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## **REVIEW ARTICLE**



# **Apex Locator - Booster to Dentist : Literature Review**

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#### Abstract

Successful root canal treatment depends on thorough cleaning & shaping and 3- dimensional fluid impervious obturation of tooth within the confines of canals. To achieve this objective the apical constriction must be detected accurately during canal preparation and precise control over working length during the procedure must be maintained. There are many methods of working length determination including radigraphs and electronic method(apex locator). Introduction of apex locators have definitely served as an effective adjuvant to radiographs.

Keywords: Apex locators, Apical constriction, Endodontics, Generation, Working length



## **1** | INTRODUCTION:

Indodontic success mainly depends on the removal of all pulp tissue, [1] necrotic material and microorganisms from the root canal.<sup>1</sup> Complete cleaning of root canal throughout its entire length is a critical requirement in root canal therapy. It is imperative that this procedure is confined to the canal in order to prevent irritation of periapical tissues and possible extension of root filling. [2] The

success of root canal therapy is dependent on estab-

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lishing a correct working length. [1] Working length is defined as the distance from coronal reference point to the point at which canal preparation should terminate. Locating exact terminus of the canal at apical constriction is an important clinical step. [3]

Traditional methods of establishing working length include use of radiography, tactile sensation and moisture on a paper point. [4] An endodontic file can be used to manually feel the location of apical constriction. Accuracy of tactile sensation is questionable in root canal with excess curvature, immature apex or calcified canal which will hinder tactile sensation of apical constriction. [5]

The development of electronic apex locator has helped to make the assessment of working length more accurate and predictable. When used with appropriate radiographs, it allows greater accuracy of working length determination. [5]

## 2 | DISCUSSION:

An Apex locator is an electronic device used in endodontics to determine the length of the Root Canal. [3] The fundamental electronic oper-ating principles are often unknown and a matter of controversy. Certain characteristics of human tissues can be modeled by a combination of electrical components, which is the base for all electronic length measuring devices. Therefore, by measuring the electrical properties of the model such as resistance and impedance, it should be possible to detect canal terminus. [6] The root canal system is surrounded by dentin and cementum that are insulators of electric current. Minor apical foramen is the point where conductive materials within the canal space is electrically conducted to PDL which itself is a conductor of electric current. [7] Thus dentin, along with tissue and fluid inside the canal forms a resistor, the value of which depends on heir dimensions, and their inherent resistivity. When an endodontic file penetrates inside the canal and approaches the minor apical foramen, the resistive properties and the resistance between endodontic file and foramen decreases. [6]

Therefore, various electronic methods have been developed that use a variety of other principles to detect canal terminus. The simplest devices measure resistance, other devices measure impedance using high frequency, two frequencies or multiple frequencies. [6]

## Classification of Apex Locators [3] :

The modified form of McDonald classification is based on the type of current flow and the opposition to the current flow as well as the number of frequencies involved.

#### Types of apex locators:

- First generation apex locators
- Second generation apex locators
- Third generation apex locators
- Fourth generation apex locators
- Fifth generation apex locators

Recently Sixth generation apex locator has been introduced.

#### Types of Electronic Root Canal Length Measurement Devices [ERCLMD's] [6]:

Resistance based, low frequency oscillation, high frequency capacitance based, capacitance and resistance based, Voltage gradient two frequencies, impedance difference two frequencies impedance ratio and Multi-frequency

## Types of electronic apex locators:

Traditional type apex locators (resistance or impedance type) and Frequency dependent apex locators. [3]

How to measure the root canal length by using *EAL* [3, 8]

All EALs function by using the human body to complete an electrical circuit.

• Apex locator's circuit is connected to the oral mucosa through a lip clip on one side and the other side to a file.

- The electrical circuit is completed when the file is placed into the root canal and advanced apically until its tip touches periodontal tissue at the apex.
- Device show apex when resistance of EAL and the resistance between the file and oral mucosa are equal.

## Other Uses of Apex Locators [3]

- Detection of root perforations
- · Diagnosis of external and internal resorption
- · Horizontal or vertical root fractures
- Teeth with incomplete root formation requiring apexification.
- Working length determination in primary teeth.
- Management of patients concern about the raditions

## Advantages [3, 9]

Accurate, easy to use, fast, less radiation exposure, artificial perforation recognization, length measurment upto apical foramen.

## Disadvantages [8, 9]

Special device is essential, Electrical condition of canal affects the accuracy, Difficulty occur in teeth with open apex, Results are very inconsistent in case of vital teeth.

## First generation apex locators [1, 3, 9]

These devices measures opposition to the flow of direct current or resistance that's why are defined as resistance base apex locators and also were found to be unreliable when compared with radiographs, as many readings were being significantly longer or shorter than the accepted working length. eg. Root canal meter, Endodontic Meter S Endodontic Meter S II (Onuki Medical Co, Tokyo,Japan)

#### Disadvantages of first generation

Requires a dry environment, files cannot contact the metal restorations, calibration is required, patient sensitivity, perforations can give false reading.

#### Second-Generation Apex Locators [3, 10]

Electrical impedance across the wall of the root canal due to the presence of transparent dentin is the basis of these apex locators eg. Sono-Explorer Mk III, Endocator

*Disadvantages* :Calibration and coated probes are required, Canals should be dried and difficult to operate.

#### Third generation apex locators [8]

These have advantge over second generation as these devices use multiple frequencies and have more powerful microprocessor which are able to process the mathematical quotient and algorithm calculations required to give accurate readings. eg. Root ZX (Figure 1), Justy II, Apit7.



FIGURE 1: RootZXApex locator

*Disadvantages:*Need to reset or calibrated for each canal.

#### Fourth generation apex locators

These are ratio type apex locators which determine the impedance at five frequencies and have built in

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electronic pulp tester. To determine the distance to the apex of root canal ,these devices take the resistance and capacitance measurement and compare them with a database.eg. AFA Apex finder, Root ZX II, Propex II. [3]

Disadvantages : Need to perform in relatively dry or in partially dried canals, inapplicable in heavy exudates or blood. [1]

#### Fifth generation apex locators

This generation is based on comparison of the data taken from the electrical characteristic of the canal and additional mathematical processing. So, the fifth generation apex locators are now being used [3], as it measures the capacitance and resistance of the circuit separately. It is supplied by diagnostic table that includes statistic of the file and also not affected by root canal conditions (dry, wet, bleeding, saline, EDTA, NaOCl). [11, 12]

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. eg. Apex\*NRG Blue (Blue Tooth Apex Locators), Apex\*NRGXFR, Endo Master (EMS Swissendo.CH), Joypex-5, E-magic, Root canal apex locator pulp tester v, Root Pi. [9]

#### Sixth generation adaptive apex locator [8, 9, 11, 13]

Analysis of the advantages and disadvantages of apex locators of the fourth and fifth generation prompted the aim at devising a method and an appliance called "sixth generation adaptive apex" locator.

This generation combines the advantages of fourth and fifth generation. The method of measuring the working length depends on canals moisture characteristics. Due to modern technology, the sixth generation adaptive apex locator is a pleasant, small-sized device no larger than a dentist's palm.

The measuring mode provides for graphic information on colored multimedia displays. Through the familiar beeping signals or sensible speech messages like that of fifth generation apex locators, the adaptive apex locator will retrieve audio information.

#### Canal measuring capability

The display of the apex locator is split into 2 sectors.

At the stage of penetrating the root canals by means of an endodontic device, information is obtained about the start of measurement when touching the outermost and the inner dentin structures. In the root canal, before the apex zone sector II/, the device provide information that we are in contact with the dentine.

Prior to reaching the apical zone /sector II/ and after a sound signal, the screen displays the zones reached by the tip of the instrument. The device issues sound or speech information that repeats the data on the display/ "two" - if the tip is in zone II before the physiological narrowing; "one" – if the tip is in zone I before the physiological narrowing.

Further motion of the endodontic instrument produces a sound signal of increasing frequencies indicating that the device expects for the tip of the instrument to penetrate into the zone of physiological narrowing/. The symbol of a moist canal is displayed which shows that the device has measured moisture in the canal and has duly adapted to measuring within liquid.

Tip of the instrument is between the physiological narrowing and the anatomical foramen when the message of 'apex' appears. The message "over" means that the tip has passed through the anatomical foramen when the message appear as 'over'

#### Advantages:

Eliminate the necessity of drying or moistening of the canal, high degree of measurement precision in the presence of blood, sodium hypochlorite or while manipulating dry canals.

Clinical observations are yet to come that will help assess the device's ability to determine the working length of root canal.

## Combination Apex Locator and Endodontic Handpiece

*The Tri Auto ZX* (J. Morita Mfg. Corp. USA; Irvine, Calif.) [8, 13]

The cordless **Tri Auto ZX** is an endodontic handpiece with a built-in apex-locator, providing the capability to monitor the root canal before, during and after instrumentation electronically. Morita's Tri Auto ZX was the first ever specialty rotary endodontic handpiece with apex locator produced. With the combined technology and accuracy of the Root ZX apex locator, the Tri Auto ZX can significantly increase safety. The Tri Auto ZX also offers control and flexibility with the adjustable torque settings and also versatility is provided by having choice of both automatic or manual mode operations.

#### Canal measurement capability:

Accurate measurement is determined in calculating the canal impedance by the ratio of two different frequencies (400Hz and 8 kHz). The accuracy of the measurement in either a dry or wet canal is equally accurate. With the Tri Auto ZX, root canal measurement, enlargement and the removal of gutta percha points can be performed safely and efficiently. The location of the file tip is indicated by LEDs on handpiece and by audible signal.

#### Advantages :

Accurate, lightweight & portable handpiece, excellent torque for instrumentation and no zero adjustment.

## **Disadvantages :**

Inaccurate readings during automatic mode operation, necessitate use of 30-mm long files many times, manual mode button is difficult to activate.

## Apex locator vs Radiograph [14, 15]

- It is a mistake to think that apex locators will eliminate radiographs from the endodontic practice.
- Apex locators are not useful in determining the canal width, canal curvature and the number of canals.
- Foudad et al have started that apex locators were not meant to replace radiograph, but to add to the information obtained by the rediograph.

## Common problem solving [16, 17]

There are some problems that are frequently associated with the use of Electronic apex locator Table 1

## Effects on the accuracy of EAL's:

1. Effect of pulp vitality on the accuracy of EAL's

Most studies have reported that pulp vitality does not affect EAL accuracy but there have been several disagreements as some studies had shown a higher accuracy for determining the apical constriction in vital canals than in necrotic canals.

In necrotic canals with severe inflammatory root resorption, the apical constriction might be altered or even non-existent with no viable periodontal tissue to respond to the EAL, which would cause a lower accuracy. Necrotic pulps with a periapical radiolucency measured 1.5mm error beyond the constriction because these radiolucencies lacked a periodontal ligament and the periapical bone which causes an abnormally long reading.

## 2. Effect of foramen size on the accuracy of EAL's

There is a general consensus that the file size does not affect the accuracy of EAL's. [18] A study was conducted by **Nguyen et al** to observe the effect on the measurement of the relative diameters of the file and the root canal using Root ZX. The length of the enlarged canals was measured using small sized files and large sized files matching the canal diameter. The initial length (IL) was measured using No.10 file and final length (FL) was obtained using No.10 and No.60 file. Differences were similar between FL-10, FL-60 and IL-10. [19]

## 3. Effect of resorption on the accuracy of EAL

The use of EAL's in apical resorption is under question because of the possible destruction of the apical constriction and the loss of the surrounding periodontal tissue. [20]**Goldberg et al** showed that Root ZX was only 62.7% accurate in such cases. [21]

## 4. Effects of different metal types

Questions have been raised many a times about the effect of metal on accuracy of apex locator, but this does not appear to be a problem. Studies had shown that nickel-titanium is better when compared to others with stainless steel being the next one. [19]

## 5. Detection of root perforation

The early detection and immediate treatment of an iatrogenic perforation is most important for predicting a good prognosis. [22] Usually bucco - lingual

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PROBLEM	REASON	SOLUTION
Unstable electronic signal and rapid wandering signs	When file touches the metalic restoration Cervical leak through the subgingival caries	Remove the metalic restoration Blowing air onto wet chamber
Apex Sign from the beginning	Too much electrolyte in the canal of	Gentle irrigation with sodium hypochlorite or saline until the drainage become reasonably controlled Need to be blot dried in some case.
Sharp drop of the signal at the apical foramen	Very dry canal When file tip is at the extremely dry point there is little or no electric contact even at high frequencies	Gentle Irrigation of the canal When EAL is used in dry conditions such as for final WL verification immediately before the obturation, the operator must judge carefully the appropriate position by sharp dropping

perforations are very difficult to diagnose as radiographic detection often hinders the existence of the perforation. [23]Kaufman et al compared three different EALs in detecting root perforations and they were clinically acceptable, where the file tip ended 0.06mm to 0.60mm short of the external outline of the root surface. [24]

## 3 | SUMMARY:

There is a general consensus that the narrowest part of the canal should be the end point for every root canal procedures. It is not possible to predictably detect the position of apical constriction clinically, indeed, the constriction is not uniformly present, or may be irregular. Electronic root canal length measuring devices offer a means of locating the most appropriate end point for root canal procedures indirectly. Most modern ERCLMDs ensures that preparation should be confined within the canal because they are capable of recording the point where the tissues of the periodontal ligament begin outside the root canal.

## 4 | CONCLUSION:

Determination of accurate working length is very difficult procedure and 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. Usually modern electronic apex locators can determine this position with accuracies of greater than 90% but still have some limitations therefore proper knowledge of apical anatomy, prudent use of radiograph and correct use of an electronic apex locator will assist practitioners to achieve predictable results.

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