

Endodontic working length determination techniques: a survey of Nigerian dentists in residency training

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ABSTRACT

Objectives: Precise working length determination is crucial for successful endodontic treatment. Variations in techniques among dentists can lead to inconsistent outcomes, emphasizing the need to investigate methods used by Nigerian dentists. To determine the preferred endodontic working length determination technique among Nigerian resident dentists and factors associated with electronic apex locator use.

Methods: This descriptive cross-sectional study targeted dentists in residency training in Nigeria. Data was collected using a self-administered questionnaire. All collected data were analyzed using IBM SPSS 26.0.

Results: The majority of participants (62.2%) use both radiographic and non-radiographic methods for working length determination. Digital tactile sensation (72.1%) and various radiographic techniques, including the Grossman formula method (34.2%) and Ingle's method (24.3%), are commonly used. However, only 27.0% use endodontic apex locators, primarily in combination with radiographic techniques. Factors influencing technique choice include gender, with males less likely to use non-radiographic techniques, and years of practice, which marginally predicts technique selection. Barriers to apex locator adoption include lack of experience (63.3%) and high cost (36.7%). Notably, all participants recognized apex locators' benefits, including reduced X-ray exposure and enhanced patient safety.

Conclusion: Nigerian resident dentists use diverse techniques for working length determination, preferring a combination of radiographic and non-radiographic methods. Endodontic apex locator use is limited due to cost and lack of experience. The benefits of apex locators are widely recognized, and clinician characteristics, such as gender and experience, influence technique choice. Understanding these factors can inform educational initiatives and improve endodontic practice in Nigeria.

Keywords: endodontic working length; apex locator; working length techniques

INTRODUCTION: Tooth length determination is a critical step in endodontic treatment,^[1] as accurate maintenance of working length during cleaning and shaping procedures is essential for successful outcomes.^[2] To achieve this, it is

recommended that working length determination be performed skillfully, utilizing practical and efficacious techniques that have been validated to provide precise results.^[2] However, locating the appropriate apical position remains a longstanding challenge in endodontics.^[3] Various techniques have been employed to determine endodontic working length, including radiographic working length determination,^[2-9] electronic apex locators,^[2-4,6,7] electronic working length determination, tactile perception working length method,^[2,3,10] paper

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point working length method,^[11] combined electronic and radiographic working length determination, combined electronic, tactile, and paper point working length method,^[3,10,11] and cone beam computed tomography.^[6]

The two most widely accepted methods for determining working length are radiographic length determination^[12,13] and the use of electronic apex locators.^[12] The most commonly used radiographic technique is the Ingle method,^[1,6,14] which involves estimating the distance between the file tip and the radiographic apex and adjusting it until the file tip is 0.5-1 mm short of the radiographic apex.^[15] Despite the radiographic technique being considered the most reliable source for tooth length determination;^[16,17] studies have shown no statistical difference between using an apex locator alone or in combination with radiographic working length determination.^[4] The adjunctive use of apex locators reduces the number of required radiographs in compliance with the ALARA principle,^[18,19] resulting in approximately zero retakes.^[3] However, one study found a reduction in working radiographs only in anterior and premolar teeth, but not in molars.^[20] Combining an apex locator with a digital imaging system may further reduce radiation dose.^[21] The use of a combined electronic and radiographic approach for working length determination is a widely accepted method.^[22] Overall, apex locators have the potential to replace traditional radiographic methods for working length determination.^[4]

The evolution of electronic apex locators has revolutionized working length determination in endodontics, progressing from simple direct current resistance measurements in first-generation devices to advanced multi-frequency measurements and ratio algorithms in later generations.^[3,23-25] The latest fifth-generation devices provide accurate measurements even in conductive fluids, offering digital, graphic, and audible feedback to ensure precise working length determination.^[24] Precise working length determination is crucial for successful endodontic treatment, but variations in techniques among dentists can lead to inconsistent outcomes. Investigating the methods used by Nigerian dentists is essential, especially given the innovations in working

length determination techniques. While studies have been conducted in other countries,^[3,12,26] few have been done in Africa, particularly Nigeria.^[13] This study aims to determine the preferred endodontic working length determination technique among Nigerian resident dentists and the factors associated with the use or non-use of electronic apex locator.

MATERIALS AND METHODS

This descriptive cross-sectional study targeted dentists in residency training in Nigeria. Data was collected using a self-administered questionnaire, which garnered information on sociodemographic characteristics such as age, gender, marital status, specialty, and years of practice. The questionnaire also sought information on the frequency of performing root canal treatments and the techniques used for working length determination. Additionally, it inquired about the specific types of radiographic and non-radiographic techniques employed, preferred techniques for working length determination, and factors influencing the choice of radiographic techniques.

The study was conducted in accordance with ethical principles outlined in the Helsinki Declaration of 1964 (revised in 2013) and approved by the University of Benin Teaching Hospital's Research and Ethics Committee, which oversees human experimentation guidelines with written informed consent obtained from all participants.

All collected data were analyzed using IBM SPSS 26.0. Descriptive statistics was employed to calculate frequencies, percentages, means, and standard deviations; providing a summary of the sociodemographic characteristics, frequency of root canal treatments, and the techniques used in working length determination. Inferential statistics, in the form of Chi-square tests and Fisher's exact tests, was performed to identify associations between categorical variables, including the relationship between sociodemographic characteristics and preferred techniques for working length determination, frequency of root canal treatments, the use of apex locators, and type of radiographic technique used. Multinomial logistic regression analysis was conducted to examine the factors influencing the use of

working length determination techniques. p value was set at 0.05

RESULTS

A total of 120 questionnaires were distributed, and 116 were returned, yielding a response rate of 96.7%. However, 5 of the returned questionnaires were not properly filled out, leaving 111 complete and usable responses for analysis.

Table 1 shows the demographic and professional characteristics of the study participants. The age range was mostly 31-40 years old (73%), with a relatively even gender distribution (males: 53.2%, females: 46.8%). Most participants were junior residents (78.4%), with varied specialties (family dentistry: 36%, oral and maxillofacial surgery: 18%, etc.). Years of practice ranged from less than 5 years (11.7%) to more than 10 years (43.2%), with 45.1% having 5-10 years of experience. The participants were a mix of experienced and new professionals from various specialties.

All participants reported performing root canal treatments, with varying frequencies. As shown in Figure 1, most participants (79.3%) perform treatments as needed, based on patient demand. Others follow a regular schedule, with treatments performed daily (8.1%), three times a week (7.2%), or twice a week (5.4%). Overall, all participants perform root canal treatments either on an as-needed basis or at regular, fixed intervals.

The majority of participants (62.2%) use both radiographic and non-radiographic methods for working length determination in root canal treatment, while 35.1% rely solely on radiographic methods. A small minority of 2.7% use only non-radiographic methods (Figure 2).

The majority of participants (72.1%) use digital tactile sensation, as a non-radiographic technique, for working length determination. Among radiographic techniques, the Grossman formula method (34.2%) and Ingle's method (24.3%) were the most commonly used, followed by radiovisiography (26.1%). The Weine's method (7.2%) and cone-beam CT (1.8%) were used less frequently. Other non-radiographic techniques, such as paper point method (18.9%), apical periodontal sensation (18.9%), and apex locator (20.7%), were also utilized by participants. (Table 2).

Figure 3 shows the factors that affect the use of radiographic working length determination in root canal treatment, with the most significant factors being the location of the apical foramen (64.9%), tooth type (64.9%), and clinical experience (61.3%), followed by canal curvature (55%), viewing conditions (24.3%), observer variability (22.5%), and film speed (3.6%).

Only 30 (27.0%) participants reported using an endodontic apex locator to determine working length, with (11) 36.7% using it sometimes and (19) 63.3% rarely using it. Among those who use it 10.0% use it alone while the remaining 90.0% use it in combination with radiographic technique.

Among respondents who have used apex locators, the most familiar generations were 2nd generation (30.0%) followed by 3rd generation (20.0%). However, when asked about the generation currently used in their practice, the responses were 5th generation (16.7%), with 60.0% of respondents not certain of the generation of apex locator currently used in their practice (Figure 4).

The results in Table 3 demonstrate a strong consensus among participants regarding the benefits of using an endodontic apex locator. The most striking finding is that all participants (100%) agreed that the device eliminates the need for X-ray exposure, significantly enhancing patient safety and comfort. Additionally, the majority of participants praised the device for its accuracy (66.7%), indicating high confidence in its ability to determine working length. Half of the participants (50.0%) also reported that the device is fast, suggesting it can streamline the endodontic treatment process. Furthermore, many participants noted that the device is easy to use (36.7%) and minimizes subjectivity in radiographic interpretation (13.3%). Overall, these findings highlight the numerous benefits of the endodontic apex locator, which can significantly enhance the quality and efficiency of endodontic care. Among those who do not use apex locators the primary barriers to adoption are lack of experience and high cost. As shown in Table 3, 34.2% of participants cited inexperience with the device as a significant barrier, while 32.4% reported that the high cost was a major deterrent. Other barriers, such as difficulty in using the device, inaccuracy in certain canal

Table 1: Characteristics of the study participants

Characteristics	Category	Frequency	Percentage (%)
Age group in years	20 to 30	12	10.8
	31 to 40	81	73.0
	41 to 50	18	16.2
Gender	Male	59	53.2
	Female	52	46.8
Status	Dental officer	6	5.4
	Junior resident	87	78.4
	Senior resident	18	16.2
Specialty	Orthodontics	10	9.0
	Restorative	7	6.4
	Paedodontics	8	7.1
	Oral and maxillofacial surgery	20	18.0
	Oral medicine	9	8.1
	Community dentistry	7	6.4
	No specific specialty	4	3.6
	Family dentistry	40	36.0
	Periodontics	2	1.8
	Oral pathology	4	3.6
Years of practice	Less than 5 years	13	11.7
	5 to 10 years	50	45.1
	Above 10 years	48	43.2
Total		111	100.0

Table 2: Radiographic and non-radiographic techniques used to determine working length among the participants

Technique	Category	Frequency	Percentage (%)
Radiographic	Grossman formula method	38	34.2
	Ingle's method	27	24.3
	Weine's method	8	7.2
	Radiovisiography	29	26.1
	Cone-beam CT	2	1.8
Non- radiographic	Digital tactile sensation	80	72.1
	Paper point method	21	18.9
	Apical periodontal sensation	21	18.9
	Apex locator	23	20.7

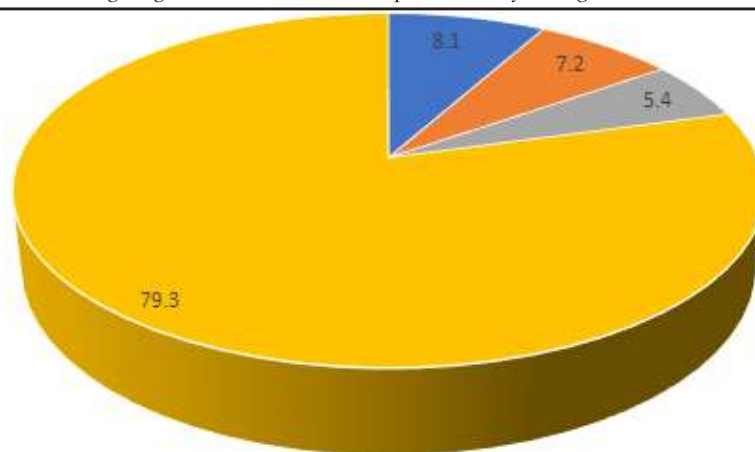
Table 3: Barriers to the use of endodontic apex locator and benefits of using endodontic apex locator for determining working length among the participants

Barriers (n=81)	Frequency	Percentage (%)
Difficult to use	1	0.9
Expensive	36	32.4
Inaccurate in calcified canals	2	1.8
Influenced by the electrical condition of the canal	1	0.9
Inexperienced with its use	38	34.2
Inaccurate in wide open apex	2	1.8
The method I use is ok	11	9.9
Benefits (n=30)		
Accuracy	20	66.7
Fast	15	50.0
Minimisation of subjectivity involved in radiographic interpretation	4	13.3
Easy	11	36.7
No requirement of X-ray exposure	30	100.0

Table 4: Multinomial logistic regression analysis to examine the factors influencing the use of working length techniques

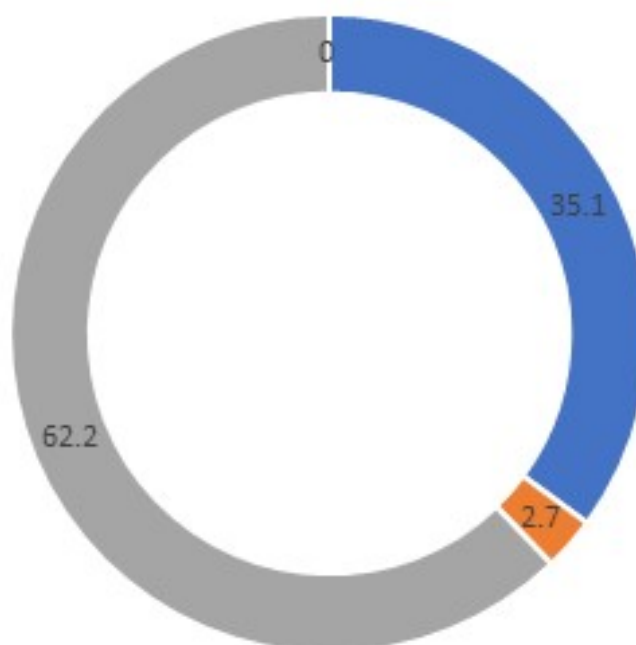
Working length determination technique	Characteristics	B	Std Error	Wald	Sig	Exp (B)
Non-radiographic	Intercept	18.894	5.238	13.012	0.000	
	Age	-0.056	1.242	0.002	0.964	0.945
	Gender	-18.897	0.000		0.000	- 6.219E
	Status	-0.540	1.613	0.112	0.738	0.583
	Years of practice	-0.014	1.051	0.000	0.990	0.987
Both radiographic and non-radiographic	Intercept	-0.518	1.759	0.087	0.769	
	Age	0.614	0.479	1.646	0.200	1.848
	Gender	-0.269	0.412	0.425	0.514	0.764
	Status	0.664	0.526	1.595	0.207	1.943
	Years of practice	-0.784	0.410	3.658	0.056	0.457

Reference category is radiographic technique



■ Daily ■ Thrice a week ■ Twice a week ■ As often as patients present

Figure 1: Frequency of performing root canal treatment by the participants



Radiographic non-radiographic Both radiographic and non-radiographic

Figure 2: Techniques used for determining working length during root canal treatment by the participants

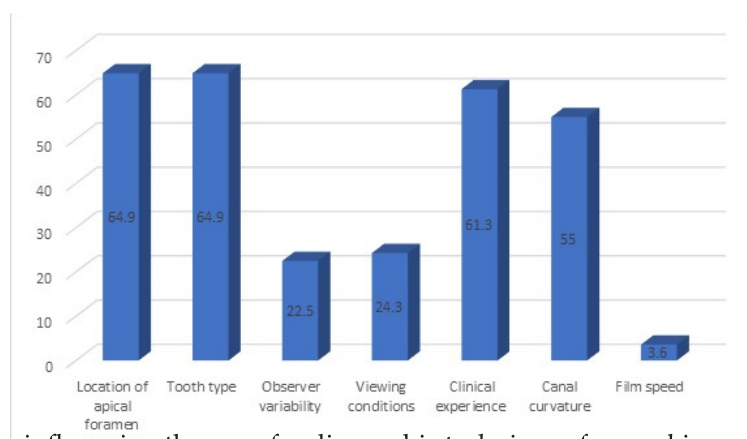


Figure 3: Factors influencing the use of radiographic techniques for working length determination among participants

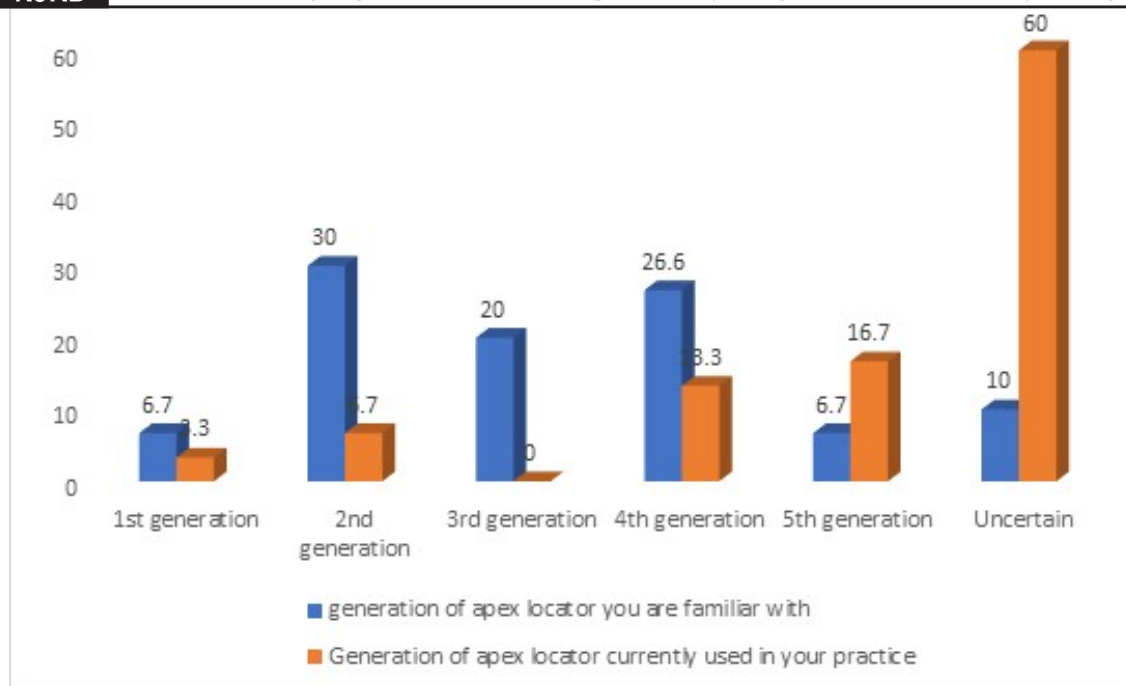


Figure 4: Generation of apex locator participants are familiar with and generation of apex locator participants currently use

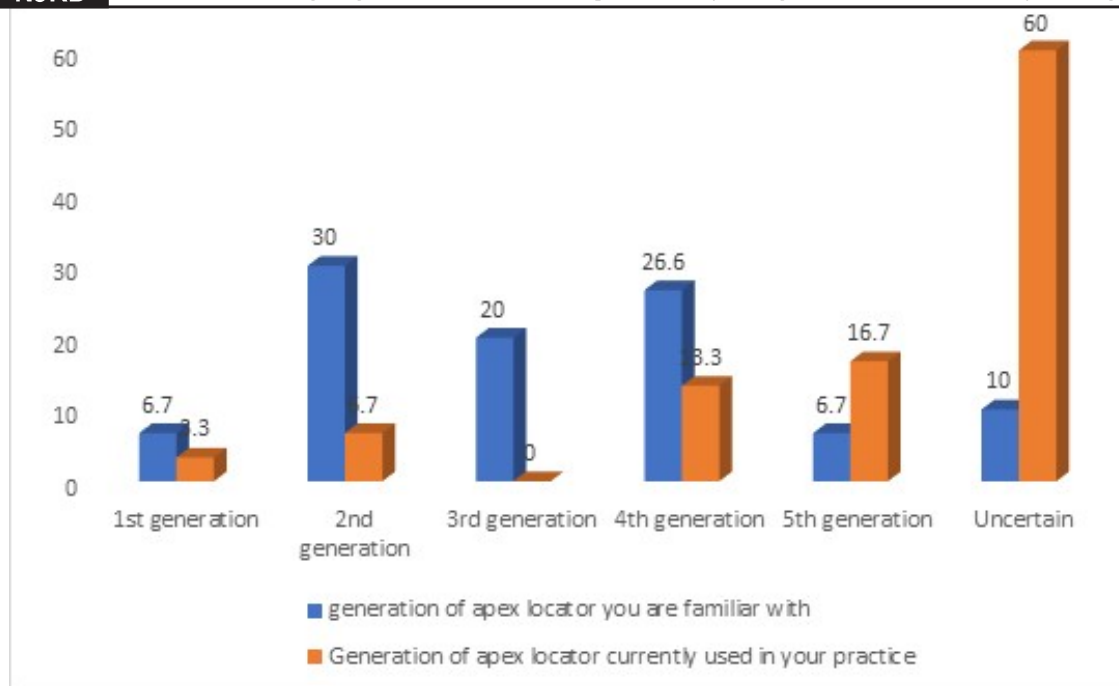


Figure 4: Generation of apex locator participants are familiar with and generation of apex locator participants currently use

conditions, and preference for current methods, were also reported, although to a lesser extent.

Table 4 revealed that age is not a significant predictor for either the radiographic or non-radiographic technique. In contrast, gender is a significant predictor for the non-radiographic technique, with males being less likely to use this technique compared to females. Status was not found to be a significant predictor for either technique. Years of practice emerged as a marginally significant predictor for both techniques. For every one-unit increase in age, the odds of choosing the non-radiographic technique decrease by a factor of 0.945. For males, the odds of choosing the non-radiographic technique are 6.211E-9 times lower than for females. For every one-unit increase in years of practice, the odds of choosing both techniques decrease by a factor of 0.457.

DISCUSSION

Accurate working length determination is a critical step in root canal treatment, influencing the success of the procedure and the health of the surrounding tissues. Various techniques are available for working length determination, each with its advantages and limitations. However, the preferred techniques and factors influencing

their adoption among dentists in residency training in Nigeria are not well understood. The study's findings provide valuable insights into the preferences and practices of dental professionals regarding working length determination during root canal treatment.

The study achieved an exceptionally high response rate of 96.7%, indicating strong interest among participants.^[27] This high response rate may be attributed to the study's relevance to participants' professional interests and the convenience of the questionnaire format.^[28,29] However, the incomplete responses highlight the importance of clear instructions and pilot-testing questionnaires to ensure data quality.

The study participants were a diverse group of dental professionals, with majority in the 31–40-year-old age range and a relatively even gender distribution with males slightly more represented than females. The relatively even gender distribution among participants, is a notable finding. Historically, dentistry has been a male-dominated profession, but in recent years, there has been a shift towards greater gender equality.^[30–32] This trend is reflected in the present study, where the gender distribution is more balanced. This change may be attributed to increased efforts to promote diversity and

inclusion in dental education and practice,^[31] as these are hallmarks of progress in any profession,^[33,34] as well as changing societal attitudes towards gender roles.^[31,32] The majority of participants were junior residents and the varied specialties represented in the study are consistent with previous studies.^[35,36]

The frequency of root canal treatment performed by participants revealed a demand-driven approach, with most participants providing treatment as needed rather than on a regular schedule. This finding aligns with previous research indicating that root canal treatment is often performed in response to patient demand, primarily due to irreversible pulpitis, which is characterized by pain.^[37-39] The unpredictable nature of dental emergencies, such as tooth decay or trauma, drives this demand-driven approach, requiring dental professionals to provide treatment on an as-needed basis rather than adhering to a fixed schedule. This approach ensures timely intervention, preventing further complications and addressing patient-specific needs.

The use of a combination of radiographic and non-radiographic methods for working length determination was common among participants, aligning with the American Association of Endodontists' recommendation,^[40] but differs from a previous study that reported radiographic method as more common.^[13] The approach of combining radiographic and non-radiographic methods enables clinicians to harness the strengths of both methods, ensuring accuracy and reliability.^[5,11] Radiographic methods provide a two-dimensional representation of the tooth, aiding in working length estimation, but may be limited by distortion and difficulty visualizing the apical constriction.^[8] It is also technique sensitive and exposes patients to radiation.^[9] In contrast, non-radiographic methods like digital tactile sensation and electronic apex locators offer high accuracy, reliability, and minimal invasiveness.^[2,8,41] These methods can also reduce the need for radiographs^[8,18,19,41] and provide precise measurements while minimizing human error. The paper point method is simple and inexpensive; but may be less accurate than other methods. By combining these methods, clinicians can optimize working length determination and improve treatment

outcomes.^[5,11,21]

Among radiographic techniques, the Grossman formula method followed Ingle's method were the most commonly used, deviating from previous reports that identified Ingle's method as the most widely used radiographic technique.^[1,6,14]

This discrepancy may be attributed to various factors, such as differences in study populations, geographic locations, or updates in clinical practices and guidelines. Additionally, the Grossman formula method may have gained popularity due to its ease of use, accuracy, or adaptability to digital radiography. The shift towards the Grossman formula method could also be influenced by educational programmes, workshops, or professional training that emphasize its benefits. Furthermore, the availability of digital tools and software may have increased the convenience and accessibility of the Grossman formula method, contributing to its higher adoption rate in this study.

The adoption rate of endodontic apex locators is alarmingly low at 27.0%, despite their benefits of improved accuracy and reduced X-ray exposure.^[8,41] The main obstacles to adoption are lack of experience and high cost. Notably, most participants prefer digital tactile sensation as their non-radiographic technique of choice, likely due to the limited availability and high cost of electronic apex locators. The cost factor is a significant barrier, limiting access to these devices, particularly in resource-constrained settings or for private practitioners with limited budgets. The high upfront cost, combined with expenses for replacement parts, maintenance, and training, may lead clinicians to opt for less accurate but more affordable methods like digital tactile sensation. To increase adoption, addressing the cost barrier through financing options, subsidies, or more affordable devices may be necessary, in addition to education and training programs.

The evolution of electronic apex locators has transformed working length determination in endodontics, with each generation offering more advantages.^[3,23-25] However, there is a disconnect between familiarity and current usage of apex locator generations. While respondents are most familiar with 2nd and 3rd generation apex locators, more than half are uncertain about the generation currently used in their practice. This lack of awareness may indicate inadequate

exposure or training on newer technologies, reluctance to adopt new technologies without proper education and support, and potential issues with continuing education in endodontics. Notably, only a few respondents reported using 5th generation apex locators, which are the most accurate and reliable.^[24] The high percentage of uncertainty raises concerns about the accuracy and reliability of working length determinations, highlighting the need for comprehensive education and training programs to ensure clinicians are proficient in using the latest technologies effectively.

The sociodemographic characteristics that predict technique selection in this study are gender and years of practice. Female clinicians may prefer non-radiographic techniques due to concerns about radiation exposure and reproductive health. Clinicians should be aware of potential biases in technique selection and consider individualized approaches based on patient needs and clinician preferences.

Conclusion:

The study reveals a diverse range of techniques used for working length determination in root canal treatment, with a preference for a combination of radiographic and non-radiographic methods. The majority of participants use digital tactile sensation, and various radiographic techniques in working length determination. The use of endodontic apex locators is limited, with cost and lack of experience being significant barriers. The benefits of apex locators, including reduced X-ray exposure and improved accuracy, are widely recognized. Gender and clinician experience may influence the choice of technique.

Recommendations:

1. Increase adoption of endodontic apex locators by addressing cost and user experience issues.
2. Provide education and training on the use of apex locators to overcome inexperience.
3. Encourage the use of non-radiographic techniques to reduce X-ray exposure.
4. Develop strategies to address gender and experience-based disparities in technique selection.
5. Conduct further research to explore the effectiveness of different techniques in various clinical settings.

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