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Clinicians' perspectives, inducements, preferences, and clinical experiences regarding the use of electronic apex locator and apex locator integrated engine-driven instrumentation: a cross-sectional study

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Abstract

Background This study aimed to investigate the perspectives, preferences, and clinical experiences regarding using electronic apex locator and apex locator integrated instrumentation of dentists and endodontists.

Methods A web-based questionnaire consisting of 3 parts and 23 closed-ended questions to achieve the objective of the study was carried out in ethical conditions between August and October 2023. The first part of survey included demographic information, while the second part was about evaluating electronic apex locator usage. In the last part, only participants' use of apex locator-integrated instrumentation was evaluated. Data were analyzed at a significance level of $p < 0.05$.

Results A total of 297 clinicians, including 59 endodontists and 34 endodontic residents/Ph.D. students participated in the questionnaire. Endodontists and endodontic residents/Ph.D. students perform statistically significantly more root canal treatments per week on average ($p = 0.001$). For the working length determination method (multiple option question), 78.5% of participants use an electronic apex locator and 39.7% apex locator-integrated engines. However, the preference rate for electronic apex determination technique was generally 95.6%, with the full rate confirmation of endodontists and endodontic residents/Ph.D. students (100%). A total of 21 endodontists out of 59 prefer apex locator integrated engine-driven instrumentation. Although many of these specialized clinicians use this technique, they stated that they measure electronic working length passively for confirmation of the working length before (90.5%) and after the preparation (66.7%).

Conclusions Dentists, as well as endodontists, are skeptical about apex locator-integrated engine-driven instrumentation. Using this technique as a supporter rather than a primary way for preparation within safe limits may give safer results in terms of treatment outcomes.

Keywords Apex locator, Engine-driven instrumentation, Endodontics, Integrated apex locator, Instrumentation

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Introduction

Engine-driven endodontics has been indispensable and efficient for clinicians in daily endodontic practice [1–3]. With the development of technology, various motion modes, a variety of metallurgy, and many brandmark products, in addition to different engine-driven motors, have been produced on the market [2, 4–6]. The enhancements in the field of endodontics for instruments and devices accompany the intention of natural tissue preservation for minimally invasive endodontics [7].

Clinicians agree that a significant biological goal of endodontics is to address pulpal and periapical pathology by disinfection and ensuing hermetically sealing of root canal systems [7, 8]. However, while there seems to be a principal consensus on root canal shaping, there are many possible variations of preparation outcomes, as evident in radiological appearance and clinical prognosis. Moreover, considerable disagreement exists over how the shaping of root canals should be performed in daily clinical practice, as well as working length limits [7, 9–11]. Accurately determining working length and instrumentation within safe apical limits may affect treatment outcomes [12–14]. Several methods are used to determine working length: finger sensitivity, the paper point control method, the radiographic method, and the electronic apex locator [15]. In clinical practice, the radiographic method and electronic apex locator are commonly used [16]. However, radiographic methods have limitations such as image distortion, patient exposure to radiation, and superposition with anatomical structures. There are also some limitations to determining the working length with an electronic apex locator. With this technique, the rubber stop may be incorrectly placed or moved during shaping, irrigation solutions or existing metallic restorations in the canal may affect the measurement, and reliable measurement may be difficult in teeth with open apexes, leading to procedural errors [15–17].

Recently, engine-driven endodontic motors with integrated apex locators have received attention due to the possibility of making root canal preparation much safer [5, 18]. While limitations have been presented with working length determination and shaping procedures, it is essential to be aware of the proper use and aright track of the real-time measurement in monitoring the anatomical limits during preparation with apex locator-integrated root canal instrumentation.

The working length can be observed while shaping the root canal with engine-driven endodontic motors and integrated apex locators. With these devices, the working length is monitored throughout the shaping process, aiming to enhance the efficiency of endodontic procedures [19]. These devices ensure continuous monitoring and maintenance of the apical limit while controlling torque and speed during root canal mechanical instrumentation [20]. When the file tip reaches the apical foramen, various functions provided by the device, such as apical reverse, apical stop, and apical slow down, can prevent over-instrumentation and, consequently, post-operative pain [17, 21]. However, there always may be disadvantages as well as advantages. Among various device movements, 'Apical stop' halts the movement immediately upon reaching the apical limit and can cause the file to clench in the dentin, leading to stress for clinicians [21].

The motivation of this study was any in vitro study conducted under specific directions for standardization is not as guiding as user comments in determining clinical techniques, which include many variational parameters. Questionnaire-based studies conducted in Türkiye have generally evaluated clinicians' approaches to endodontic treatment procedures [22, 23]. There is a lack of detailed survey studies regarding determining working length and using integrated motors. This study aimed to investigate the perspectives, inducements, preferences, and clinical experiences regarding the use of electronic apex locators and apex locator-integrated instrumentation by dentists and endodontists.

The null hypotheses in this study were created as follows:

> H_1: The electronic apex locator is the most preferred method for determining working length.
> H2: Using an integrated apex locator, one of the current devices, is common among clinicians.
> H3: Endodontists prefer integrated apex locators in their clinical practice.

Methods

Determining the number of participants and ethical considerations

The Raosoft web-based sample size calculation module (http://www.raosoft.com/samplesize.html) was employed to determine the requisite sample size. It was found that 248 patients would provide reliable results with a margin of error of 5.20%, a confidence level of 90%, a population size of 20,000, and a response distribution of 50% [24]. Ethics committee approval for the study was obtained from the local Non-Interventional Ethics Committee with protocol number 2023/190. The study was conducted in accordance with the STROBE of the cross-sectional studies protocol. A statement of written informed consent for participation was obtained from all participants, and participants consented to their inclusion in the study by completing their online submission.

Quantitative study setting

The survey form was created via Google Forms. The questionnaire consists of 3 parts and 23 closed-ended questions in total. The first part consisted of 4 questions about the demographic information of the participants, including age, the date of graduation, and the workplaces where the participants are employed. The second part, consisting of 8 questions, was about evaluating electronic apex locator usage. In this part, the method of determining the working length, the stages of using the apex locator, the use of periapical radiography, and the use of the integrated apex locator were questioned (Table 1). For participants who do not use the integrated apex locator, the survey ended at question 12. The last part, consisting of 11 questions, was only about evaluating the use of the integrated apex locator. In this part, questions such as various cases in which the integrated apex locator was preferred, working length monitorization during instrumentation, compliance with passive measurement and postoperative conditions, and combination with which kinematics and ease of use were questioned (Table 2).

Quantitative data collection

An online questionnaire was created for dentists, endodontists, endodontic residents, Ph.D. students, pediatric dentists, and residents/Ph.D. students in Türkiye. This study was structured as an online, cross-sectional survey with participants' identities anonymized. The

Table 1 Questionnaire 2- evaluation of electronic apex locator device usage

	Frequency	%
Number of root canal treatments performed per week		
1–2	40	13.5
3–5	61	20.5
6–10	82	27.6
> 10	114	38.4
The preference of working length determination technique (~)		
Electronic apex locator	233	78.5
Apex locator integrated-endomotor	118	39.7
Panoramic radiography	17	5.7
Paper point	22	7.4
Finger sensitivity	61	20.5
Periapical radiography	179	60.3
The preference for electronic working length determination		
Yes	284	95.6
No	13	4.4
In addition to using an apex locator, the stage/stages of taking periapical radiographs (~)		
Postoperative	183	64.2
Determining the working length	85	29.8
Gutta-percha confirmation	205	71.9
I do not take periapical radiographs	31	10.9
Pre-operative	83	29.1
During root canal treatment, the stage/stages of additional measurements with an apex locator (~)		
Before obturation	76	26.7
After extirpation	145	50.9
After the access cavity preparation	153	53.7
After coronal enlargement	101	35.4
The file type used for electronic working length determination with the apex locator device		
Hand file	242	84.9
Engine-driven nickel-titanium	43	15.1
Do you perform kinematic (with the apex locator cable attached) shaping with your integrated apex locator motor?		
Yes	131	46
No (survey ends)	154	54

~ Multiple answers

Table 2 Questionnaire 3- evaluation of apex locator-integrated engine-driven instrumentation usage

	Frequency	%
In which cases do you prefer to use an apex locator-integrated engine-driven instrumentation more often? (~)		
Multi-rooted teeth	15	11.5
Narrow/calcified canals	12	9.2
Wide canals	12	9.2
I use it routinely in every case	106	80.9
Retreatment cases	13	9.9
Single-rooted teeth	10	7.6
Do you perform passive measurements before instrumentation to determine the working length, in addition to using an apex locator-integrated engine-driven endomotor?		
Yes	99	75.6
No	32	24.4
Do you experience any discrepancies when performing the main cone gutta-percha fit on teeth instrumented with an apex locator-integrated engine-driven endomotor?		
Gutta-percha is extruding apically	13	9.9
Gutta-percha is short	24	18.3
The gutta-percha cones fit properly	94	71.8
How do you monitor the working length during apex locator-integrated engine-driven instrumentation?		
I listen to the device's sound	29	22.1
I follow the device's indicator	79	60.3
I follow the reference point of the rotary file	23	17.6
Do you find the indicator of the integrated device matching the reference point that you set according to the initial working length measurement during preparation?		
Yes	114	87
No	17	13
Have you observed any change in postoperative pain in your patients when using an apex locator-integrated engine-driven instrumentation?		
Yes, postoperative pain has increased	1	0.8
Yes, postoperative pain has decreased	41	31.3
No, I haven't noticed any difference	89	67.9
Have you observed any change in postoperative flare-ups in your patients when using an apex locator-integrated engine-driven instrumentation?		
Yes, postoperative flare-up has increased	1	0.8
Yes, postoperative flare-up has decreased	32	24.4
No, I haven't noticed any difference	98	74.8
Which kinematics do you prefer for the apex locator-integrated engine-driven mode?		
Reciprocation- Rotation	58	44.3
Reciprocation	19	14.5
Rotation	54	41.2
Rate the difficulty of monitoring working length for rotation kinematics when preparing in integrated mode. (0-very easy, 5-very difficult)	Figure 2	
Rate the difficulty of monitoring working length for reciprocation kinematics when preparing in integrated mode. (0-very easy, 5-very difficult)		

~ Multiple answers

link was sent to the participants via e-mail and various social media platforms (WhatsApp, Instagram, Facebook groups) between August and October 2023. In the form, brief information about the questionnaire was given at the beginning, and a button containing the survey that those who wanted to participate could click on was added. The participants were able to quit at any time without completing the questionnaire. Any personal data were requested for impartial data collection.

Quantitative data analysis

Data were analyzed in IBM SPSS V23. Yates correction, Fisher-Freeman-Halton test, Fisher's Exact test, and Pearson Chi-Square test were used to compare categorical data, and multiple comparisons were examined with the Bonferroni Corrected Z test. Analysis results were presented as frequency (percentage) for categorical variables. The significance level was taken as $p < 0.05$.

Results

Questionnaire 1. Demographic data set

Two hundred ninety-seven clinicians who performed root canal treatment in their clinical practice participated in the study. 65.3% of the participants were women and 34.7% were men. Detailed demographic data distributions of the participants are presented in Fig. 1. It was observed that 52% of the participants' workplaces were university hospitals. More than half of the participants were between 20 and 30. More than half of the participants had at least ten years of clinical experience, and 19.9% were endodontists who work in various workplaces.

Questionnaire 2. Evaluation of electronic apex locator device usage

Table 1 presents the responses of the participants to the second part of the survey. In a given week, the distribution of root canal treatments performed by participants is as follows: 13.5% perform 1–2 treatments, 20.5% perform 3–5 treatments, 27.6% perform 6–10 treatments, and 38.4% perform more than 10 treatments. Endodontists and endodontic residents/Ph.D. students perform statistically significantly more root canal treatments per week on average ($p = 0.001$) (Table 3). For the working length determination method (multiple options), a large majority of participants, 78.5%, use an electronic apex locator device, 39.7% apex locator-integrated endomotor, 60.3% periapical radiography, 5.7% panoramic radiography, 7.4% paper point and 20.5% use finger sensitivity. However, in general, the rate of using the electronic apex determination technique was 95.6%, with the full rate confirmation of endodontists and endodontic residents/Ph.D. students (100%). 20.5% of the participants preferred the combination of 'periapical radiography and electronic apex locator device. Most of the participants who did not use the electronic apex locator were dentists working in public hospitals, regardless of the title ($p < 0.001$) (Table 3), and some of them added comments to the optional open-ended comment section in the survey, not because they did not prefer it, but because it was not available in their clinics. Most participants preferred electronic measurement after access cavity

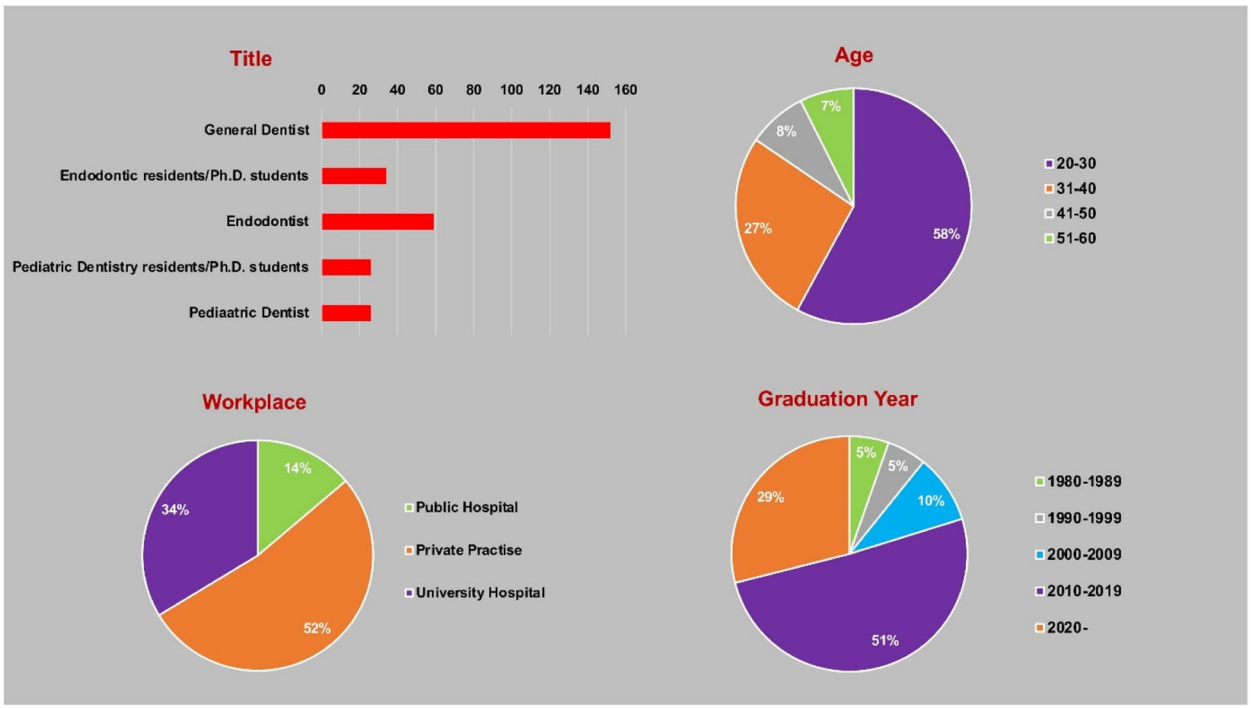

Fig. 1 Detailed demographic data distributions of the participants

Table 3 Comparison of categorical variables of Questionnaire 1

						Test statistics	*p*
	Number of root canal treatments performed per week						
	1–2	**3–5**	**6–10**	**> 10**			
Workplace							
Public Hospital	5 (12.2)	6 (14.6)	11 (26.8)	19 (46.3)		8.704	0.191*
Private Practise	15 (9.6)	35 (22.4)	49 (31.4)	57 (36.5)			
University Hospital	20 (20)	20 (20)	22 (22)	38 (38)			
Title							
General Dentist	22 (14.5)[abc]	32 (21.1)[ab]	55 (36.2)	43 (28.3)[a]		80.141	**0.001****
Endodontic residents/Ph.D. students	0 (0)[c]	0 (0)[c]	7 (20.6)	27 (79.4)[b]			
Endodontist	3 (5.1)[bc]	9 (15.3)[bc]	11 (18.6)	36 (61)[b]			
Pediatric Dentistry residents/Ph.D. students	9 (34.6)[a]	12 (46.2)[a]	4 (15.4)	1 (3.8)[a]			
Pediatric Dentist	6 (23.1)[ab]	8 (30.8)[ab]	5 (19.2)	7 (26.9)[a]			
Working length determination preference (~)	**Graduation year**						
	1980–1989	1990–1999	2000–2009	2010–2019	2020-		
Electronic apex locator	13 (81.3)	15 (93.8)	24 (85.7)	117 (77.5)	64 (74.4)	28.024	0.259*
Apex locator integrated-endomotor	4 (25)	3 (18.8)	9 (32.1)	70 (46.4)	32 (37.2)		
Panoramic radiography	3 (18.8)	2 (12.5)	0 (0)	8 (5.3)	4 (4.7)		
Paper point	1 (6.3)	0 (0)	2 (7.1)	13 (8.6)	6 (7)		
Finger sensitivity	4 (25)	4 (25)	6 (21.4)	30 (19.9)	17 (19.8)		
Periapical radiography	7 (43.8)	9 (56.3)	21 (75)	94 (62.3)	48 (55.8)		
Electronic working length determination preference							
		Yes		No			
Year of graduation							
1980–1989		16 (100)		0 (0)		2.241	0.630*
1990–1999		16 (100)		0 (0)			
2000–2009		28 (100)		0 (0)			
2010–2019		144 (95.4)		7 (4,.)			
2020-		80 (93)		6 (7)			
Workplace							
Public Hospital		31 (75.6)[a]		10 (24.4)		27.711	**< 0.001***
Private Practise		154 (98.7)[b]		2 (1.3)			
University Hospital		99 (99)[b]		1 (1)			
Title							
General Dentist		141 (92.8)		11 (7.2)		6.48	0.104*
Endodontic residents/Ph.D. students		34 (100)		0 (0)			
Endodontist		59 (100)		0 (0)			
Pediatric Dentistry residents/Ph.D. students		25 (96.2)		1 (3.8)			
Pediatric Dentist		25 (96.2)		1 (3.8)			

* Pearson Chi-Square test

** Fisher-Freeman-Halton test

~ Multiple answers

[a-c] No difference exists between groups with the same letter

preparation or pulp tissue extirpation. Besides, a significant number of them stated that they confirmed the length with an electronic measurement before obturation. The results show that hand files were used to determine the working length.

Questionnaire 3. Apex Locator-integrated engine-driven instrumentation preference

General evaluation

One hundred thirty-one (46%) of 297 participants were included in the third part of the survey because of stating the use of apex locator-integrated engine-driven

instrumentation. Of these, 80.9% stated that they use apex locator-integrated engine-driven instrumentation routinely in every case. In addition to using apex locator-integrated engine-driven instrumentation, the rate of those who determined the working length passively was 78.6%. 60.3% of the participants who use apex locator-integrated engine-driven instrumentation have monitored the limits by the device's screen indicator. Most of the participants reported that the initial working length was compatible with the device indicators during the instrumentation (87%), and master gutta-percha cones were properly fit after the apex locator-integrated engine-driven instrumentation (72.8%). Table 2 presents the responses of the participants to the third part of the survey. Figure 2 presented the kinematic preference of the participants who use apex locator-integrated engine-driven instrumentation and the responses about the difficulty levels of motions. Table 4 presents the statistical comparison of categorical variables according to the apex locator integrated engine-driven instrumentation preference.

Endodontist spesific evaluation

Figure 3 presents the endodontist-specific comparison of categorical variables according to the apex locator integrated engine-driven instrumentation preference. A total of 21 endodontists out of 59 prefer apex locator integrated engine-driven instrumentation. Besides, 16 (76.2%) of them informed that they routinely use for every case. Although many of these specialized clinicians use this technique, they stated that they measure electronic working length passively for confirmation of the working length before (90.5%) and after the preparation (66.7%). Although no clear difference was observed between the distributions, it was observed that endodontists evaluated the use of the rotation technique as easier than reciprocation.

Discussion

Basically, this study aimed to assess the dentists' perspective and clinical experience concerning apex locator-integrated engine-driven instrumentation. The null hypotheses determined in this study were partially accepted based on the statistical analysis performed. To the best of our knowledge, no study has evaluated the clinical feedback from the viewpoint of integrated devices. In this context, the general results showed a heterogeneity of issues regarding how to use. This is due to a lack of comprehensive evidence regarding apex locator integrated engine-driven instrumentation, as well as the devices and techniques. There is no consensus on the limits of this integrated technique and no guidelines for its usage. Hence, El Ayouti et al. emphasized this gap in

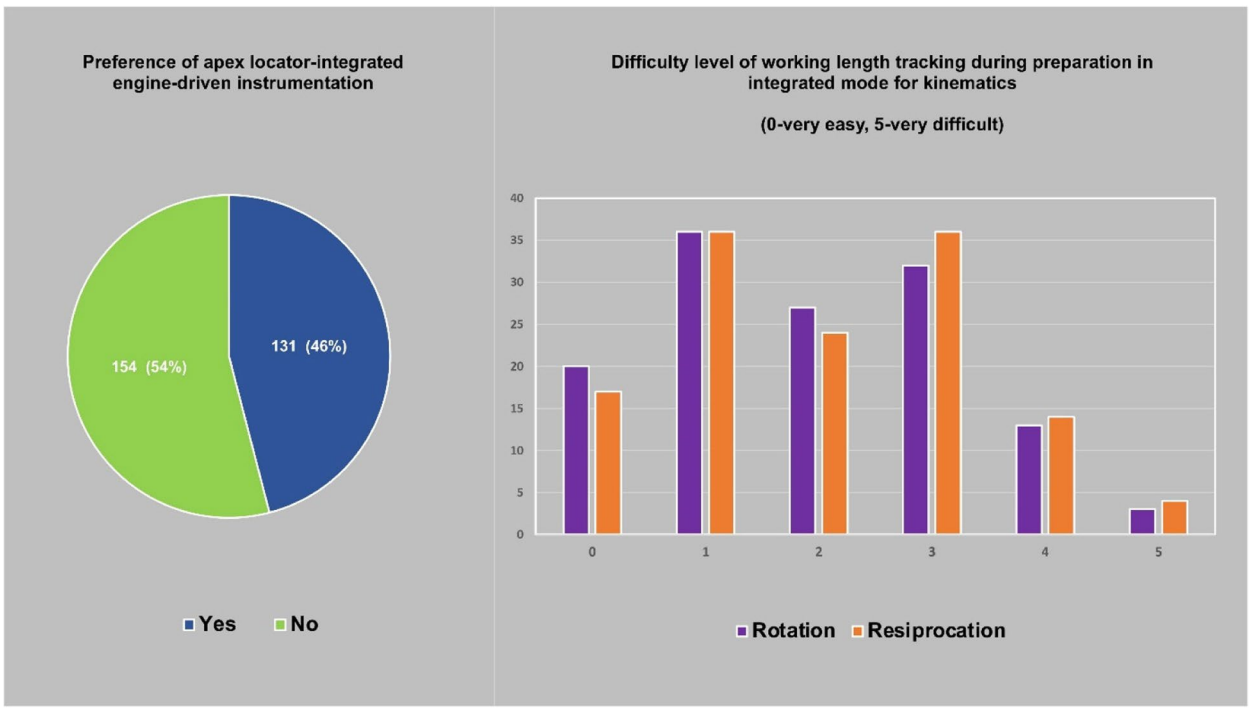

Fig. 2 Kinematic preference of the participants who use apex locator-integrated engine-driven instrumentation and the responses about the difficulty levels of motions

Table 4 Comparison of categorical variables according to the apex locator integrated engine-driven instrumentation preference

			Test statistics	*p**
Apex locator-integrated engine-driven instrumentation preference				
	Yes	No		
Year of graduation				
1980–1989	7 (43.8)	9 (56.3)	3.565	0.468
1990–1999	6 (37.5)	10 (62.5)		
2000–2009	10 (35.7)	18 (64.3)		
2010–2019	74 (51)	71 (49)		
2020-	34 (42.5)	46 (57.5)		
Workplace				
Public Hospital	21 (65.6)	11 (34.4)	5.682	0.058
Private Practise	68 (44.2)	86 (55.8)		
University Hospital	42 (42.4)	57 (57.6)		
Title				
General Dentist	73 (51.4)	69 (48.6)	8.807	0.066
Endodontic residents/Ph.D. students	11 (32.4)	23 (67.6)		
Endodontist	21 (35.6)	38 (64.4)		
Pediatric Dentistry residents/Ph.D. students	15 (60)	10 (40)		
Pediatric Dentist	11 (44)	14 (56)		
Do you experience any discrepancies when performing the main cone gutta-percha fit on teeth instrumented with an apex locator-integrated engine-driven endomotor?				
	Extrude	Short		
Do you perform passive measurements before instrumentation to determine the working length, in addition to using an apex locator-integrated engine-driven?				
Yes	8 (29.6)	19 (70.4)	–-	0.275*
No	5 (50)	5 (50)		
Do you perform passive measurements after instrumentation to determine the working length, in addition to using an integrated apex locator?				
Yes	8 (42.1)	11 (57.9)	0.323	0.570**
No	5 (27.8)	13 (72.2)		
Which kinematics do you prefer for the apex locator-integrated engine-driven mode?				
Reciprocation-Rotation	6 (33.3)	12 (66.7)	0.839	0.804***
Reciprocation	3 (50)	3 (50)		
Rotation	4 (30.8)	9 (69.2)		

* Fisher's Exact test

** Yates Correction

*** Fisher-Freeman-Halton test

the literature and highlighted the need for evidence on the subject [25].

Despite a better understanding of the etiology of root canal-related pathologies and significant technological advances in recent years, the standard of endodontic treatment may be lower than ideal. There is evidence that many clinicians are not fully qualified theoretically and practically related to the factors affecting the root canal treatment's prognosis, and some do not comply with the principles of evidence-based best practice [26]. Clinicians specializing in endodontics provide a valuable health service. Still, the increasing patient population and the increasing perception of preventive medicine from the perspective of both healthcare providers and patients create a worldwide restriction regarding accessibility to endodontic treatment providers [27]. According to a survey conducted in the United States, it was reported that 16% of the participants did not perform any endodontic treatment, and almost half of those who did refer multi-rooted, especially molar teeth treatments, to a specialist [28]. According to a study conducted in the Kingdom of Saudi Arabia, it was reported that 40% of dentists did not perform endodontic treatments at all, and the majority did not perform the treatment of teeth

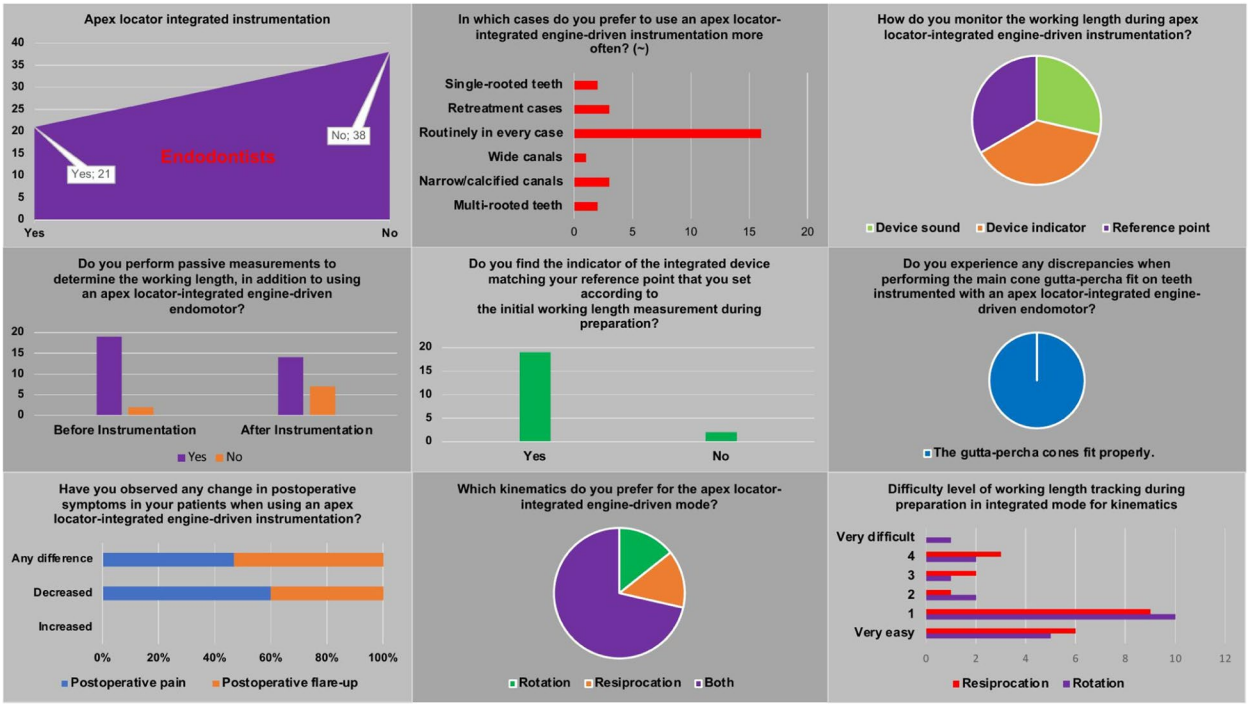

Fig. 3 Endodontist-specific comparison of categorical variables according to the apex locator integrated engine-driven instrumentation preference

requiring endodontic treatment, except for single-rooted anterior teeth [29]. In this study, clinicians who never perform root canal treatment were not included due to not being the target population. However, the results align with previous studies on general dentists' average weekly treatment numbers other than endodontists and endodontic residents/Ph.D. students. The undergraduate education may be the primary reason for the observed phenomenon [30]. Performing optimal root canal treatment requires experience over time. Dissatisfaction with clinical experience resulting from complicated and unsuccessful root canal treatments may discourage general dentists from addressing more complex cases.

Determining accurate working length is a fundamental step for successful root canal treatment prognosis; the epidemiological and histological evidence suggested minimal wound healing after removing irreversibly damaged tissue, and contact between obturation material and periapical tissue produces optimal healing [11, 13, 31]. The European Society of Endodontology (ESE) commits to electronic working length determination followed by confirmation of the length with a periapical radiograph during root canal treatment [32]. The results of this study, which has a heterogeneous participant portfolio, mostly general dentists, in terms of various years of experience, showed that there is not much doubt about determining the working length with the most appropriate technique. The response distribution of overall participants' working length determination preferences correlates with worldwide endodontists and endodontic post-graduate students [33].

There are several studies in the literature regarding working length determination. A survey from Türkiye (2012) reported that using electronic apex locators rate was 12.8% [34]. Topkara et al. reported that the usage rate of electronic apex locators for determining the working length was 69% in a study from Türkiye in 2017 [23]. The difference may be due to the target audience, or it may be due to adaptation to new technology over time. In this study, the usage rate of the electronic apex locator was found to be higher. The change may be because clinicians are better adapted to the devices with updated licenses and clinical training over time. According to the results of this study, all endodontists use electronic apex locators. These results were consistent with those recently reported by Kurnaz and Kiraz [35]. However, Topkara et al. reported that the usage rate of apex locator-integrated engines for determining the working length was 32.4% [23]. According to this recent survey, 46% of all participants used apex locator-integrated engine-driven instrumentation. The authors believe the low use rate of integrated engines compared with the use of apex locator devices may be interpreted as the lack of scientific evidence regarding usage

techniques and post-treatment outcomes for changing clinical habits.

Accurate root canal working length is a dynamic concept during root canal treatment. The size of the working length may be reduced, especially for curved root canals; thereby, venturing control of the apical limits during instrumentation is crucial [5, 36]. Preflaring is also recommended as an essential step during mechanical instrumentation of the root canal, not only because it improves the access of the files to the canal but also because it allows one to obtain more accurate electronic determinations of working length [37]. In general, it can be understood from the results that clinicians who perform root canal treatment are not primarily aware of this situation. A large majority stated that they perform electronic measurements after preparing the entrance cavity or pulp extirpation. However, there is a difference in the responses on this point by endodontists and those trained in the field of endodontics. The endodontists and the endodontic residents/Ph.D. students unanimously responded to using an electronic apex locator device, besides the majority performing measurements after coronal preflaring initially or additional, as well as confirming before the obturation.

Since engine-driven technology began to develop in the history of endodontics [3], the need to conserve apical limits and control the tactile sense [38] had led to the idea of the combined use of devices. In 1997, the first apex locator-integrated engine-driven device was introduced by Kobayashi et al. [39]. Campbell et al. evaluated the effects of this device operating at different limits on an apical extent [40]. Unfortunately, the in vitro results pointed out that the construction was frequently enlarged [40], although the apex locator in the component was the gold standard for passive measurements [6, 41–44]. Studies conducted since then have reported similar results [5, 18, 45].

Endodontics is a constantly moving field regarding materials and devices, and the reflection of current tools into clinical daily practice is relatively rapid [46]. Although the use of electronic apex locator devices and engine-driven nickel-titanium is widespread in the daily endodontic clinical approach, it is clear that users have doubts about the combined use of these tools. Apex locator integrated engine-driven instrumentation, used to stay within the safe operating range, was mostly expressed with satisfaction based on the answers concerning gutta-percha fit, postoperative pain and flare-up, and initial reference point match. However, when the results of this study are evaluated both in general and by endodontists specifically, data emphasized that the majority of dentists do not prefer apex locator-integrated engine-driven instrumentation. Besides, evaluated by users, it was seen that they need re-confirmation at different stages. Therefore, no correlation could be established regarding the postoperative outcome regarding apex locator-integrated instrumentation. However, even if working length confirmation was achieved in the various stages, participants were informed of inconsistent results concerning observation in terms of short or extruded gutta-percha apical fit regardless of the kinematics.

Currently, more than 160 engine-driven instrumentation systems are available, manufactured with various NiTi alloys, using different kinematics such as rotation or reciprocation, centric or eccentric motion [3]. When worldwide user preferences were evaluated, different results without any superiority were observed in terms of kinematic preference [28, 46–50]. Consistent with the previous evidence, the results of this study also showed that the apex locator integrated engine-driven instrumentation kinematic preference was quite similar. However, participants' comments also indicate that integrated use with rotation was more manageable than reciprocation. Previous published studies also suggest that there may be more questionable results in terms of integrated use of reciprocal than rotation [18, 45, 50]. However, there is a lack of evidence as to whether this is due to the difficulty of use or the incompatibility of the kinematic interaction with the device receivers.

There are several limitations to this study. The first is that, even though a sufficient sample size has been reached, the heterogenic participation rate for the sections may be insufficient to reach a clear conclusion. The low frequency of apex locator-integrated engine-driven instrumentation may have prohibited obtaining more detailed information. Thus, although the results are considered to contribute to the literature, more studies with homogenous participation are needed. Since the survey could not be conducted with the same participants at different times due to the lack of e-mail collection, consistency between the answers could not be evaluated at various intervals. Also, only those interested in this topic may have participated in the study, so it is possible that the participants did not fully represent the general population of dentists and endodontists. Additionally, online surveys may not reach all segments of the target population equally, potentially missing those less likely to participate in online studies. Despite the limitations, the authors believe the survey results contribute to the literature.

Conclusions

The majority of participants stated that they used an electronic apex locator to determine working length. Those who could not use it noted that it was unavailable in their workplaces. Providing equipment by workplaces is

essential for clinicians to adapt to technology. In addition, dentists, as well as endodontists, are skeptical about apex locator-integrated engine-driven instrumentation. Using this technique as a supporter rather than a primary way for preparation within safe limits may give safer results in terms of treatment outcomes. More evidence regarding the integrated technique and further device development are still in demand.

Authors' contributions

S.K: data curation; formal analysis; methodology; software; validation; visualization; writing – review & editing. S.K.Ö: data curation; formal analysis; methodology; validation. E.Ş: data curation; methodology. O.Ö: conceptualization; data curation; investigation; methodology; supervision; validation; writing – original draft; writing – review & editing.

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Availability of data and materials

Data availability statement: The data supporting this study's findings are available from the corresponding author upon reasonable request.

Declarations

Ethics approval consent to participate

Ethics committee approval required for the study was obtained from the Kocaeli University Non-Interventional Ethics Committee with project number 2023/190. The study was conducted in accordance with the STROBE of cross-sectional studies protocol, and participants consented to their inclusion in the study by completing their online submission.
All participants were asked to written informed consent to participate in the survey before the questionnaire and agreed to be included in the study by completing their online submission.

Consent for publication

Not applicable.

Competing ınterests

The authors declare no competing interests.

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