EJPMR, 2025, 12(12), 372-377 **Research Article** **Impact Factor 7.065**

EUROPEAN JOURNAL OF PHARMACEUTICAL AND MEDICAL RESEARCH

www.ejpmr.com

ISSN (O): 2394-3211
ISSN (P): 3051-2573
Coden USA: EJPMAG

ACCURACY OF DIFFERENT ELECTRONIC APEX LOCATORS IN LOCATING ROOT PERFORATIONS IN CURVED CANALS UNDER DRY AND WET CONDITIONS: A COMPARATIVE IN VITRO STUDY

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DOI: https://doi.org/10.5281/zenodo.17812807

How to cite this Article: 1C. Sunil Kumar, 2Chittuluri Harika, 3*Kandimalla Susrutha, 4Vamsee Krishna Nallagatla, 5S. Sunil Kumar, 6K. S. Chandra Babu (2025). Accuracy Of Different Electronic Apex Locators In Locating Root Perforations In Curved Canals Under Dry And Wet Conditions: A Comparative In Vitro Study. European Journal of Pharmaceutical and Medical Research, 12(12), 372–377.

Article Received on 05/11/2025 **Article Revised on 25/11/2025** **Article Published on 01/12/2025**

ABSTRACT

Aim: Aim of the study was to evaluate the accuracy of electronic apex locators in detecting the simulated root perforations in curved canals both in dry and in the presence of 3% sodium hypochlorite (Wet). **Materials AND Methodology:** Thirty mandibular molars with curved mesial roots were selected and perforation was simulated in the danger zone 4 mm from the furcation area. The actual length where the perforation site was created was measured by visual method using a #15 K file and data were recorded, following which teeth were embedded in alginate moulds. The perforation site was electronically measured using three apex locators: E-pex, DentaPort Root ZX (J-Morita), CanalPro (Coltene) in dry condition and in the presence of 3% NaOCl. The values obtained were compared with values obtained by visual method and analysed. **Results:** In the present study, DentaPort Root ZX showed more accurate values between electronic location of perforation (ELP) and actual location of perforation (ALP)(P=0.1) in both dry and wet conditions. There were no significant differences in the readings of ALP and ELP in different canal conditions when each group is compared to other two groups. **Conclusion:** In dry & wet conditions, DentaPort Root ZX group showed better results than E-pex & CanalPro in determining the length of the root perforation. In wet conditions, in the presence of 3% NaOCl, all the apex locators showed a significant difference from the manual value in detecting the root perforation.

KEYWORDS: The values obtained were compared with values obtained by visual method and analysed.

INTRODUCTION

Root perforation is an artificial communication between the root canal system to the supporting tissues of teeth or to the oral cavity.[1] Root perforations, may have serious implications, occur in approximately 3–10% of endodontically treated teeth.[2] It lowers the prognosis of endodontic treatment, and often leads to extraction of the tooth. Ingle et al. have found that the second most common reason for failure associated with endodontic treatment is root perforation. Perforations can occur during operative procedures such as post preparation as well as during endodontic treatment. The frequency of

root perforations has been reported to range from 3% to as high as 10%.[3]

Due to these root perforations, the infection either from the root canal or the periodontal tissues brings about inflammatory sequel which prevents healing. Many factors contribute to the healing of these perforation sites which include time from the perforation detection and its sealing, size, and shape of the perforation as well as its location.[4,5]

A potential detection of these root perforations during endodontic treatment is of utmost importance as it leads to extrusion of irrigation solutions or sealers into the peri-radicular tissues and instrumentation in the periodontal space. There are various methods to detect these perforations such as profuse bleeding from root canal during instrumentation and indirect evaluation of bleeding by paper points, radiographic assessment, and electronic apex locators (EALs).[6]

Radiographs taken at different angulations are an important supplementary aid along with other diagnostic methods in detecting root perforations. Diagnostic value of radiographs is limited in certain situations such as when perforation is located in buccal or palatal aspects of the root, the superimposing anatomical structures, and radiopaque materials.[4] Electronic working length determining devices are excellent adjunct to radiographs in locating apical foramina, root resorptions, and fractures more accurately.[7]

Previously used apex locators were not accurate in the presence of irrigating solutions. whereas the modern generation EALs use two or more different frequencies to calculate the impedance and promise to work even in the presence of irrigating solutions such as saline and sodium hypochlorite (NaOCl) which are most commonly used.[8]

E-pex, DentaPort Root ZX, and CanalPro are modern apex locators. Available literature yielded no studies that have compared the accuracy of these apex locators in determining root perforation in curved canals of molars; therefore, the aim of the present study was to assess the accuracy of E-pex, DentaPort Root ZX (J-Morita), and CanalPro (Coltene) apex locators in detecting simulated root perforations in curved canals in the presence of different irrigating solutions. The null hypothesis of the present study was that there is no difference between the three apex locators in determining the root perforations in different canal conditions when compared to the manual method.

MATERIALS AND METHODOLOGY

For this comparative in vitro study 30 permanent mandibular molars with curved mesial roots (10°–20°) were selected according to the Schneiders method. Teeth were mechanically debrided and disinfected. Following this, the samples were stored in saline till use.

Roots with fractures, calcification, previous root perforations, and root resorption were excluded from the study. Evaluation of the root was thoroughly done by taking radiographic images.

To all the third mandibular molars access cavity preparation was done till complete deroofing of the pulp chamber (fig-1).

Fig 1- Preparation of endodontic access cavity.

Apical patency of mesial canals was checked using #10 K file by introducing it through the access cavity. The canal was instrumented with #15 K file and irrigation with 3% NaOCl and saline was done (fig 2)

Working length is determined using 15k file manually and confirmed using radiograph.

Fig 2- Apical patency with 15 k file.

For the purpose of standardization, perforation of approximately 1.5 mm was made at a distance of 4 mm apical from the furcation area in the mesial roots using a #12 round bur directed perpendicular to the long axis of the root (fig 3)

Fig 3- Artificial perforation made with bur.

A #15 K file was introduced through the access opening, till it reaches the perforation site and can be visualized with naked eye. Working length of perforation site is recorded followed by which 0.5 mm was reduced from this length and was recorded as the actual length of the perforation site (fig 4).

Fig 4: Determination of working length of perforation site using manual method.

The perforated teeth were embedded till the cervical region according to the model developed by Kaufman and Katz in plastic molds that contained freshly mixed alginate teeth were divided into three groups randomly before determining the working length with apex locators.

GROUP-I: DentaPort Root ZX (J Morita)
GROUP-II: CanalPro (Coltene)
GROUP-III: E-pex (Orikam)

A #15 K file was held with the file holder of apex locator and introduced into the root canal through the access opening, with the lip clip placed in contact with the alginate till 0.0 reading was obtained which indicate the file has reached the perforation site (fig 5).

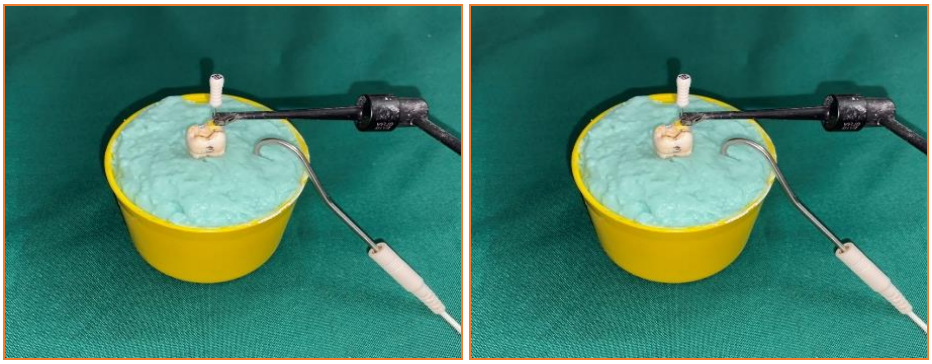

Fig 5- Determination of the location of perforation site using electronic apex locator.

The electronic length of the perforation site (ELP) was recorded with each apex locator in the respective groups after adjusting the rubber stopper and reducing 0.5 mm from the measured length.

RESULTS

In this study, E-pex, DentaPort Root ZX, and CanalPro were used to measure the accuracy of electronic apex locators in determining the location of the perforation site.

In the present study, DentaPort Root ZX showed more accurate values between the electronic location of perforation (ELP) and actual location of perforation (ALP)(P=0.1) in both dry and wet conditions.

In the present study, there were no significant differences in the readings of ALP and ELP in different canal conditions when each group is compared to the other two groups.

In the present study, all apex-locators showed near-accurate results to the actual location of perforation.

DESCRIPTIVE ANALYSIS

	Manual	Dry	Wet
DentaPort Root ZX	11.6±1.41	11.7±1.31	11.55±1.46
CanalPro	11.3±1.29	11.4±1.33	11.2±1.18
E-pex	11.3±1.31	11.5±1.35	11.1±1.3

PAIR COMAPRISON OF ACTUAL LENGTH (MANUAL) WITH THE ELECTRONIC LENGTH

Groups	Apex locators		Mean difference	P value
DentaPort ZX	Manual (11.6±1.41)	Dry (11.7±1.31)	1.00	0.1(NS)
		Wet (11.55±1.46)	0.05	0.1(NS)
CanalPro	Manual (11.3±1.29)	Dry (11.41±1.33)	0.00	1.00(NS)
		Wet (11.2±1.18)	1.00	0.983(NS)
E-pex	Manual (11.3±1.31)	Dry (11.5±1.35)	0.00	1.00(NS)
		Wet (11.1±1.3)	0.05	0.996(NS)

DISCUSSION

An accurate device that locates root canal perforations is an essential contribution to successful treatment. Radiographic detection of root canal perforation has the disadvantage of lacking accuracy in the presence of anatomic structures, and it only provides an image in 2 dimensions.[9,10]

Root canal measurements on preexisting cone-beam computed tomography (CBCT) scans are a potential new method for determining root canal length before initiating endodontic treatment. By taking advantage of all the visual information available in the field of view, clinicians can apply already existing CBCT data toward further interventions in the same region of the jaw, such as root canal treatments.[11] However, Shemesh et al[12], showed that the ability to detect root perforations on the basis of periapical radiographs is very limited, and that even CBCT cannot detect strip perforations in root-filled teeth. The limitations of CBCT in the presence of root canal filling material have already been demonstrated in the detection of root fractures.[13] This limitation of CBCT demonstrates the importance of an immediate diagnosis of root perforation, even during endodontic treatment, for the adoption of the correct treatment to prevent bone destruction and to avoid a poor prognosis.

Several studies have demonstrated that EALs can accurately determine the working length in 75%–97.5% of the root canals with mature apices.[14,15] It has been suggested that EALs can accurately determine the location of the apical foramen, apical constriction, 0.5 mm coronal to the major foramen, and root canal resorptions.[16] In the previous studies evaluating both the determination of working length or root perforation, ±0.5 mm tolerance was clinically accepted. Thus, for perforation diameters <1 mm, it can be said that the success rate of the accuracy of EALs decreases as the perforation diameter gets narrower.[6,17,18] Such large perforations can practically occur iatrogenically while searching for a calcified canal, while using large files or coronal shapers, during postplacement or naturally in cases of resorption.[19]

However, the accuracy and repeatability of the DentaPort Root ZX (J Morita), CanalPro (Coltene), and E-Pex (Orikam) in locating root canal perforations have not yet been tested and reported in the literature.

The teeth with artificially made perforation were kept in alginate models prepared as per Kauffman's method which have been used in several studies. There are several other medias available that can be used as an electroconductive medium such as agar, gelatin, saline, and sponge. However, in this study, alginate was used, as it is a good electroconductive medium that stays around the tooth due to its colloidal gel form and simulates the periodontal condition. In addition to this, it can be easily manipulated and is cost-effective.[20]

Even though EALs are relatively accurate, some of the factors like wet and dry conditions, may affect the efficiency of EAL. But the newer generation apex locators consist of powerful microprocessors and can calculate alogarithms for an accurate result.

In this study Naocl was used to simulate wet conditions, as it was most commonly used endodontic irrigant.[6]

In the present study, DentaPort Root ZX, CanalPro, and E-pex apex locators are used to detect the root perforations both in dry and wet canals (containing Naocl) and compared with the manual visual method, the results are in following manner DentaPort Root ZX showed better results followed by CanalPro and E-pex.

DentaPort Root ZX accuracy remains unaffected by the presence of electrolytes and can be allocated to fact that

the impedance of DentaPort Root ZX is measured at each frequency and the position of file is determined from the ratio between impedances at higher and lower frequencies.[6,21]

Different electrolytes have varied dielectric constants; change in electrolyte material, which is a change in dielectric constant, will influence equally numerator & denominator & hence ratio will remain unaffected.[6,15]

CanalPro (Coltene) showed the next best results after DentaPort Root ZX in the present study, which measures 2 frequencies that are alternated & not mixed, thus making the measurement much more immune to various kinds of electromagnetic noise.[22]

Extrapolating these results to clinical practice, it may be inferred that retaining these irrigating solutions at the perforation site is a challenge, and the material used to mimic the periodontal ligament (PDL) may not provide the same resistance as natural PDL. Therefore, more in vivo studies should be conducted to correlate these results to different clinical conditions.

CONCLUSION

Based on the results obtained and taking into account the limitations of this study, it could be concluded that among all the compared groups: In dry conditions, the DentaPort Root ZX group showed better results than E-pex & CanalPro in determining the location of the root perforation. In wet conditions, in the presence of 3% NaOCl, all the apex locators showed a significant difference from the manual values in detecting the root perforation.

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