Original Article

DOI: 10.7860/JCDR/2025/80248.22106

Dentistry Section

Precision of Working Length Determination of Two Different Apex Locators in Teeth with Periapical Lesion: An In-vivo Study

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ABSTRACT

Introduction: Accurate working length determination is critical for the success of root canal treatment. While Electronic Apex Locators (EALs) have improved accuracy compared to radiographs, their performance can be affected by presence of periapical lesion.

Aim: To evaluate and compare the precision of a fifth generation Integrated apex locator (CanalPro CL2i) with a third generation apex locator (Root ZX Mini) in determining the working length in single-rooted teeth with and without periapical lesion.

Materials and Methods: In the present in-vivo study, 30 single-rooted teeth indicated for root canal treatment, were assigned into two groups. Teeth with absence of periapical lesion (Group 1) consisted of 15 teeth and the periapical lesion group (Group 2) included 15 teeth with presence of radiographic periapical lesion of size 5 mm, approximately. In each canal, CanalPro CL2i and Root ZX mini were used to determine working length. Under local anaesthesia and rubber dam isolation, an access cavity was prepared for each tooth. Electronic working length measurements were determined with a #15k file in the presence of 2.5% Sodium hypochlorite (NaOCl) irrigant. The mean value of working length of both EALs was recorded and evaluated by the independent sample t-test. A p-value of <0.05 was considered significant.

Results: A total of 30 patients were included with mean age of 41.2 years. Out of 30, 18 were female and 12 male patients. Intragroup analyses of mean working length measurements did not show significant differences within both the groups, Group 1 (p=0.987) and Group 2 (p=0.663), when using either Canal Pro CL2i or Root ZX mini.

Conclusion: Presence of periapical lesion had no influence on the precision of both EALs. Both RootZx Mini and Integrated apex locator Canal Pro Cl2i were comparable in precision in determining working length in cases with and without periapical lesion.

Keywords: Electronic apex locator, Integrated endodontic motor, Root ZX mini

INTRODUCTION

The success of endodontic treatment relies on several key factors such as accurate diagnosis, effective treatment planning, proper access cavity preparation, thorough cleaning and shaping of the root canals, and effective obturation. One of the key challenges during a root canal treatment is determining the extent to which the working instruments should be advanced within the root canal, and the precise point at which the preparation and obturation should be terminated [1]. Working length has been defined as "the distance from a coronal reference-point to the point at which canal preparation and obturation should terminate [2]. Proper establishment of working length is essential to avoid over-instrumentation or over-filling of the root canal, which supports the healing of the apical tissues [3].

Determining working length using periapical radiographs can be prone to distortion and may result in an overestimation of the actual working length. EALs provide a more precise and convenient method for determining working length. They can be used multiple times throughout the root canal treatment, thereby minimising patients' exposure to radiation [4]. Accuracy and precision are crucial for EALs. Accuracy refers to the EAL's ability to accurately identify the true endpoint of the canal, while precision indicates the consistency of endpoint measurements for the same canal when using the same EAL in subsequent determinations [4].

Apical Periodontitis (AP) is an infectious condition of the periapical tissues that alters the apical root canal structure through inflammatory resorption, often leading to changes or loss of the apical constriction [5]. Since EALs depend on the integrity of the apical constriction and the presence of the periodontal ligament, such alterations in teeth with periapical lesions can compromise their accuracy and reliability in determining working length [6].

Recent improvements in EALs have significantly enhanced their accuracy and adaptability [7]. The introduction of the Integrated Apex Locator (IAL), which allows the endodontic motor and apex locator to function together, offers notable advantages for working length measurement by shortening chairside time during treatment [8].

A study by Adorno CG et al., in 2021 concluded that the presence of a periapical lesion affected the repeatability of EALs [4]. To the best of our knowledge, no studies have been conducted using Integrated apex locator in teeth with periapical lesion. Hence, the present study aimed to compare the precision of an Integrated Apex locator Canal Pro CL2i, Coltene with Root ZX mini, J Morita in determining the working length in single-rooted teeth with periapical lesion.

MATERIALS AND METHODS

The present cross-sectional study, was conducted in the Department of Conservative Dentistry and Endodontics, Vokkaligara Sangha Dental College, Bangalore, Karnataka, India, from October 2024 to January 2025. Ethical approval for the study was obtained from the Institutional Ethics Committee (KIMS/IEC/A217/D/2024), and the study was prospectively registered under the Clinical Trials Registry of India (CTRI/2024/10/074685). Written informed consent was obtained from all participants prior to enrolment in the study.

Inclusion and Exclusion criteria: The inclusion criteria comprised single-rooted, single canal premolar teeth with straight canals, a

matured root apex, and periapical lesion measuring approximately 5 mm in size. Teeth showing radiographic signs of internal/external resorption, calcified canals, curved canals >30°, immature root apex, mutilated coronal structures, retreatment cases and patients with debilitating diseases were excluded from the study.

Sample size calculation: The sample size for the present study was estimated using GPower software [9] (latest ver. 3.1.9.7; Heinrich-Heine-Universi-ta ̈t Du ̈sseldorf, Du ̈sseldorf, Germany). The sample size estimation was performed at 5% alpha error ($\alpha = 0.05$), with an effect size of 1.10 (Based on the findings from previous study done by Sinha S et al., in 2023) [10] and the power of the study at 80%, revealed that a minimum of 30 samples will be necessary for the study. The sample size was divided into 15 samples each for two groups.

Study Procedure

Thirty patients scheduled for root canal treatment were divided into two groups. group 1 included 15 teeth without any periapical lesion and group 2 included 15 teeth diagnosed with asymptomatic AP, showing a radiographic periapical radiolucency of approximately 5 mm in diameter.

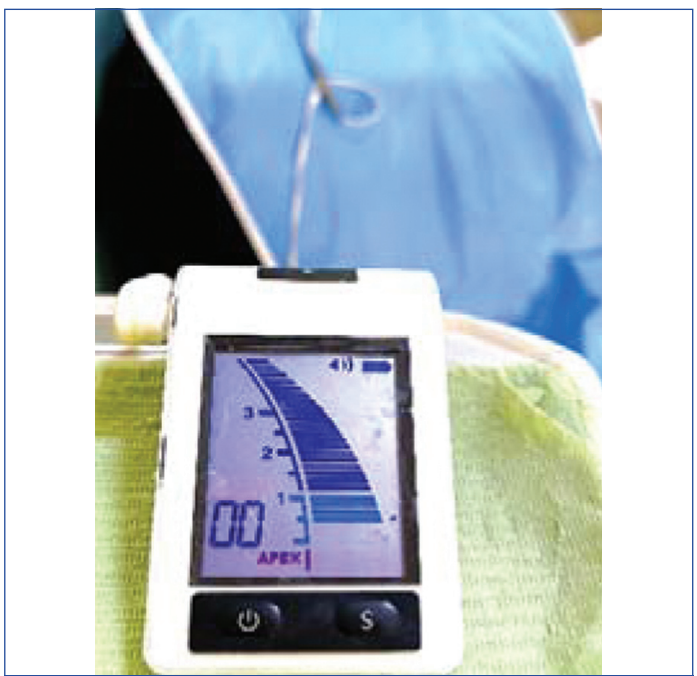
After preoperative radiographic [Table/Fig-1] and clinical examination, the samples that met the inclusion criteria were included for the study. The lesion size was standardised by obtaining intraoral periapical radiograph using parallel cone technique and measuring the horizontal and vertical extent of the lesion on Scanora software [Table/Fig-2].

[Table/Fig-1]: Preoperative radiograph.

[Table/Fig-2]: Measurement of extent of periapical lesion using Scanora software.

Two different operators performed the procedure in each subgroup {CanalPro CL2i (Coltene/Whaledent, Switzerland) and Root ZX mini (J Morita Corp, Tokyo, Japan)}. Both operators performed the procedures independently in each subgroup to minimise operator bias. After administration of local anaesthesia and rubber dam placement, a standard endodontic access cavity was performed. The root canal was irrigated with 2.5% NaOCl and coronal flaring was performed with an Orifice opener (HyFlex CM, Coltene Whaledent, Switzerland). Excess fluid in the pulp chamber was cleared before taking root canal measurements. The patients were subjected to EAL and IAL for working length determination in random sequence and all the patients were subjected to both WL measurements. The working length was measured using both the EAL and the Integrated Apex Locator, and the values were confirmed radiographically with a #15K file (Mani, Inc., Tochigi, Japan). The electronic working length was determined by using the Canal Pro CL2i (in Working Length Mode) and Root ZX mini as per manufacturer's instructions. The file was advanced into the root canal until "0.0" reading displayed for Canal Pro CL2i, along with a solid tone indicating that the apex has been reached [Table/Fig-3]. The file was inserted into the canal until the reading indicated the "apex" red line, then gently withdrawn to the specified green line for Root ZX mini [Table/Fig-4]. After the file was removed from the canal, the working length was measured from the coronal reference point to the apex using a ruler caliper (Dentsply Maillefer) and recorded 0.5mm

[Table/Fig-3]: Canal Pro CL2i displaying 00 reading.



[Table/Fig-4]: Root ZX mini displaying green line.

was subtracted from the value, as the EAL detects the apical foramen and apical constriction is generally located 0.5-1.0 mm short of the apical foramen [11]. Valid measurements were those that remained stable for at least five seconds. Three separate measurements were taken for each tooth, and the average of these measurements was recorded as the electronic working length [5]. The readings of Canal Pro CL2i were recorded as subgroup A and Root Zx mini as subgroup B. The values were recorded and analysed statistically.

STATISTICAL ANALYSIS

Independent student t-test/Mann-Whitney Test (based on data distribution) was used to compare the mean WL between both the EALs. The level of significance (p-value) was set at $p<0.05$. All the analysis was done using Statistical Package for Social Sciences (SPSS) version 26 (Armonk, NY:IBM Corp).

RESULTS

A total of 30 patients were included in the study, with 15 teeth each in groups. The age of participants ranged from 18 to 60 years, with a mean age of 41.2±11.8 years. The sample comprised both male and female patients (18 females and 12 males). Descriptive statistics of working length measurements obtained using Canal Pro CL2i and Root ZX Mini showed close agreement between the two devices in both groups. The mean working length for group 1 was 21.69±2.59 mm with Canal Pro CL2i and 21.71±2.56 mm with Root ZX Mini. In group 2, the mean values were 20.32±2.01 mm and 20.27±1.90 mm, respectively.

Intragroup comparisons were done using Independent sample t-test. A summary of the results is given in [Table/Fig-5], which depicted that intragroup comparison of mean values showed no statistical significance in group 1 (p=0.987) and group 2 (p=0.663) when using either Canal Pro CL2i or Root ZX mini.

Groups	Devices	Mean (mm)	Standard Deviation	p-value
Group 1 Without Lesion	A) Canal Pro Cl2i	21.698	2.59	0.987 NS
	B) Root ZX Mini	21.714	2.56	
Group 2 With lesion	A) Canal Pro Cl2i	20.32	2.01	0.663 NS
	B) Root ZX Mini	20.27	1.90	

[Table/Fig-5]: Intragroup comparisons of mean values in Group 1 and Group 2. NS: Non significant

DISCUSSION

The present study demonstrated that both, integrated apex locator Canal Pro CL2i and Root ZX mini performed comparably, showing no statistically significant difference in determining the working length of single-rooted teeth, irrespective of the presence or absence of a periapical lesion. AP is an infectious condition of periapical tissues originating from the root canal. It causes immune and inflammatory responses, leading to changes in periapical tissues [5]. In such cases involving necrotic teeth with periapical lesions, the apical root canal structure can be significantly altered. The inflammatory root resorption associated with these lesions can lead to changes in the apical constriction, or even the complete absence of it [5]. Additionally, in teeth with periapical lesions, the periodontal ligament may be absent, further complicating the performance of EALs [6]. This can lead to inaccurate apex locator readings, affecting their reliability in determining the correct working length in such teeth [12]. This highlights the impact of periapical lesions on the functionality of apex locators and the need for careful consideration when using these devices in clinical practice.

The Root ZX Mini, a third-generation EAL, is regarded as the gold standard and operates on the "ratio method," utilising dual frequencies and proportional impedance [13]. Designed for portability, it is noted for its reduced sensitivity to intracanal contents [8]. The Root ZX Mini also includes automated calibration, shock resistance, and three programmable memory settings [8]. Its performance, accuracy, and consistency have been reported to be on par with those of the original Root ZX [14]. Advancements in the technology has led to apex locators that have been used in combination with the endomotors to simultaneously determine the WL during root canal instrumentation, for example, CanalPro CL2i endomotor with integrated apex locator [15].

No studies have evaluated and compared the efficacy of Canal Pro CL2i Integrated apex locator in teeth with periapical lesion. Hence, the current study evaluated the precision of Integrated CanalPro CL2i and RootZx Mini in teeth with and without periapical lesion.

The results of the current study revealed that both the EALs had no statistically significant difference in determining working length in single rooted teeth with and without periapical lesion; the results of which are in accordance with the previous studies. In their studies in 1993, Mayeda DL et al., and Frank AL and Torabinejad M concluded that the Endex apex locator showed accurate readings regardless of the presence of periapical lesions or resorption at the root apex [6,16]. Caliskan MK et al., in 2014, evaluated in-vivo the accuracy of two EALs of different generations in teeth with large periapical lesions and persistent intracanal exudate and concluded that both the EALs ProPex and Apex Pointer were comparable [17]. Ravichandra C et al., in 2015 in his study showed that there was no difference in the accuracy among both the EALs (Propex pixi and Root ZX mini) in determining the working length in teeth with and without periapical lesion [18]. In their 2016 study, Ustun Y et al., concluded that for teeth with large periapical lesions and intracanal exudate, Cone Beam Computed Tomography (CBCT) images yielded results similar to those obtained using the Raypex 6 and Propex Pixi apex locator devices, the results of which may be attributed to the use of novel technologies in the EALs, both of which operated using a multiple frequency system for measurements [12]. Bhullar KK et al., in 2022 concluded that in teeth with a large periapical lesion working length determined using CBCT scan was most accurate and reliable as compared to a periapical radiograph and EAL [19]. Whereas, Adorno CG et al., in 2021 showed that electronic working length measurements using Root ZX II and RomiApex A-15 were more repeatable when no periapical lesion was present. This could be because of the presence of apical root resorption caused by the periapical lesion and the type of EAL employed [4]. The strength of this study is the in-vivo evaluation of precision of Integrated apex locator in determining the working length in teeth with periapical lesion.

Limitation(s)

The limitations of the study are the inclusion of teeth with smaller lesion size measuring 5 mm. The results are limited to teeth with straight roots and, therefore, cannot be applicable to teeth with curved canals.

CONCLUSION(S)

The presence of periapical lesion had no influence on the precision of both EALs. Both Root Zx Mini and the integrated apex locator Canal Pro CL2i are comparable in precision in determining working length in cases with and without periapical lesion. Future studies should be done comparing different generations of EALs, in teeth with larger periapical lesions and in multi-rooted teeth.

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PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: May 13, 2025
- Manual Googling: Sep 08, 2025
- iThenticate Software: Sep 18, 2025 (19%)

ETYMOLOGY: Author Origin

EMENDATIONS: 6

AUTHOR DECLARATION:
- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? Yes
- Was informed consent obtained from the subjects involved in the study? Yes
- For any images presented appropriate consent has been obtained from the subjects. Yes

Date of Submission: **Apr 29, 2025**
Date of Peer Review: **Aug 13, 2025**
Date of Acceptance: **Sep 20, 2025**
Date of Publishing: **Dec 01, 2025**