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Accuracy of two Electronic Apex Locators in Presence of Sodium Hypochlorite: An In Vitro Study

Rashmi Issar[1*] Shashi Ranjan[2] Pankaj Singh[3] Amitabh Kumar Sinha[4] Md. Tarique Naseem[5] Kunal Kumar[6]

[1]Associate Professor, Department of Conservative Dentistry & Endodontics, Patna Dental College & Hospital, Patna, Bihar, India.
[2]Professor, Department of Oral Pathology, Dr. B.R. Ambedkar Dental College, Patna, Bihar, India.
[3]Clinical Tutor, Department of Conservative Dentistry & Endodontics, Patna Dental College & Hospital, Patna, Bihar, India.
[4]Dental Surgeon, PHC Dandkhora, Katihar, Bihar, India.
[5]Clinical Tutor, Department of Conservative Dentistry & Endodontics, Patna Dental College & Hospital, Patna, Bihar, India.
[6]Clinical Tutor, Department of Orthodontics, Patna Dental College & Hospital, Patna, Bihar, India.

ABSTRACT

Background: A successful root canal treatment has many confounding factors. Amongst them, determination of working length plays a key role. In the present study, we have compared the efficacy of digital IOPA Xray, a third-generation and a fifth-generation apex locator on single-rooted extracted teeth in the presence of sodium hypochlorite. The data obtained were analyzed by the Chi-square test ($p < 0.05$) and the comparative test of Kolmogorov-Smirnov. The comparison of IOPA Xray to both the apex locators was statistically significant, but the comparison between Dentaport ZX and Woodpex III was not statistically insignificant.

Keywords: Apex locator, Impedance, RVG, Working length.

INTRODUCTION

The success rate of root canal treatment can reach up to 90% - 94%, which mandates the knowledge of canal terminus and the limit of the root canal and periodontal tissues. Accurate working length (WL) determination is a crucial factor for successful root canal treatment which reduces the chances of insufficient cleaning of the canals or damage to the periapical tissues from over instrumentation (Sjögren et al., 1990; Ricucci and Langeland, 1998).[1-3]

The working length is defined as the distance from the coronal reference point to the point at which canal preparation and obturation should terminate. The apical constriction marks the transition between the pulpal and periodontal tissue at which the working length should be established. It is mostly located at 0.5-1mm from the major foramen.[4] Radiographic method and electronic apex locator are often used to measure the root canal length. Dental intra oral periapical radiograph has its limitations because of distortion so as to provide a two-dimensional picture of a three- dimensional structure of the tooth with the result that is less representative. The safety and accuracy is also argumentative, because of the radiation exposure and presence of foramen, maxillary sinus and bone patterns. Although no other device is considered a replacement of IOPA Xray.[5] Electronic root canal length measurement device has a more accurate measurement result when compared to IOPA radiograph. Electronic root canal length measurement device is used to determine the position of cementodentinal junction, which is the end of the root canal and the beginning of periodontal tissues. Root canal dentin and cement area insulator to electric currents. Through the minor apical foramen, there lies a connection to the periodontal ligament, which is a conductor for electricity. The basic assumption with all electronic

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*Correspondence Dr. Rashmi Issar.
Department of Conservative Dentistry & Endodontics, Patna Dental College & Hospital, Patna, Bihar, India.
Email: Not Disclosed

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length measuring devices is that human tissues have certain characteristics that can be modelled by a combination of electrical components. Custer (1918) described the first electronic device used for WL determination. Suzuki (1942) studied the use of direct current to measure WL. Sunada (1962) demonstrated that the electrical resistance between the periodontal ligament and the oral mucosa had a constant value of approximately 6.5 kΩ.[6-8]

Modern Electronic Apex Locators (EALs) uses alternating current and detect changes in the impedance of the canal where the impedance is the ratio between the applied voltage and the resulting current in an alternating current electrical circuit (Venturi and Breschi, 2005). Apex locators determine the WL by measuring impedance with different frequencies between the file tip and the canal fluid. New generation devices show more consistent and accurate measurement because it measures the characteristic impedance using more than two frequencies. Plotino et al. (2006) stated that the precision of instruments measuring impedance with five frequencies is near to100% while the device impedance ratio of the two frequencies reached an accuracy of 97.37% .[9-10]

The present study is a comparison of the efficacy of Dentaport ZX a two frequencies impedance ratio device of 4th generation (J. Morita Mfg Corp Kyoto, Japan) and Woodpex III a multiple frequency-based devices of 5th generation (Guilin WoodPecker Medical Instrument Co. Ltd., Guilin, China) in the extracted tooth with sodium hypochlorite used as an irrigant.

MATERIALS AND METHODS

Fifty single-rooted extracted teeth with closed apices, and no defect on the root surface were collected for the study. All teeth were cleaned and stored in normal saline. Access opening was done using Endodontic Access kit (Dentsply Maillefer, Ballaigues, Switzerland). After achieving straight-line access, the canals were negotiated by #10 K file (Dentsply, Maillefer). (Fig. 1a)

The working length was determined by RVG (Vatech EZ RVG, Classic 1.5) for each tooth specimen and recorded 0.5mm short of radiographic apex from a reproducible reference point. (Fig. 1b)

WL would be determined for all the samples by Dentaport ZX (J. Morita Mfg Corp Kyoto, Japan) and by Woodpex III (Guilin WoodPecker Medical Instrument Co. Ltd., Guilin, China). The readings from Dentaport ZX were grouped under Group A, and readings from Woodpex III were grouped under Group B. (Fig. 1c, 1e)

In a plastic container, alginate was poured in to simulate the periodontal tissue. The alginate was mixed according to the manufacturer's instructions and then poured into plastic containers. Each tooth was embedded in the alginate to the level of the cement-enamel junction before it was set and the plastic containers. The circuit was completed by holding the lip clip in hand. The working length measurements were assessed immediately after the alginate was set so that the reading won't be altered by the dryness of the alginate.

The root canals were irrigated by Sodium Hypochlorite (Parcan, 3 % NaCl, Septodont). All the canals were measured using both Dentaport ZX (Group A) and Wooodpex III (Group B) with the recording adjusted at the display showing 0.5mm. (Fig. 1c, 1e) The silicone stopper on the file was carefully positioned, and the file was removed, and WL measured by the use of an endodontic ruler (Dentsply. Maillefer, Switzerland) and the reading was recorded for all canal.

All samples were vertically split and measured the actual length from reference point to apical constriction under 10X magnification of dental operating microscope (CRB International). (Fig. 1d)The measurement results of radiographs, Group A and Group B were subtracted with the measurement results of actual length in order to obtain the value of difference. The positive value showed the measurement was more than the actual length. A negative value showed the measurement was less than the actual length. With reference to the study by Real et al. (2011) the following three categories were divided for the measurements.[11]

1) (−) <0.5 mm (shorter than the actual length of the teeth)

2) (0) ± 0.5 mm (length approaching actual length)

3) (+) > 0.5 mm (longer than the actual length of the teeth)

Statistical Analysis

The data obtained were analyzed with Chi-square test ($p < 0.05$) and the comparative test Kolmogorov-Smirnov.

RESULTS

Distribution of number and percentage of samples measured for radiograph, Group A and Group B can be seen in Table 1, Graph 1.

The determining of the location of the apical constriction on the category (0); Radiograph measurements were only 60% of samples showing ±0.5mm reading, Group A presented as many as 95% out of 50 samples, and Group B had 91% samples.

Table 2 is a statistical analysis using the Kolmogorov-Smirnov test for the three groups: the value of significance-(p) between the two frequencies-based electronic devices and multi frequencies-based is 1.000 ($p > 0.05$). These results illustrate that the two groups did not have a significant difference. As the two groups compared with radiographs, there was a significant difference value.

Table 1: Methods of measurements and its accuracy.

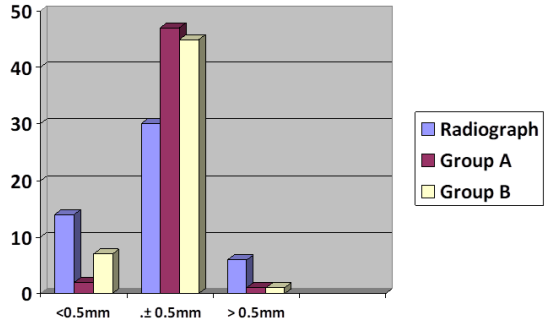
Method of measurement	(-)	(0)	(+)	Total
Radiograph	28% (n=14)	60%(n=30)	12%(n=6)	100% (50)
Dentaport ZX-Gr A	4%(n=2)	95%(n=47)	2%(n=1)	100% (50)
Woodpex III- Gr B	7%(n=4)	91%(n=45)	2%(n=1)	100% (50)

(−) = <0.5 mm from actual length; (0) = ±0.5 mm from actual length; (+) = >0.5 mm from actual length

Table 2: Methods of measurements and comparison.

Method of Measurement	p values
Radiograph vs Group A	0.015*
Radiograph vs Group B	0.021*
Group A vs Group B	1.00

*Significantly different, significance analysis by Kolmogorov-Smirnov test.



Graph 1: Radiograph comparison.

DISCUSSION

Endodontic treatment, due to its increase in demand and treatment costs today needs to be performed with higher efficiency and consistency. To achieve this precision working length becomes the most critical factor. Root canal preparation should terminate at cementodentinal junction or the apical constriction (Ricucci and Langeland, 1998; Gordon and Chandler, 2004). Root canals that are over or underprepared decreases the success rate of endodontic therapy (Seltzer et al., 1973). Several studies (McDonald and Hovland, 1990; Weine, 1996) suggests that reducing 0.5 mm from the radiological root canal length to calculate the WL keeps the preparation of canals within a range at which apical constriction is generally located. [1,2,12-14]

In the present study, the most reliable methods for WL determination were used, i.e. radiographs and apex locator in the presence of 3% NaOCl and their efficacy was compared. Radiographic method of determining the WL is one of the most commonly used methods. However, it has limitations such as distortion, radiation exposure and interpretation variability. One way of minimizing these distortions is by the use of the paralleling technique. However, elongation of images was even found to be present in paralleling cone technique of approximately 5%.

Radiovisiography with CCD or CMOS technology has some advantages over the conventional method, which includes speedier image acquisition, a much lower radiation dose, and image editing ability to clearly study the details. In this study, digital radiography was used (Vatech EZ classic sensor). But the accurate determination of the WL with radiographic method still remains a challenge.[15]

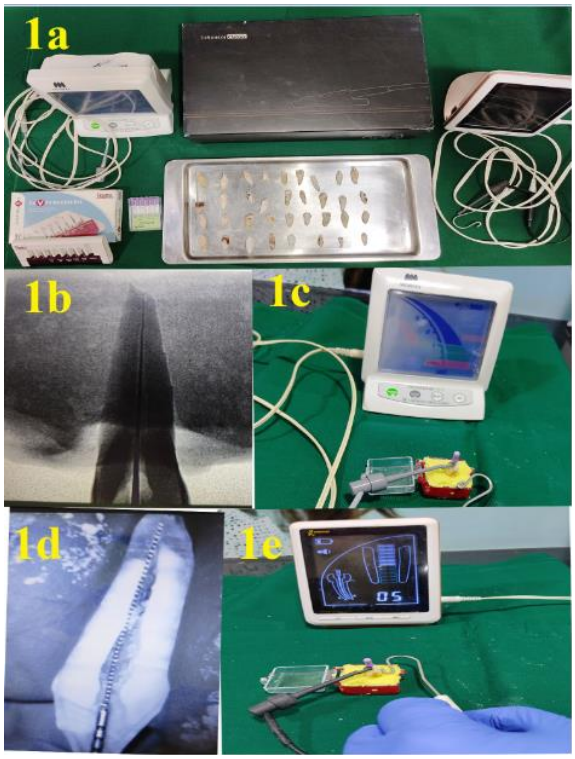


Fig 1: (a) Materials used in the study (b) WL measurement by RVG (Classic EZ Sensor, Vatech) (c) WL measurement by Dentaport ZX (d) WL measurement after sectioning of teeth under microscope 10X (e) WL measurement by Woodpex III.

Electronic methods for WL determination has progressed substantially and gained popularity in modern endodontic treatment. The DentaPort Root ZX delivers absolutely precise measurements, independently of any flushing or rinsing fluids or blood which may be present in the root canal. It has automatic calibration for the highest possible precision even with changing canal conditions. This third-generation apex locator measures the impedance values at two frequencies (8 & 0.4 kHz) and calculates a quotient of impedance. However, there is still a concern as to whether high electroconductive irrigants such as saline, anaesthetic solution, and sodium hypochlorite can affect the reading. Woopex III is a fifth-generation apex locator which calculates the working length based on multiple frequencies and has automatic calibration. In this in vitro study, two modern electronic apex locators, namely DentaportZX and WoodpexIII were used to calculate the length of the root canal. An in vitro model was used in the study, and the advantages of the model were its simplicity, ease of use, and the ability to have strict control over the experimental conditions tested. This alginate model embedded with extracted teeth provides electrical resistance corresponding to that of the periodontium. These in vitro models do provide valuable insight into the function of EALs and enable objective examination of a number of variables that cannot be practically tested clinically.[16, 17]

Although no present studies compare the efficacy of Dentaport ZX to Woodpex III individual studies quoting their efficacy as an apex locator and in comparison to other apex locators are discussed further. In various studies by D'Assunção et al., Fellipe et al. and Pagavino et al. Dentaport ZX was found to be very accurate in determining WL. The findings of the present study were that 95% samples showed exact WL. They reported that the Dentaport ZX was accurate in determining the major foramen to ± 0.5 mm in 89.7%, 86%, and 82.75% of the samples in studies by D'Assunção et al, Fellipe et al. and Pagavino et al. respectively.[18-20]

In a study by Angel M. et al., 2017 the efficacies of three different apex locator was compared in an in vitro study. Dentaport ZX showed the minimum deviation from WL, i.e. 0.18mm and Woodpex I had the greatest difference of 0.32mm. In the present study, we compared a third and a fifth-generation apex locator, and the results were not statistically significant. While Dentaport ZX showed exact WL with 95% of the samples, Woodpex III showed resemblance in readings in 91% of the samples. Both these apex locators showed a highly statistically significant result when compared to radiograph, which showed only 60% samples corresponding to the real WL by Kolmogorov-Smirnov test. The lonely use of EALs without the preoperative and postoperative radiographs is not recommended in clinical practice due to the large variations in tooth morphology and to the medico-legal record keeping requirements (Gordon and Chandler, 2004). The combined use of radiography

and EAL for WL determination has resulted in greater accuracy (ElAyouti et al., 2002). D'Assunção., et al. (2007).[17, 12, 16, 18]

In a study by Tapia et al. 2017, in an in vitro model, the difference in real and electronic measurement of Woodpex III and Raypex VI was -0.018 and -0.065, respectively. The Woopex III turned out to be more precise. [21] Further in vivo studies are to be done on multi-rooted teeth with known anatomical variations to prove the efficacy of Dentapozt ZX and Woodpex III apex locators.

CONCLUSION

The results were statistically significant when working length determination was compared by IOPA Xray and both the apex locators. The ratio two frequency root canal length measurement device has the same accuracy as with multiple frequency devices with no statistical difference, although further in vivo studies to prove the efficacy of these apex locators is needed.

CONFLICTS OF INTEREST

The authors declare they have no potential conflict of interests regarding this article.

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