Electronic Apex Locators

Sonal Soi†, Sumit Mohan††, Vineet Vinayak†††, Prabhjot Kaur††††

† Senior Lecturer, Department of Conservative Dentistry & Endodontics, Institute Of Dental Sciences, Bareilly (U.P)
†† Senior Lecturer, Department of Conservative Dentistry & Endodontics, Institute Of Dental Sciences, Bareilly (U.P)
††† Professor, Department of Conservative Dentistry & Endodontics, Institute Of Dental Sciences, Bareilly (U.P)
†††† BDS Intern, Institute Of Dental Sciences, Bareilly (U.P)

Date of Receiving : 23/Sep/2012
Date of Acceptance : 25/Oct/2012

ABSTRACT: *Success or failure of endodontic treatment depends, among other parameters, on an accurate determination of the working length. Electronic apex locators (EALs) are a routinely used procedure in endodontic practice; yet their accuracy has been reported to vary from 35% to 100%. The operating systems of the EALs (frequency or impedance quotient) and different investigative methodologies explain the higher accuracy obtained with the current generation of devices. It is difficult to draw conclusions on the basis of the results obtained with the new generation EALs because of research variables that can influence the results.*

KEYWORDS: Apex locators, Endodontics, Root apex, Working length

INTRODUCTION

An electronic apex locator is an electronic device used in endodontics to determine the position of the apical foramen and thus determine the length of the root canal space. The apex of the root has a specific resistance to electrical current, and this is measured using a pair of electrodes typically hooked into the lip and attached to an endodontic file. The electronic principle is relatively simple and is based on electrical resistance; when a circuit is complete (tissue is contacted by the tip of the file), resistance decreases markedly and current suddenly begins to flow. According to the device this event is signaled by a beep, a buzz, a flashing light, digital readouts, or a pointer on a dial. Electronic apex locators reduce the number of radiographs required and assist where radiographic methods create difficulty. They may also indicate cases where the apical foramen is some distance from the radiographic apex. Other roles include the detection of root canal perforation. The development of the electronic apex locator has helped make the assessment of working length more accurate and predictable (Fouad & Reid 2000).[1] This article reviews the development, action, use and types of electronic apex locators.

HISTORY

The original electronic apex locators operated on the direct current principle. A problem with these devices was that conductive fluids such as hemorrhage, exudate, or irrigant in the canal would permit current flow and therefore gave a false reading. Newer devices are impedance-based, using alternating current of two frequencies; these measure and compare two electrical impedances that change as the file moves apically. The benefit is that these devices are much less affected by fluid conductive media in the canal.

An electronic method for root length determination was first investigated by Custer (1918).[2] The idea was revisited by Suzuki in 1942 who studied the flow of direct current through the teeth of dogs. He registered consistent values in electrical resistance between an instrument in a root canal and an electrode on the oral mucous membrane and speculated that this would measure the canal length (Suzuki 1942).[3] Sunada took these principles and constructed a simple device that used direct current to measure the canal length. It worked on the principle that the electrical resistance of the mucous membrane and the periodontium registered 6.0 kΩ in any part of the periodontium regardless of the persons age or the shape and type of teeth (Sunada 1962).[4]

ELECTRONIC APEX LOCATORS GENERATIONS

THE FIRST GENERATION

Also known as resistance based apex locators, measure opposition to the flow of direct current or resistance.The Root Canal Meter (Onuki Medical Co., Tokyo,Japan) was developed in 1969. It used the resistance method and alternating current as a 150 Hz sine wave.Pain was often felt due to high currents in the original machine, so improvements were made and released as the Endodontic Meter and the endodontic Meter S II (Onuki Medical Co.) which used a current of less than 5 μA (Kobayashi 1995).[5] Other devices in the first generation include the Dentometer (Dahlin Electromedicine, Copenhagen, Denmark) and the Endo Radar (Elettronica Liarre,Imola, Italy). These devices were found to be unreliable when compared with radiographs, with many of the readings being significantly longer or shorter than the accepted working length (Tidmarsh et al. 1985).[6]

THE SECOND GENERATION

Also known as impedance based apex locators, measure opposition to the flow of alternating current or impedance. Second generation apex locators were of the single frequency impedance type which used impedance measurements instead of resistance to measure location within the canal. Impedance is comprised of resistance and capacitance and has a sinusoidal amplitude trace. The property is utilized to measure distance in different canal conditions by using different frequencies (Inoue 1972)[7]. An increasing number of second generation apex locators were designed and marketed but all suffered similar problems of incorrect readings with electrolytes in the canals and also in dry canals.

THE THIRD GENERATION

Third generation apex locators are similar to the second generation except that they use multiple frequencies to determine the distance from the end of the canal. These units have more powerful microprocessors and are able to process the mathematical quotient and algorithm calculations required to give accurate readings.

The Endex/Apit :The relative values of frequency response method detects the apical constriction by calculating the difference between two direct potentials picked up by filters when a 1 kHz rectilinear wave is applied to the canal. This was described by Saito & Yamashita (1990)[8] and the method was used to develop the Apit (also marketed as the Endex by Osada Electric Co., Tokyo, Japan), the original third generation apex locator (Frank & Torabinejad 1993).[9] The Apit is able to measure lengths with electrolytes in the canal but needs to be calibrated in each canal .The main shortcoming of early apex locators (erroneous readings with electrolytes) was overcome by Kobayashi et al. (1991)[10] with the introduction of the ratio method and the subsequent development of the self-calibrating Root ZX (J. Morita, Tokyo, Japan) (Kobayashi & Suda 1994).[11] The ratio method works on the principle that two electric currents with different sine wave frequencies will have measurable impedances that can be measured and compared as a ratio regardless of the type of electrolyte in the canal. The capacitance of a root canal increases significantly at the apical constriction, and the quotient of the impedances reduces rapidly as the apical constriction is reached. Kobayashi & Suda (1994) showed that the ratio of different frequencies have definitive values, and that the ratio rate of change did not change with different electrolytes in the canal. The change in electrical capacitance at the apical constriction is the basis for the operation of the Root ZX and its reported accuracy. Since its introduction, Root ZX has received considerable attention in the literature. It has become the benchmark to which other apex locators are compared, and maintains a 95% world market share for apex locators in use today (Lively 2003, personal communication . There are several other third generation apex locators in use world-wide. These include the Justwo or Justy II (Yoshida Co., Tokyo, Japan), the Mark V Plus (Moyco/Union Broach, Bethpage, NY, USA) and theEndy 5000 (Loser, Leverkusen, Germany).

THE FOURTH GENERATION

Bingo 1020/Ray-Pex 4 - The Bingo 1020 (Forum Engineering Technologies, Rishon Lezion, Israel) claims to be a fourth generation device and the unit uses two separate frequencies 400 Hz and 8 kHz similar to the current third generation units. The manufacturers claim that the combination of using only one frequency at a time and basing measurements on the root mean square values of the signals increases the measurement accuracy and the reliability of the device (Apex locator Bingo '1020' 1999). (Kaufman et al. 2002).[12]

THE FIFTH GENERATION

5th generation apex locator was developed in 2003. It measures the capacitance and resistance of the circuit separately. It is supplied by diagnostic table that includes the statistics of the values at different positions to diagnose the position of the file. Devices employing this method experience considerable difficulties while operating in dry canals. During clinical work it is noticed that the accuracy of electronic root canal length measurement varies with the pulp and periapical condition (Kovacevic et al., 2006).[13] So, pulp condition and periapical diseases should be considered to evaluate the relation between the pulp state and accuracy of electronic apex locators.

THE SIXTH GENERATION

Adaptive Apex Locator overcomes as the disadvantages of the popular apex locators 4th generation low accuracy on working in wet canals, as well the disadvantages of devices V th generation difficulty on working in dry canals and necessarily of compulsory, additional wetting. Adaptive Apex Locator continuously defines humidity of the canal and immediately adapts to dry or wet canal. This way it is possible to be used in dry and in additional wetted canals as well, canals with blood or exudates, canals with still not-extirpated pulp.

USES

Innovative uses for apex locators have been reported. All modern apex locators are able to detect root perforation to clinically acceptable limits and distinguish both large and small perforations (Fuss et al.1996)[16] (Kaufman et al 1997)[17]. Azabal et al (2004)[14] found Justy II was able to detect simulated horizontal fractures but was unreliable when measuring simulated vertical fractures . This aids in decision making and consideration of treatment of options (Nahmias et al 1983)[18]. Suspected periodontal and pulpal perforation during pinhole preparation can be confirmed by all apex locators as a patent perforation will cause the instrument to complete a circuit and indicate that instrument is beyond the apex (Ingle et al 2002)[15]. Any connection between root canal and the periodontal ligament such as root fracture ,cracks and internal/external resorption will be recognised by the apex locators which serves as an excellent diagram tool in these circumstances (Chong and Pitt ford 1994)[20]. Multiple function apex locators are becoming more common and several have vitality testing function. Combination electronic apex locators and electronic handpieces are also becoming common and are able to achieve excellent results with same accuracy as the stand- alone units(Steffen et al 1999)[19]

ADVANTAGES AND DISADVANTAGES

Apex locator	Advantages	Disadvantages
Resistance	1. Easy to operate	1. Requires a dry type environment.
	2. Uses K-type files	2. Files cannot contact the metal restorations
	3. Operates w/ RC Prep	3. There should be no caries or defective restorations.
	4. Digital readout.	4. Requires calibration.
	5. Detects perforation.	5. Requires a lip clip with good contact.
	6. Built in pulp tester.	6. Patient ensitivity.
		7. Should use a file that fits the canal snugly.
		8. Perforations can give false reading.
		9. Contraindicated in patients w/ pacemakers.

APEX LOCATOR IMPEDANCE TYPE

ADVANTAGES:	DISADVANTAGES:
1. Operate in fluid environment	1. Requires calibration
2. Analogue meter	2. Requires coated probes.
3. No patient sensitivity	3. Can not use files.
4. Operates with RC Prep	4. No digital read-out.
5. No lip clip	5. Difficult to operate.

FREQUENCY TYPE

ADVANTAGES:	DISADVANTAGES
1. Easy to operate	1. Must calibrate each canal
2. Operates in fluid environment	2. Sensitive to canal fluid level
3. Uses K-Type files	3. Needs fully charged battery
4. Analogue read-out	
5. Operates with RC Prep	
6. Low voltage electrical output	

CONCLUSION

No individual technique is truly satisfactory in determining endodontic working length. The CDJ is a practical and anatomic termination point for the preparation and obturation of the root canal and this cannot be determined radiographically. Modern electronic apex locators can determine this position with accuracies of greater than 90% but still have some limitations. Knowledge of apical anatomy, prudent use of radiographs and the correct use of an electronic apex locator will assist practitioners to achieve predictable results.

REFERENCES

1. Fouad AF, Reid LC. Effect of using electronic apex locators on selected endodontic treatment parameters. J Endod 2000; 26: 36-47.
2. Custer C.Exact methods for locating the apical foramen. Journal of the National Dental Association 1918 ; 5: 815-9.
3. Suzuki K .Experimental study on iontophoresis. Japanese Journal of Stomatology 1942;16: 411-29.
4. Sunada I. New method for measuring the length of the root canal. J Dent Res 1962; 41: 375-87
5. Kobayashi C.Electronic canal length measurement. Oral Surg, Oral Med, Oral Path, Oral Rad and Endod 1995; 79: 226-31.
6. Tidmarsh BG, Sherson W, Stalker NL. Establishing endodontic working length: a comparison of radiographic and electronic methods. N Z Dent J 1985;81: 936.
7. Inoue N. Dental 'stethoscope' measures root canal. Dental Survey 1972; 48: 389.
8. Saito T, Yamashita Y.Electronic determination of root canal length by newly developed measuring device. Influences of the diameter of apical foramen, the size of K-file and the root canal irrigants. Dentistry in Japan 1990; 27: 65-72.
9. Frank AL, Torabinejad M. An in vivo evaluation of Endex electronic apex locator. J Endod 1993; 19: 177-79.
10. Kobayashi C, Okiji T, Kaqwashima N, Suda H, Sunada I. A basic study on the electronic root canal length measurement: Part 3. Newly designed electronic root canal length measuring device using division method. Japanese Journal of Conservative Dentistry 1991; 34: 144-28.
11. Kobayashi C, Suda H . New electronic canal measuring device based on the ratio method. J Endod 1994; 20: 11-14.
12. Kaufman AY, Keila S, Yoshpe M.Accuracy of a new apex locator: an in vitro study. Int Endod J 2002; 35: 186-92.
13. Kovacevic M, Tamarut T. Influence of the concentration of ions and foramen diameter on the accuracy of electronic root canal length measurementan experimental study. J Endod 1998; 24: 346-51.
14. Azabal M, Garcia-Otero D, de la Macorra JC. Accuracy of the Justy II apex locator in determining working length in simulated horizontal and vertical fractures. Int Endod J 2004; 37: 174-77.
15. Ingle J, Himel T, Hawrish C et al. Endodontic cavity preparation. In: Ingle J, Bakland L, eds. Endodontics. Hamilton, Ontario: BC Decker, pp.2002; 517-25.
16. Fuss Z, Assooline LS, Kaufman AY Determination of location of root perforations by electronic apex locators. Oral Surg, Oral Med, Oral Path, Oral Rad and Endod 1996; 82: 32-49.
17. Kaufman AY, Fuss Z, Keila S, Waxenberg S Reliability of different electronic apex locators to detect root perforations in vitro. Int Endod J 1997; 30: 4037.
18. Nahmias Y, Aurelio JA, Gerstein H Expanded use of the electronic canal length measuring devices. J Endod 1989 ;9: 34-79.
19. Steffen H, Splieth CH, Behr K Comparison of measurements obtained with hand files or the Canal Leader attached to electronic apex locators: an in vitro study. Int Endod J 1999 ;32: 10-37.
20. Chong BS, Pitt Ford TR Apex locators in endodontics: which, when and how? Dental Update 1994 ; 21: 328-30

Corresponding Address:
Dr.Prabhjot Kaur
Email: peekiee20@gmail.com

LIST OF PHOTOGRAPHS

Fig a: EAL Gen 1

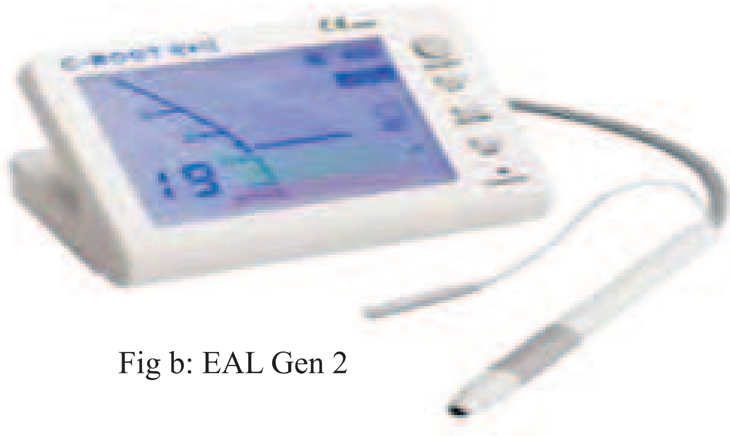

Fig b: EAL Gen 2

Fig c: EAL Gen 3

Fig d: EAL Gen 4

Fig e: EAL Gen 5

Fig f: EAL Gen 6