ISSN: 0976-3104
SPECIAL ISSUE (RAE)
Handa et al.

THE IIOAB JOURNAL

ARTICLE OPEN ACCESS

THE EFFECTIVENESS OF TWO APEX LOCATORS IN DETECTING SIMULATED HORIZONTAL ROOT FRACTURES: AN INVITRO STUDY

Aishwarya Handa[1]*, Nitin Shah[2], Jyoti Mandlik[3], Sarita Singh[4]

Dept. Of Conservative Dentistry and Endodontics, Bharati Vidyapeeth University, Dental College and Hospital, Pune, Maharashtra, INDIA

ABSTRACT

The aim of this in vitro study was to evaluate the accuracy of two electronic apex locators (EALs): Root ZX and Propex II, in the detection of fractures in teeth having simulated horizontal root fractures (HRF). A sample size of 40 recently extracted, single rooted, permanent human teeth with sound roots and with no evidence of root resorption or fracture was selected for this study. Post decoronation of the tooth at the CEJ, endodontic access was prepared and patency of the canal was checked using 15 K files (Dentsply, Tulsa, Okla) along with use of EDTA as the chelating agent. Horizontal root fractures were simulated using a 0.2mm thick disc horizontally until half of the canal was exposed circumferentially, in the horizontal plane, either at coronal, middle or apical third of the tooth by operator No.1. The teeth along with the Lip clip of the Apex Locator were embedded in an alginate model and the alginate was continuously bathed with water to maintain the conductivity of the medium. Once the respective EAL read "APEX" on gradual advancement of a 25 K file through the canal, readings were noted using a digital vernier caliper as suggestive Horizontal fracture length by Operator No. 2 . The Real Fracture lengths (RFL) were then measured using a size 40 K file (Dentsply, Tulsa, Okla) under 3x magnification and with these actual length readings the readings of the two EALs were compared, allowing a tolerance of 0.5mm and 1.0mm .Results were analyzed using analysis of variance and measurements recorded were analyzed with the Mc Nemer's chi-square ($\chi 2$) test. ($p\_0.05$) Both the EALs used in our study detected fracture location with approximately 50% accuracy at 0.5mm tolerance level but at 1.0 mm tolerance level Root ZX showed 90% accuracy and Propex II showed 70% accuracy. Thus Root ZX showed a higher accuracy rate in detection of simulated horizontal root fractures. Results concluded that the investigated EALs are capable of determining the working length of the HRF and that Root ZX showed a higher accuracy rate in detection of simulated horizontal root fractures. It should be emphasised that the results obtained in this in vitro study cannot be directly extrapolated to the clinical situation, but can provide an objective examination of a number of variables that are not practical to test clinically.

Received on: 5th-March-2016
Revised on: 21st-March-2016
Accepted on: 7th– March-2016
Published on: 9th– June-2016

KEY WORDS

Electronic Apex Locator (EAL); Root ZX; Propex II; Horizontal Root Fracture (HRF)

***Corresponding author: Email:** aishwarya_h@hotmail.com; **Tel.:** +91-9822308623

INTRODUCTION

Root Fractures have been marked as one of the most notorious injuries for a tooth, as they exhibit inadequate discernable signs and symptoms and are often difficult to diagnose and hence treat, along with having an unprecedented prognosis. Incomplete root fractures whether vertical, horizontal, or oblique in nature are often among the most difficult cases to diagnose clinically and radiographically in clinical endodontic practice [1]. Horizontal root fractures maybe located either in the apical third, middle third, or the cervical third of the root, and primarily dictate the treatment protocol and prognosis of the tooth. Andreason found that in teeth with root fractures with displaced apical segments, the coronal segment can lose its vitality while the apical segment remains vital, under such circumstances an endodontic treatment is performed only on the coronal root canal segment, considering the fracture plane as the limit of the working length [2]. Although the outcome of a horizontal root fracture is generally favorable (60%-80% cases), complications such as pulpal necrosis, radicular resorption, and pulpal canal obliteration can arise [2]. Thus a unitary diagnosis followed by a correct treatment protocol, vastly dictates a favorable or an unfavorable outcome.

Foundation of a sound treatment protocol for a supposed root fracture depends majorly on a complete history of possible trauma and thorough diagnosis. Although Clinical diagnosis and Radiographic examinations are vital pillars of good diagnosis, they fall short in truly detecting presence or absence of root fractures, because of the varied directions and angulations of propagated fractures [1, 3].

THE IIOAB JOURNAL
ISSN: 0976-3104

Electronic Apex Locators as an adjunctive diagnostic tool for detection of root fractures have proven to be of significant importance as it uses the electrical resistance principle. Any fracture site that communicates with the periodontium, on file introduction within the canal, will be detected as a new connection between the canal and periodontium and be read as "apex" on the digital display monitor [1, 4].

The accuracy of EALs was poor because of the influence of fluids or pulp tissue in the canal. Advances in EALs technology have led to the development of EALs that make accurate readings in the presence of electrolytes. In vivo studies show the Root ZX to be accurate in locating the minor diameter to within 1mm. Recently, a new fifth generation EAL, the Propex II, has been developed (Dentsply Maillefer). It measures with multi-signal frequencies the energy of the signal, not the amplitude as for all EALs [5]. All modern EALs are able to detect root perforations and lateral canals within a clinically acceptable limit [6, 4]. Any connection between the root canal and the periodontal membrane, such as root fracture, cracking and internal or external root resorption will be recognized by the EAL, which serves as an excellent diagnostic tool in these circumstances [7].

The aim of this study was to evaluate in vitro the effectiveness of two apex locators in detecting simulated horizontal root fractures and to prove apex locators as an additional clinical diagnostic aid in detecting fractures and their exact location so as to help the clinician to decide on the best treatment option for the particular tooth.

MATERIALS AND METHODS

Forty single rooted, permanent human teeth, extracted for periodontal reasons, were used in this study. Teeth were preserved in 10% formalin for 24 hrs and then in 0.9N saline till further use. Teeth with sound roots and no evidence of root resorption or fractures were used. The teeth were decoronated at Cemento-Enamel Junction so as to prepare flat uniform horizontal surfaces and endodontic access cavity was prepared using Endo access bur (Dentsply). The canals were located and the patency of the canals was checked using 15 K files (Dentsply, Tulsa, Okla) along with EDTA as the chelating agent. Horizontal root fractures were simulated using a 0.2mm thick disc until half of the canal was exposed circumferentially, in the horizontal plane, at coronal, middle or apical third of the tooth by operator No.1. After fracture simulation, access cavities were dried with cotton pellets and all root canals were dried with absorbant paper points. The teeth along with the Lip clip of the Apex Locator were embedded in an alginate model as suggested by Kaufman et al [8]. The alginate was continuously bathed with water to maintain the conductivity of the medium. First the fractures in all the samples were detected using the third generation apex locater (Root ZX) with its lip clip embedded in the alginate model. The 25 K file was gradually advanced down in the canal without excessive force until the liquid crystal display of Root ZX indicated the flashing word "APEX". Once the beeping sound was heard the file stopper was placed adjacent to the flat coronal surface. The file was removed, and the distance between the stopper and the file tip was measured with a digital vernier calliper to 0.01 mm accuracy. Similarly the readings were taken with the fifth generation apex locater Propex II. All the readings were carried out by a second operator, who was kept blind about the fracture locations. This was done to avoid biased readings and to ensure standardization of the experimental technique.

After recording the lengths of the simulated fractures, using both apex locaters, the samples were removed from the Alginate model and the fractures were completed with the safe sided diamond disc to obtain the actual fracture length measurements. The Real fracture lengths [RFL] were then measured using a size 40 K file (Dentsply, Tulsa, Okla) under 3X magnification and with these actual length readings, the readings of the two EALs were compared, allowing a tolerance of 0.5mm and 1.0mm. Measurements were obtained and those not within these limits were considered as unacceptable.

RESULTS

The length measurements obtained with the two apex locators were analyzed and the accuracy was compared with actual fracture lengths observed under 3X magnification, with the Mc Nemer's chi-square (χ^2) test ($p<0.05$). **Table-1** shows that at 0.5 mm tolerance the p value for Propex II and Root ZX ($p<0.001$) is highly significant, whereas on comparing the accuracy between Propex II and Root ZX the p value is not significant. **Table-2** shows that at 1.0 mm tolerance the p value for Propex II ($p<0.001$) is highly significant, p value for Root ZX ($p>0.05$) is not significant whereas on comparing the accuracy between Propex II and Root ZX the p value is significant.

In this study at $\pm$0.5 mm tolerance both the EALs showed statistically significant results when compared with real fracture length (RFL) and at $\pm$1.0 mm tolerance Propex II showed statistically significant result but Root ZX showed statistically insignificant result. Also at $\pm$1.0 mm tolerance level a statistically significant difference was found between the two EALs, with Root ZX being more accurate than Propex II **[Figure-1]**.

THE IIOAB JOURNAL
ISSN: 0976-3104

Table-1: Percentage Accuracy of fracture location between the two apex locaters with a 0.5 mm tolerance

Tolerance	Accuracy	Propex II (n%)	Root ZX (n%)
0.5 mm	Accurate	17 (42.5%)	19 (47.5%)
	Non accurate	23(57.5%)	21(52.5%)

Non accurate	Propex II (n%)	Root ZX (n%)
Long	1(2.5%)	3(7.5%)
Short	22(55%)	18(45%)

Accuracy at 0.5 mm tolerance	Mc Nemer's Chi-square (χ^2) Test	P value
Propex II vs RFL	21.04	p<0.001 **HS**
Root ZX vs RFL	19.04	p<0.001 **HS**
Propex II vs Root ZX	0.1	p>0.05 NS

n- number of samples (40) , %- percentage in each group, RFL- Real fracture length

Table: 2. Percentage Accuracy of detecting location of fracture between the two apex locaters with a 1.0 mm tolerance

Tolerance	Accuracy	Propex II (n%)	Root ZX (n%)
1 mm	Accurate	28 (70%)	36(90%)
	Non accurate	12(30%)	4(10%)

Non accurate	Propex II (n%)	Root ZX (n%)
Long	1(2.5%)	
Short	11(27.5%)	4(10%)

Accuracy at 1.0 mm tolerance	Mc Nemer's Chi-square (χ^2) Test	P value
Propex II vs RFL	10.08	P<0.001 **HS**
Root ZX vs RFL	2.25	P>0.05 NS
Propex II vs Root ZX	6.12	P<0.01 **Sig**

n- number of samples (40), %- percentage in each group. RFL- Real fracture length

DISCUSSION

Root Fractures are traumatic injuries of teeth involving dentin, pulp and cementum. Horizontal root fractures that comprise 0.2%-7% of all traumatic injuries commonly occur in the anterior maxillary region [9], and incisors with complete root formation are the most affected teeth because of the decreased elasticity of the alveolar bone cavity [10]. The type and location of fracture depends on age of patient, amount of force, and direction of blow [11]. Diagnosis of root fractures cannot be done by means of radiographs within the first hours after the dental trauma incident; thus the necessity of periodical clinical and radiographic controls becomes necessary [3]. Clinically, one must carefully evaluate mobility, the displacement of the coronal segment, the presence or absence of tenderness on palpation of the soft tissues, and percussion of the teeth in question [9]. Accurate radiographic diagnosis poses challenges if the root fracture plane is beveled buccopalatally, making its interpretation on the radiograph difficult. Also the radiographic accuracy is influenced by a number of factors such as tooth inclination, position and angulation of x-ray beam, and superimposition of the anatomical structures among others [2].

One of the perplexing problems in endodontic therapy is unforeseen horizontal or vertical fractures of the root canal wall which are often difficult to diagnose and to treat. It has been postulated that apex locaters could be used to determine the position of a fracture if it communicates with the periodontal membrane. Nahmias et al [12] and Chong and Pittford et al [13] reported that if there is any connection between the root canal and the periodontal

THE IIOAB JOURNAL
ISSN: 0976-3104

membrane such as root fracture and cracks it would be recognized by the EALs. Ebrahim et al evaluated in vitro the accuracy of three different apex locaters in detecting simulated horizontal and vertical root fractures, they found that the three EALs tested were accurate and acceptable clinical tools in the detection of horizontal root fractures [7]. From a theoretical point of view, EALs would mark the first zone having a periodontal communication as the apex rather than marking the true foramen. This communication could be a fracture, a fissure, a perforation or a lateral canal [4].The accuracy of EALs is influenced by many factors for example electrolytes, foramen size, resorption, pulp vitality and instrument size. There are still concerns as to whether high electro conductive irrigants such as blood, irrigant fluids can affect the accuracy of EAL performance [14]. Clinically these factors must be considered while using EAL to detect the root fracture. Clinically it is more important to be able to diagnose the exact location of a fracture rather than its mere presence as this can influence the treatment options and eventual fate of the teeth [15].

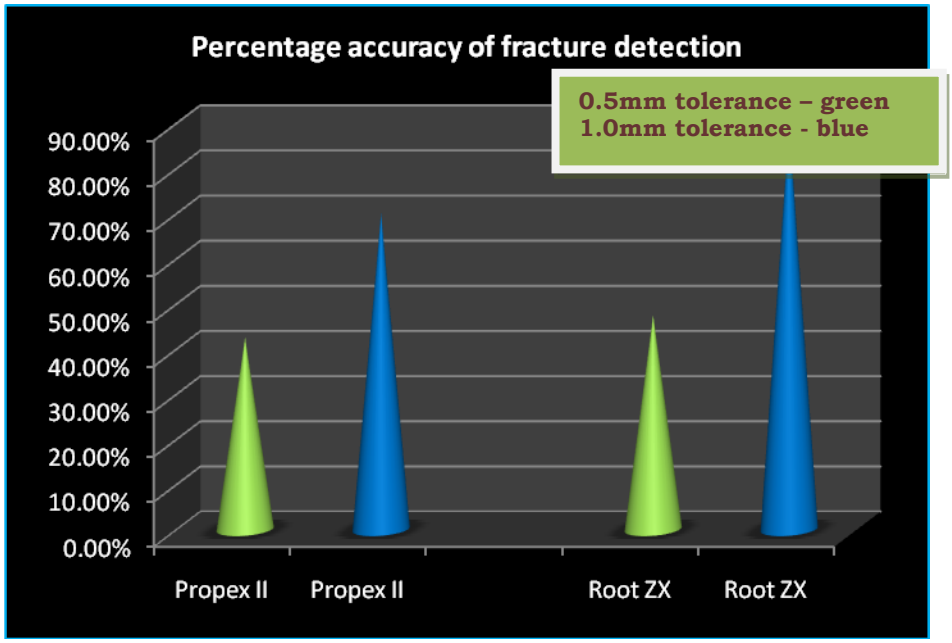

Fig: 1. The percentage accuracy of fracture detection of both the apex locaters (third – Root ZX and fifth – Propex II) at 0.5 mm and 1.0 tolerance

In our study we compared third generation apex locater (Root ZX) and fifth generation apex locater (Propex II) for their accuracy in detecting the simulated horizontal root fractures. The Root ZX, third generation apex locater that uses dual frequency and comparative impedance principles, was described by Kobayashi and Suda. The Root ZX simultaneously measures two impedances at two frequencies by ratio method [12]. A number of in vitro and in vivo studies on the accuracy and reliability of Root ZX to locate apical constriction have been reported but there are very few documented studies on accuracy of Root ZX to detect the horizontal root fracture. In a study conducted by Ebrahim et al the Root ZX was more accurate in detection of horizontal root fractures than the other apex locaters [7]. Ozgur Topuz et al compared the accuracy of two apex locating hand pieces in detecting simulated horizontal root fractures. In this study Tri Auto ZX was more successful than TCM Endo V in detecting the simulated horizontal fractures [1]. Fernando Goldberg et al evaluated the ability of four EALs to determine the location of simulated horizontal oblique root fractures. The results of this study showed that Root ZX showed unacceptable measurements as compared to Propex and NovApex [3]. Dr Lotika Beri and Dr. Gaurang compared three EALs for detecting the location of simulated oblique fractures and found that Root ZX showed 86.6% accuracy at 0.5mm tolerance [2]. Hua Xi, Kou Qiang, Yi Xue, Za Zhi conducted a study to evaluate the accuracy of Root ZX in detecting simulated horizontal root fractures. They concluded Root ZX lacks diagnostic value for horizontal root fractures without soft tissue ingrowth, but provides preferable veracity for horizontal root fractures with soft tissue in growth [16].

The Propex II is a ratio type apex locater that determines the impedances at two frequencies like the third

THE IIOAB JOURNAL
ISSN: 0976-3104

generation apex locaters but unlike the third generation apex locaters it only uses one frequency at a time that eliminates the need for filters that separates the different frequencies which helps eliminate the noise inherent in the filters, and increases the accuracy [17]. Very few studies have been conducted to evaluate the accuracy of Propex II, since the time it has been developed and all of them relate its accuracy with respect to working length. An ex vivo studies conducted by Luigi Ciancoi et al [5] and Manuele Mancini et al [18], showed that the Propex II gave more accurate results as compared to other two EALs in determining working length. Contrary to these results, in an In- vitro study conducted by Mahima Tilakchan et al [19] and Kenner Bruno Miguita et al [20]; the Propex II was not as accurate as other EALs tested. However, the literature review reveals that there are no studies evaluating the accuracy of Propex II to detect root fractures and in this respect ours maybe the first study.

The results of our study show that both the EALs are able to detect the fracture location. These results are in agreement with those of Azbal et al [4], Ozgur Topez et al [1], Fernando Goldberg et al [3], who found that the EALs were able to detect simulated horizontal root fractures. Measurements attained with the ± 0.5mm tolerance range are considered highly accurate. Shabahang et al [21] and Fernando Goldberg et al [3] suggested that 1.0 mm tolerance be considered as clinically acceptable, especially when the determination of the apical limit becomes more difficult because of the fracture plane inclination with respect to the root axis. Also, in contrast to the apical terminus, no constriction can be felt at the site of fracture during treatment [3]. Moreover, another source of error that may arise in the direct determination of the fracture length might be the difficulty in the visual control of the relation between the rubber stopper/reference point, rubber stopper/ digital vernier calliper scale, and file tip/ digital vernier calliper scale. In addition, sometimes it is challenging to visualize the exact point where the tip of the file reached the cervical border of the foramen, even with magnification [17]. Therefore in our study ± 0.5 mm and ± 1.0 mm tolerance levels from real fracture location (RFL) were used to test the accuracy of the two EALs. Both the EALs used in our study detected fracture location with approximately 50% accuracy at 0.5mm tolerance level but at 1.0 mm tolerance level Root ZX showed 90% accuracy and Propex II showed 70% accuracy. Thus Root ZX showed a higher accuracy rate in detection of simulated horizontal root fractures. These results are in agreement with those obtained by Ebrahim et al [7] and Dr. Lotika Beri [2].

Literature review reveals that the EALs show tendency to make shorter measurements than the longer ones [4, 22]. Our study is in accordance to these findings. The results of our investigation show that both the EALs gave a far greater number of shorter measurements than longer ones, as compared to RFL. Research has yet to support a significant increase in accuracy or precision of 5th generation Propex II over the 3rd generation Root ZX. Recent studies have not shown improvement in 4th and 5th generation EALs when compared to the 3rd generation Root ZX in terms of accuracy in locating the minor constriction. The use of the descriptor "fourth and fifth generation" appears to be an attempt to imply product superiority rather than to describe a factual improvement in technology [13]. Although a few studies [2,3,4,7] have examined the ability of EALs in detecting the root fractures, no studies are present in current literature on the accuracy of the Propex II device in fracture detection. The manufacturer does not specify any technical characteristics of Propex II and hence it is unclear as to why Propex II is not as accurate as Root ZX in detecting the fracture.

CONCLUSION

Under the experimental conditions of this study, it can be concluded that the investigated EALs are capable of detecting horizontal root fractures. They also determine the working length of the coronal root segment in a high percentage of teeth with horizontal root fractures at a ±1.0mm tolerance. Nevertheless, further research needs to be conducted to study the role of EALs in cases with root fractures. Understanding and overcoming the minor discrepancies between EAL readings and the Real Fracture length may make EALs an important diagnostic tool in accurately detecting horizontal root fractures.

FINANCIAL DISCLOSURE

We authors report no financial interests or potential conflicts of interest.

ACKNOWLEDGEMENT

I acknowledge the faculty of the department and laboratory persons involved in this study for their guidance and support.

CONFLICT OF INTERESTS

There is no conflict of interest amongst the authors.

REFERENCES

THE IIOAB JOURNAL
ISSN: 0976-3104

[1] Özgür Topuz, Özgür Uzun, A Cemal Tinaz, Emre Bodrumlu and Güliz Görgül. [2008] Accuracy of Two Apex-locating Handpieces in Detecting Simulated Vertical and Horizontal Root Fractures. *J Endod* 34:310–313.

[2] Lotika Beri, Gaurang Matariya. [2009] The Evaluation of three Electronic apex locators in teeth with simulated Incomplete Oblique root fractures. *JICDRO*,1(3): 49–53.

[3] Fernando Goldberg, Santiago Frajlich, Sergio Kuttler, Emilio Manzur, Benjamin Briseno Marroquin .[2008] The evaluation of four Electronic apex locaters in teeth with simulated Horizontal oblique root fractures. *J Endod* 34: 1497–1499.

[4] Azabal M, Garcia-Otero D, de la Macorra JC [2004] Accuracy of the Justy II Apex Locator in determining working length in simulated horizontal and vertical fractures. Int Endod J 37:174 – 177.

[5] Luigi Cianconi, Vincenzo Angotti, Gabriele Conte and Manuele Mancini. [2010] Accuracy of three electronic apex locators compared with digital radiography: An ex vivo study. *JOE* December 36; 12:2003-2007

[6] Inamdar Saquib, Sureshchandra B. Electronic Apex locaters- A millennium perspective. *Endodontology* 37–41

[7] Ebrahim AK, Wadachi R, Suda H [2006] Accuracy of three different electronic apex locators in detecting simulated horizontal and vertical root fractures. *Aust Endod J* 32:64 –69.

[8] AY Kaufman, S Keila, M. Yoshpe. [2002] Accuracy of a new apex locator: an in vitro study. IEJ 35:186-192.

[9] Paolo Borelli and Pasquale Alibrandi [1999] Unusaual horizontal and vertical root fractures of maxillary molars: An 11 year follow up. *JOE* (25)2; 136–139

[10] Tabsin Yildirim and Nimet Gencoglu. [2009] Use of Mineral trioxide aggregate in the treatment of horizontal root fractures with a five year follow up: Report of a case. *JOE* (35):2; 292–295

[11] Akhil Rajput, Ida Ataide, Marina Fernandes. [2009] Uncomplicated crown fracture, complicated crown-root fracture, and horizontal root fracture simultaneously treated in a patient during emergency visit: a case report. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 107:e48-e52)

[12] Ebrahim AK, Wadachi R, Suda H [2007] Electronic apex locators – A Review. *J Med Dent Sci* 54: 125–136.

[13] Timothy J Finkler. [2011] The Effect of Insulating K-Type Files on Accuracy and Reliability as Used in Two Electronic Apex Locators. Virginia Commonwealth University Richmond, Virginia

[14] Euiseong Kim and Seung- Jong Lee [2004] *Electronic Apex locator*. *DCNA* 48:35–54.

[15] Hani Al Kadi, LM Sykes, Z. Vally. [2009] Accuracy of the Raypex-4 AND Propex Apex locaters in detecting horizontal and vertical root fractures: An In vitro study. *Smile dental journal* 4(3): 12–15.

[16] Hua Xi, Kou Qiang, Yi Xue, Za Zhi .[2010]. An in vitro study of Root ZX root apex locator to diagnose horizontal root fracture. Dept of Stomatology, The Third Hospital of Peking University, Beijing 100191, China 28(1):102–103.

[17] Manhal A.R. Majeed ,Ahmed Gh. Subhi [2011] Assessment of the accuracy of a fifth generation apex locator -in vitro study. *J Bagh Coll Dentistry* 23(1):12–17.

[18] Manuele Mancini, Roberto Felici, Garbriele Conte Marco Costatani and Luigi Cianconi [2011] Accuracy of three electronic apex locators in anterior and posterior teeth: An ex vivo study. *JOE* 37(5); 684–687.

[19] Mahima Tilakchand, Kailash N Malu and Kidiyoorc K H [2010]. Evaluation of accuracy of two electronic apex locators Viz Propex II and element apex locator; an in vitro study. *IJDA* 2(4): 327–331.

[20] Kenner Bruno Miguita, Rodrigo Sanchez Cunha, Felipe Davini, Carlos Eduardo Fontana and Carlos Eduardo da Silveira Bueno [2011] Comparative analysis of teo electronic apex locators in working length determination at endodontic therapy- An in vitro study. *RSBO* 8(1):25–29

[21] Sharokh Shabahang, William WY Goon and Alan . Gluskin. [1995] An in vivo evaluation of Root ZX electronic apex locator. *JOE* 22(11): 616– 618.

[22] Benjamin Briseno – Marroquin, Santiago Frajlich, Fernanado Goldberg and Brita Willerhausen. [2008] Influence of instrument size on the accuracy of different apex locators an in vitro study. *JOE* 34(6): 698–702.

ABOUT AUTHORS

Dr. Aishwarya Handa MDS *Post graduate student and of late working as Consultant Endodontist; Healthsprings and Mydentist Mumbai-400059, Maharashtra, INDIA*

Dr. Nitin Shah *MDS, Professor and Head of Department of Conservative dentistry and Endodontics Bharati Vidyapeeth Deemed University Dental College and Hospital, Pune - 411 043, Maharashtra, INDIA*

Dr. Jyoti Mandlik *MDS, Associate Professor; Department of Conservative Dentistry and Endodontics at Bharati Vidyapeeth Deemed University Dental College and Hospital, Pune - 411 043, Maharashtra, INDIA*

Dr. Sarita Singh*, MDS, Assistant Professor; Department of Conservative Dentistry and Endodontics at Bharati Vidyapeeth Deemed University Dental College and Hospital, Pune - 411 043, Maharashtra, INDIA*