansion upon setting, ability to bond with gutta percha which has been impregnated and coated with bioceramic particles and eliminate a gap between the sealer and GP. ([23]) These favorable properties of a bioceramic sealer allow for a shift from the long held concept of minimizing the sealer and maximizing the thermoplasticized GP due to the inherent shortcoming of shrinkage with previously utilized sealers. In essence this is the basis of the concept of the single cone hydraulic condensation where a cone of GP is utilized to facilitate the placement and positioning of bioceramic sealer throughout the root canal system. ([23]) Although not found to be significantly different between the ADA and AAE members, this is an idea which seems to have caught favor because single cone hydraulic technique was found to be the most common technique for obturating with ADA members (26.4%) and the 3rd most common for AAE members (20.3%)

Other studies have looked at clinical technique differences between Endodontist and General practitioners, as well as within the individual groups. One recent one investigated specifically the usage of bioceramic sealers between the two groups. ([24]) Overall, they found that among those who used bioceramic sealers, the single cone hydraulic technique was used most often. When further broken down, it was also mostly seen with general dentists. Whereas, when endodontist utilized bioceramic sealers, they generally utilized more thermoplasticized obturation techniques. This is in agreement with the results of our current investigation as a bioceramic sealer was found to be utilized significantly more with AAE members who had a significantly greater reporting of utilizing thermoplasticized techniques. A separate survey was conducted to inquire about trends of obturation techniques among members of endodontic societies. They found a majority of respondents utilized a warm technique, but they also preferred the use of epoxy resin-based sealer. ([25])

Caution should be utilized when interpreting these results as our response rate was relatively low with only 9.3% of ADA members responding, and 28.3% ADA members responding. Our survey housing software site was able to let us see how many of our sent invitations were opened. 26498 ADA member recipients opened the emails with only 9.3% responding (n=2462). A slightly larger percentage of AAE members responded with 28.3% of the 2898 AAE members who opened the emails, participating. (n=819) Multiple different reasons could have contributed to the low response rate. Some may have been disinterested with the subject of the survey and chosen not to open respond. Another possibility could be that because we used Survey Monkey as our survey hosting program, and it isn't specific for dental/medical related research surveys, people have grown tired of being solicited for their opinions from this venue and may have placed filters for their incoming electronic correspondence. Whatever the reason our response rate was lower than anticipated.

CONCLUSIONS:

Within the limitations of this study, significant differences were found between ADA and AAE members regarding the use of the following types of sealers: ZOE, $Ca(OH)_2$, bioceramic, and "unknown." Significant differences were also found for the following obturation techniques: lateral compaction, warm vertical compaction, continuous wave, carrier-based, and hybrid. Significantly more ADA members utilize, $Ca(OH)_2$, and "unknown" sealers and perform obturation with lateral compaction and carrier-based techniques while significantly more AAE members utilize ZOE, bioceramic sealers and perform obturation with warm vertical compaction, continuous wave, and hybrid techniques.

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OBTURATION TECHNIQUES

SIG Differences ADA: Lateral Compaction (n=369, 19.5%); Warm Vertical (n=275, 14.6%); Continuous Wave (n=156, 8.3%); Carrier Based (n=468, 24.8%); Hybrid (n=47, 2.5%)

SIG Differences AAE: Lateral Compaction (n=31, 4.9%); Warm Vertical (n=175, 27.4%); Continuous Wave (n=243, 38.0%); Carrier Based (n=5, 0.8%); Hybrid (n=44, 6.9%)

NON-SIG Differences ADA: Single Cone Hydraulic (n=498, 26.4%); Sealer Based (n=26, 1.4%); Plasticized Technique (n=49, 2.6%)

NON-SIG Differences AAE: Single Cone Hydraulic (n=130, 20.3%); Sealer Based (n=1, 0.2%); Plasticized Technique (n=10, 1.6%)

SEALERS

SIG Differences ADA: ZOE (n=320, 16.9%); $Ca(OH)_2$ (n=527, 27.9%); Bioceramic (n=509, 27.0%); Unknown (n=99, 5.2%);

SIG Differences AAE: ZOE (n=150, 23.5%); $CA(OH)_2$ (n=27, 4.2%); Bioceramic (n=313, 49.0%); Unknown (n=1, 0.2%)

NON-SIG Differences ADA: Epoxy/Resin (n=420, 22.4%); "Other" (n=13, 0.7%)

NON-SIG Differences AAE: Epoxy/Resin (n=148, 23.2%); "Other" (n=0, 0.0%)

AAE Results:

- 4985 invitations sent,
  - 2898 opened (58.1%)
    - 819 Total Responses [28.3% of those who opened responded]
      - 719 Complete 87.8%
      - 100 partial 12.2%
  - 1692 Unopened (33.9%)
  - 88 bounced (1.6%)
  - 852 clicked through (17.1%)
  - 313 Opted out (6.3%)

ADA Results:

- **ADA Totals**
  - 81091 invitations sent,
  - 26498 opened (32.7%)
    - 2462 Total Responses [9.3% of those who opened responded]
      - 2073 Complete (84.2%)
      - 389 partial (15.8%)
  - 50078 Unopened (61.8%)
  - 2029 bounced (2.5%)
  - 2639 clicked through (3.3%)
  - 2452 Opted out (3.0%)