ORIGINAL RESEARCH PAPER

Endodontic

ELECTRONIC APEX LOCATORS

KEY WORDS:

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ABSTRACT

Success or failure of root canal treatment depends on various factors, one amongst them is the ability to determine the working length with accuracy. Though radiographs are commonly used for determining the working length, they are inaccurate. Apex locators work on the basis of resistance and impedence and determine the location of apical foramen with accuracy. This review article focuses on the various advantages and functions of apex locator.

INTRODUCTION

Determining the working length with accuracy is the basic foundation on which the outcome of the shaping and cleaning is based. Calculating the working length correctly helps the clinician to shape and clean the canal without any risk of leaving or extruding debris and also obturate the canal and obtain proper hermetic seal. Earlier, the most commonly used device for this was radiographs, which are a two dimensional representation of a three dimensional structure, and hence resulted in incorrect measurements.

In the year 1918, Custer used electric current to measure the working length of a root canal.[1] Following which studies that were conducted by Suzuki and Sunada determined that the resistance between oral mucous membrane and periodontal ligament was constant at 6.5k.[2,3]

With the introduction of electronic era in endodontics, apex locators were introduced. These machines utilize the electrical impedance and resistance instead of relying on visual inspection.[4] This review article gives an overview of the basics of electronic apex locators , as well as describes methods to increase the precision of apex locators.

Advantages of electronic apex locators

1. Overcomes hindrance caused on radiographs by several anatomical structures such as impacted teeth, increased bone density, zygomatic arch, overlapping roots or impacted teeth.[5]
2. Reduction of treatment time.[5]
3. Radiation exposure is reduced.[5]
4. Can be used on pregnant patients.[5]
5. Accurate compared to radiographs.[6]
6. Defects such as resorptions, cracks or fractures on root, and perforations can be detected.[6]

Electrical circuit of a tooth[7]

Dentine and cementum are insulators whereas periodontal ligament is a conductor of electricity. In a root canal, the walls of the canals act as an insulator, and the apical foramen acts as a channel through with various conductive materials within the canals can be connected to periodontal ligament. The resistance offered by the tooth depends upon the length and cross sectional area and resistivity of the dentin, tissue and fluid.

As an endodontic file is introduced into the canal and is moved towards the apical foramen, the resistive material inside the canal decreases hence the resistance decreases. Along with resistance, a tooth also has capacitance when alternating current is applied. The file and the periodontal ligament acts as two conductive plates and cementum dentine, tissue and other fluids act as a separator. Hence on application of current, tooth behaves like a capacitor.

Factors affecting the accuracy of apex locators

1.Irrigants: Studies conducted showed that more electroco nd uctive the solution was, more was the inaccuracy.

Study	Apex locator	Irrigating solutions	results
Jenkins et al (in vitro study)8	Root ZX	2% lidocaine with 1:100,000 epinephrine, 5.25% sodium hypochlorite, RC Prep, liquid ethylenediaminetetraacetic acid (EDTA), 3% hydrogen peroxide(H2O2), and Peridex	Sodium hypochlorite showed most deviation
Meares and Steiman (in vitro study)9	Root Zx	2.5% and 5.25% Sodium hypochlorite	No difference
Pilot and Pitts (in vivo study)10	Sono Explorer Mark IV	RC prep, 70% isopropyl alcohol, 14.45% EDTA sodium solution, normal saline, and 5.25% NaOCl)	Sodium hypochlorite showed most error

2.Pulp vitality: Most studies have reported that pulp vitality does not affect the accuracy of apex locators, however there are several authors who disagree. Authors have suggested that difference might be due to root resorption, no viable periodontal tissues or altered or nonexistent apical constriction seen in non vital cases.

Study	Apex Locator	Results(Accuracy)
Arora and Gulabivala (In vivo)11	Endex	Vital tissue : 88.9% Non Vital Tissue: 45.4%
Mayeda et al (in vivo)12	Endex	No statistically significant difference
Stein and Corcoran13	AFA Apex Finder	Vital pulp:93.9% Non vital pulp:73.6%

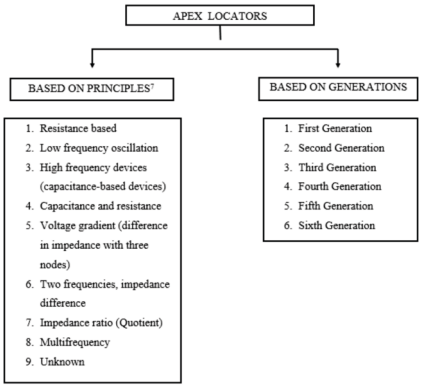
3.Foramen size: Huang said that if the size of apical foramen was 0.2mm or less, electroconductive irrigants did not affect the measurements recorded.[14] In a study the working length was calculated before and after apexification process, they concluded in all cases the measurement was 2-3mm short before apexification, whereas the measurements were 100% accurate after apexification. Stein et al had concluded that as the width of the major foramen increased, the distance between the tip and the foramen increased hence resulting in inaccurate readings.[13]

4.Resorption: If resorption of the apex leads to inadequate contact between the file tip and canal wall, The reading obtained is inaccurate.

5.Root Perforation: Any perforation on the root surface will act like an apical foramen, leading to contact between the file tip and periodontal ligament, which will result in completion of the circuit and hence the reading obtained will be shorter, indicating perforation.

6.Type of Metal: Although earlier it was thought that the metal used for making the file, may influence the working length, studies conducted to check the same showed it did not have any affect.

CLASSIFICATION:



First generation:
First-generation devices, also known as resistance apex locators, measure the resistance to direct current as the file tip reaches the apex (6.5 k).

- Devices in the first generation include:[4]

TRADE NAMES	MANUFACTURER
Root Canal Meter	Onuki Medical Co., Tokyo,Japan
Endodontic Meter	
Endodontic Meter S II	
Dentometer	Dahlin Electromedicine, Copenhagen, Denmark
Endo Radar	(Elettronica Liarre, Imola, Italy

Disadvantages:
1. As high direct current is applied, patient often felt pain during the measurement procedure.[5]
2. The readings with these devices were significantly inaccurate.[4]
3. In presence of blood, pus, pulp or irrigants , the length were not recorded correctly.[4]

Second Generation
These are also known as impedance based apex locators. They use a single frequency to measure the canal length.

TRADE NAMES	MANUFACTURER
Sono-Explorer	Hayashi Dental Supply,Tokyo, Japan
Sono-Explorer Mark II	
Sono-Explorer Mark II Junior	
Sono-Explorer Mark III	
Endocater	Yamaura Seisokushu, Tokyo, Japan
Apex Finder	Analytic/Endo, Orange, CA, USA
Endo Analyzer	
Digipex I,	Mada Equipment Co., Carlstadt, NJ, USA
Digipex II	
Digipex III	
Exact-A-Pex	Ellmann International, Hewlett, NY, USA
Formatron IV	Parkell Dental, Farmingdale, NY, USA
Root Canal Meter Mark II	Onuki Medical Co., Tokyo, Japan

Disadvantages:
- Incorrect reading in both dry and wet canals.[4]

Third generation
- They use the ratio of multiple frequencies to determine the working length.
- They have more powerful microprocessors and are able to process the mathematical quotient and algorithm calculations required to give accurate readings.

TRADE NAME	MANUFACTURER
Endex/Apit	Osada Electric Co., Tokyo, Japan
Root ZX	J. Morita Co., Kyoto, Japan
Dentaport ZX	
Justwo or Justy II	Yoshida Co., Tokyo, Japan
Mark V Plus	Moyco/Union Broach, Bethpage, New York, USA
Endox	Co. Lysis, Milan, Italy
Apex Finder AFA Model 7005	EIE Analytic Endodontics, Orange, California, USA
Mini Apex Locator	Sybron Endo
Apex Finder	Endo Analyzer 8001; Analytic Technology, Redmond, WA, USA
Neosono-D	Amadent Medical and Dental, Co., Cherry Hill, New Jersey, USA
Neosono Ultima EZ	Satelec Inc., Mount Laurel, New Jersey, USA
Foramatron D10	Parkell Electronic Division, Farmingdale, New York, USA
Apex NRG	Kibbutz Afikim, Israel
NovApex	Forum Technologies, Rishon Le-Zion, Israel
Neosono MC	Amadent Medical and Dental, Co., Cherry Hill, New Jersey, USA
Apit 7	Osada, Tokyo, Japan
DatApex	Dentsply-Maillefer, Ballaigues, Switzerland
Endy 5000	Loser, Leverkrusen, Germany

Fourth generation
Based on dual frequency.

Bingo 1020	Forum Engineering Technologies, Rishon Lezion, Israel
Elements Diagnostic Unit and Apex Locator	SybronEndo, Anaheim, CA, USA
Propex	Dentsply-Maillefer, Ballaigues, Switzerland
Raypex 4	VDW, Munich, Germany

Fifth generation
It measures the resistance and capacitance separately instead of measuring the impedance.[6]

TRADE NAME	MANUFACTURER
i-RooT	Emagic Finder Series ,S-Denti, Seoul, SouthKorea
Emf 100 Delux	

Joypex 5	Henan, Zhengzhou, china
Raypex 5	VDW, Munich, Germany
Propex pixi	Dentsply-Maillefer, Ballaigues, Switzerland
Propex II	

Supplied with a diagnostic table that included the statistics of the value at different position to diagnose the position of the file.[6]
Various apex locators available in market are:

Disadvantages:
Difficult to use in dry canals[6]
The accuracy varies with pulpal and periapical status.[4]

Sixth Generation
It is also known as adaptive apex locators.
This defines the condition of the canal and adapts to the dry or wet condition present in the canal.[6]

TRADE NAME	MANUFACTURER
Apex Locator Adatptive	Optica Laser, Yanev- Dental LTD, Bulgaria

Advantages:[6]
Used in dry and wet canals.
Can be used in canals with blood or inextirpated pulp.

Combination of Apex Locators
1. Apex locator and endodontic handpieces
a. Tri Auto ZX (J. Morita Co., Kyoto,Japan)
b. Dentaport ZX (J. Morita co.)
c. Sofy ZX (J. MoritaMfg. Corp.; Irvine, Calif.)
d. Endy 7000 (Ionyx SA, Blanquefort, France)
2. Apex locators and Pulp Vitality tester
a. Digipex I,II, III (Mada Equipment co., Carlstadt, NJ, USA)

CONTRAINDICATIONS
1.Presence of fluid:
- First and Second generation apex locators gave inaccurate readings when fluid was present in the canal.
- The third, fifth and sixth generation show accurate results even in presence of moisture, however completely drying the canal while using these locators may adversely affect the readings

2.Constrictions in the canal: Dentine debris may break the electrical circuit between file placed inside the canal and the periodontal ligament. Constant recapitulation and irrigation is required to avoid this. Also preflaring of the canals will help in increasing the accuracy of the readings.

3.Cardiac pacemakers:[15] Various studies have shown that devices such as electric pulp tester, EALs, and electrosurgical instruments can interfere with cardiac pacemaker. However there are also studies which show that no change in cardiac pacemakers activity is seen while using an apex locator.

Other uses[5]
- Detect root perforations
- Detect fractures
- Root resorption
- Root canal constrictions
- Root canal retreatment
- Endodontic treatment in primary teeth

Clinical use[5,16]
- Pre-operative radiographs must be taken to gain information about the anatomy,shape, apex closure , fractures or perforations present.
- Any metallic restorations present have to be removed as they might cause electrical shunting.
- As most of the apex locators work best in moist conditions, excess fluid in the canals should be removed.
- Irrigating solutions do not affect the third and fourth generation apex locators, however they should not be flooded in the canals.
- The file used should be in contact with the canal walls, as loose file may cause improper reading.
- As most apex locators are most accurate when displaying '0' or 'Apex' reading, the file should be advanced till the locator shows '0' reading and then 0.5 should be subtracted from it.
- Recheck the working length after shaping the coronal two third of the canal.
- The apex reading should only be accepted if the visual analogue bar of the apex locator is stable and moves in symphony with the movent of the file.
- If inflammatory exudates are present, an intracanal medicament needs to be placed and the working length should be checked at a subsequent visits.

CONCLUSION
No individual technique is truly satisfactory in determining endodontic working length. The CDJ is the termination point for the preparation and obturation of the root canal and it cannot be accurately 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.

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