

# Evolution of Electronic Root Canal Length Measurement Device -A Literature Review

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## Abstract

**Summary:** An electronic apex locator(EAL) is a device used to measure the working length (WL) of the root canal space(RCS) and proved to be a great help to the endodontist reducing radiation exposure of both patients and clinicians and providing accurate reading for the WL. Evolution of different generations of EAL helped to eradicate the shortcomings of the previous generations providing precise measurement of the WL. Electronic Apex locators are used to detect any perforations, furcation involvement, also used to detect horizontal fractures, also to detect internal or external resorption. With so many uses, it is still contraindicated in patients with pace makers and inaccurate reading in canals with common irrigants like Ethylenediamine tetraacetic acid and sodium hypochlorite. It requires dry or partially dry canals to give readings with accuracy. It also gives inaccurate reading in the presence of semi-conductive materials and hence the canals should be free of them. Though it provides almost precise measurement of the WL it cannot be replaced with radiographs but can be used as an adjunct with it. Pre- and post-operative radiographs are still necessary for the success of the endodontic treatment as it provides an idea for any periapical lesion and degree of curvature of roots. Acceptance of an electronic apex locator to determine the correct WL has still not gained approval worldwide. Lack of exposure to the technology by the operator, inadequate knowledge of the root canal anatomy and cost of the instrument are also the factors for it not gaining worldwide acceptance.

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

## Introduction

The accomplishment of an endodontic treatment or its success depends on complete elimination of the contents from the root canal system (RCS) before shaping that include biofilm, planktonic bacteria, bacterial toxins, organic infected tissue, inorganic debris and smear layer which refers to cleaning of the root canal.<sup>1</sup>

Shaping refers to de-roofing of the pulp chamber, removal of obstacles, pre flaring to reach middle and apical third also smoothening the walls of the RCS. Bio mechanical preparation plays a vital role for the accomplishment of the endodontic treatment. This can be achieved with accurate endometrics. The success of endodontic treatment with periapical lesions and necrotic pulps depends on the apical end of the filling

material used in root canal.<sup>2</sup>

Traditionally, radiographs were used to measure and regulate the extent of the RCS and point of termination at the minor constrictor.<sup>3</sup> The development of the electronic apex locator came as a boon for the endodontist to evaluate the accurate working space and to reduce radiation exposure of the clinician and the patient and minimizing on the number of radiographs.<sup>4</sup>

An apex locator is an device applied to measure the length and position of the minor constrictor. The apical portion of the root has specific resistance to electrical current, and it is measured using a pair of electrodes which is attached to the endodontic file on one end and hooked to the lip at the other end to form an circuit.<sup>5</sup>

**Importance of working length:**

Working length (WL) is defined as the distance from a coronal reference point to the point at which canal preparation and obturation should terminate," according to Glossary of Endodontic terms.<sup>3,6</sup>

The determination of a precise WL is a crucial step in the root canal therapy. The biomechanical preparation of the RCS cannot be done correctly if the WL is not determined with accuracy. Thus, the predictable endodontic treatment success stresses on achieving a precise WL determination.<sup>7</sup>

Over & underestimation of the WL can result in failure. Overestimated WL can lead to preparation of the RCS beyond the apex, which can bring about damage in the peri-apical area. Underestimated WL results in inadequate debridement in the canal which eventually leads to failure of the treatment causing dissatisfaction to both the dentist and the patient.<sup>1</sup> Since determination of the WL plays a vital role in root canal treatment, some procedures may be suggested:<sup>1</sup>

A: Application of tactile sensation using paper cones is one of the methods that is used due to their ease and relative efficacy. This technique can be inaccurate in patients with and apical curvature and teeth with an open apex  
 B: Radiograph is a most used method for determining WL where the apex is kept 0.5-1 mm shorter than the radiographic apex. The radiographic technique has its recompenses, such as direct opinion of the RCS and the canal curvature or any incidence of any peri-apical lesions, but radiographs give a 2D view of a 3D object. In an addition, a drawback of radiation is that it can be hazardous to the dental staff, clinician and the patients.  
 C: Introduction of the electronic apex locators (EAL) came with advantages like reduction in number of radiographs and elimination of radiographic obstacles.

The development and the principal design of the initial apex locator's dates back to 1942, in which Suzuki investigated the circuit on dogs and came to a conclusion there is some electrical resistance observed between the periodontal ligament (PDL) and the oral mucosa which

had a persistent charge. These proceedings were taken into consideration and presented into daily clinical practice by Sunada (1962) which measured the electrical resistance between periodontal ligament and oral mucosa.<sup>3</sup> Therefore calculation of WL should be done with accuracy, using methods that have already proven to give precise and correct results and by procedures that are easy and practical to perform and should be confirmative.<sup>8</sup>

An understanding of the anatomy of the apex and the apical region is required to gain the idea of the WL. The structure of the minor & major constrictor changes with increase in time of life due to hard tissue deposition.<sup>1</sup>

**Mode of action of Apex Locators:<sup>4,6</sup>**

Electronic Apex Locators works by completing the electric circuit using the human body. There are two sides of an apex locator, one part of the circuit is connected to the oral mucosa via a clip that attaches to the lip whereas the additional part is fixed on to an endodontic instrument. The circuit gets completed when the endodontic instrument is sited in the RCS and is moved apically till it reaches the apex and touches the periodontal tissue. The system specifies that the apex has been reached when the electrical resistance of the electronic apex locator and the resistance between oral mucosa and the endodontic instrument are same.

When the tip of the endodontic instrument contacts the tissue, an electrical circuit is completed and the resistance decreases evidently and the current swiftly and rapidly begins to flow. This current flow signalled by a beep or a buzzer or digital readout or pointer on the screen display. The electrical characteristic of the tooth structure is measured and a precise location of the endodontic instrument in the RCS is determined.

Classification of electronic apex locators according to Generations of EALs (Evolution of EALs)<sup>3</sup>

1. The first-generation apex locators determine the WL of the RCS by means of the resistance technique. This generation of apex locators measured the obstruction

to the flow of direct current (resistance) and henceforth called Resistance based apex locators.

These devices gave false interpretations in obstructed and wet canals and also in carious and defective restoration, in cases with perforations and also in patients who had cardiac pacemakers. For example: The Root Canal Meter, Dentometer

2. The 2<sup>nd</sup> generation apex locators determine the WL using the impedance method. This generation of apex locators measures the obstruction to the flow of alternating current hence known as impedance-based devices. These units perform the task by utilizing the current of a single frequency.

Second generation apex locators are devices based on impedance measurement that functions on the principle that there is electrical impedance across the root canal wall as there is transparent dentin present. The tooth increases in electrical impedance across the root canal walls, which is greater apical area compared to the coronal area. At the cemento-dentinal junction the impedance level drops intensely. Examples: Endocater, Sono explorer Apex finder endoanalyzer, Digi pex

One major disadvantage of these devices was that it gave false reading of electro-conductive materials. The RCS should be completely unrestricted by any electro-conductive materials to gain correct interpretation.

3. Third Generation Electronic Apex locators are known frequency dependent apex locators. These work on the principle of comparative impedance and frequency. These electronic apex locators are based on the aspect that different locations in the RCS can give difference in impedance ranging from extremely high (8KHz) and extremely low 400(Hz) frequencies. This difference in the frequencies is seen minimum in the coronal portion of the root canal. Difference in frequencies increases as the endodontic instrument penetrate deeper into the canal. Frequencies are seen highest at cemento-dentinal junction. For examples: Apit –Endex (Osada, Japan)/ Apit or Endex

The disadvantage of this device was that it needs to be “reset” or “calibrated” for every canal. For example: The Root ZX

Other third generation apex locators include:

1. Apex Finder AFA Model 7005 (EIE Analytic Endodontics, USA).

4. The 4<sup>th</sup> Generation electronic Apex Locators are the ratio type apex locators which regulate the impedance at 5 different frequencies and they have a pulp tester which is in-built. These devices take the capacitance and resistance measurement and evaluate them with a database to estimate the distance from the apex of the root canal to the tip of the file.

Multi-frequency measurement system is a system employed to estimate the length from the tip of the endodontic instrument being used to the apical foramen by measuring changes in impedance occurring between the two electrodes. This technique apparently leads to less specimen mistake and more reliable readings.

The electronic apex locators of this particular generation are by far the most reliable in their group due to their high accurateness and dependability.

A noteworthy disadvantage of this generation devices is that, for accurate readings they require partially or completely dry canals.

e.g., Bingo 1020/, The Ray-Pex 4 and 5

5. The Fifth Generation Electronic Apex Locators is a recent measurement technique that was developed based on the judgement of the facts engaged from the electrical distinctive of the canal and additional mathematical processing. And so, 5<sup>th</sup> generation apex locators are dual frequency ratio type and they are being used currently.

These devices were introduced in 2003. It calculates resistance & capacitance of the circuit discretely. It comes with a diagnostic table which comprises the statistics of the file. It has greatest exactness in all root canal condition like bleeding, dry, wet canals

(saline, NaOCl, EDTA). The apex locators retaining this technique experience significant problems while working in dry canals.

During any of the clinical procedure it was seen that the accuracy of electronic root canal length measurement varies in conditions in periapical lesions or any damage to the pulp.

The fifth-generation electronic apex locators come with a graphic illustration, digital read out and a signal which is audible. The pulp testing machine which is in built can be used to access tooth vitality.

These devices were introduced to handle the problems related with previous generations apex locators.

6. The Sixth Generation Electronic Apex Locators is an adaptive apex locator. The efficiency of this generation electronic apex locators in long term use are yet to be known. A main advantage of this device is eradicating the need of wetting and drying of the canal.

Adaptive 6<sup>th</sup> generation apex locators immediately adapt to wet or dry canal and is also possible to be used in canals with blood or exudate.

Additional uses of Electronic Apex Locators: <sup>6</sup>

- It has the ability to detect root perforations.
- It helps to determine the location of pulpal floor or root perforations
- It can detect horizontal fractures
- It helps to confirm an assumed periodontal or pulpal perforation
- It helps to recognize any connection between the periodontal membrane & the root canal such as internal or external resorption root fractures or cracks.
- They detect vitality of the tooth

Combination of electronic handpiece and EALs (Ex. Root ZX II) are also becoming popular as they achieve

outstanding outcomes with same and exact precision as the stand-alone units. The Root ZX has been combined with a handpiece to measure root canal length with a rotary instrument being used. The handpiece uses rotary instruments made from nickel-titanium that rotate at the speed of 240-280 rpm.

Contraindications associated with Apex locators:<sup>9</sup>

1. Non- Isolated Tooth with rubber-dam.
2. Immature Tooth with Open Apex.
3. Using Electric devices as Pacemaker.
4. Inflamed and Infected Periapical Area
5. Periapical-Periodontal lesions.
6. Severe Intra-Canal Resorption
7. Auxiliary canals

Problems associated with apex locators: <sup>3</sup>

- Root ZX can give inaccurate readings if the canal is filled with blood or exudate.
- Presence of any calcification or dentin debris can affect the accurate determination of the WL.
- The accuracy of the reading of the apex locator interferes with cardiac pacemakers.
- They do work appropriately when common irrigants in the canal such as sodium hypochlorite and EDTA are used.
- High cost of the instrument.
- Technique sensitive

Hence, the of apex locators cannot be used alone but should be just as an adjunct with pre- and post-operative radiograph as it through radiographs that a clinician can judge any periapical lesion and also the anatomy and morphology of the tooth. Radiographs are used for medico-legal records.

### Conclusion

No particular method is suitable in determining the WL.<sup>3</sup> The apex or the apical terminus is an anatomic termination point for the preparation of the root canal and obturation of the root canal and this should be determined with the assistance of both radiographs and an EAL. This will give results with precisions greater than 90%.<sup>4</sup> Hence, appropriate familiarity of the root canal anatomy, judicious use of radiographs and the accurate use of an electronic apex locator will help clinicians to attain an expectable working length of the root canal system for further endodontic treatment.<sup>5</sup> Though at any stage apex locators will not be to replace radiographs, but can definitely serve as an effective adjunct.

**Ethical Clearance :** Nil

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