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Electronic Apex Locators: A 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 accomplish this goal, the apical constriction must be precisely recognised during canal preparation, and during the process, perfect control over working length must be maintained. Working length may be determined using a variety of techniques, including the electronic approach. Apex locators have unquestionably been a useful adjuvant to radiographs since their introduction. This article outlines the characteristics of the electronic apex locators that are currently in use, including their evolution, generations, historical context, method of operation, categorization, issues related to usage, and level of clinical acceptability.

Keywords: Apex Locators, Root Canal, Working Length, Apical Constriction, Apical Foramen

Introduction

According to general consensus, it is widely understood that root canal therapy techniques should be limited to the root canal system. The accurate determination of working length helps greatly to have a better prognosis to the root canal treatment. This can only be accomplished if the length of the tooth and the root canal are precisely measured [1], for which various procedures have been developed to determine the terminus of the root canal.

Taking radiographs has traditionally been used to establish the point of termination for endodontic instrumentation and obturation. However, this method may prove slightly challenging because the apical constriction cannot be detected radiographically and variations in technique, angulations, and exposure alter this image, resulting in errors and multiple exposures that can be harmful to the patient [2]. As a result, electronic root canal working length estimation has grown significantly [3, 4].

The advancement of electronic apex locators (EALs) has rendered working length more reliable, precise, and predictable. For more than 40 years, EALs have been used in clinically in order to establish the file location in the canal. When connected to a file, these devices can identify the point at which the file exits the tooth and enters the periodontium [4, 5].

The purpose of this article is to review the development, mode of operation, fundamental working principles, classification, numerous generations easily available, challenges linked to them, and clinical acceptance of various Electronic Apex Locators.

Determination of Working Length

The most optimum physiologic apical limit of the working length is the cemento-dentinal junction (CDJ), when the pulp tissue changes into the periapical tissue. It is also known as the minor diameter. The CDJ and minor constriction, however, may not always correspond, especially in senile teeth owing to cementum deposition, causing variations in the location of the minor diameter. Hence, it is recommended to establish the Apical Constriction at the apical limit of the working length, where it is feasible to clean and shape or obturate the canals [6].

The apical foramen is not typically located at the tooth's anatomical apex. In 50-98% of cases, the apical foramen may be positioned up to a distance of 3.0 mm to one side of the anatomical apex. Kuttler reported that the distance between the apical constriction and the apical foramen is 0.659 mm in adults and 0.524 mm in young people [7].

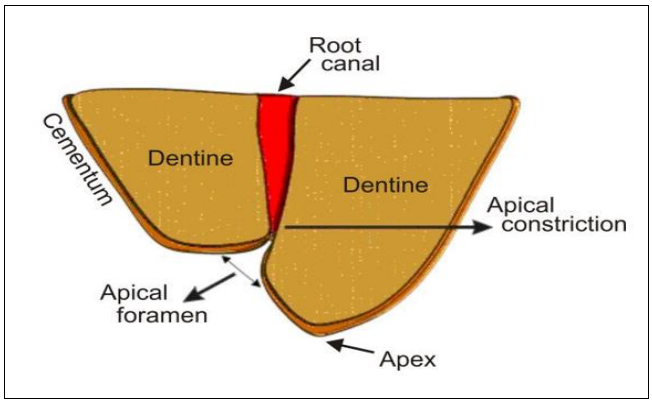

Fig 1: Anatomy of Root Apex

Significance of Working Length

- Determines how far the instruments can be placed and worked into the canal, and hence how deeply the tissues, debris and metabolites can be removed.
- Defines the maximum depth at which the canal filling can be placed. It influences the level of pain and discomfort experienced by the patient following the session.
- If calculated correctly, it will play a vital part in determining treatment success; but if calculated incorrectly it may result in treatment failure [8].

Determination of Working Length Using Radiography

Radiography is the most prevalent method for determining working length. A radiograph is acquired after an endodontic instrument is placed into the root canal to a depth roughly comparable to the apical constriction. The working length is estimated approximately by measuring the tip of file on radiograph from the radiographic profile of the apex. A radiograph for determining root canal length has been reported to be accurate in solely 80% of cases.

Direct digital radiography has not yet been proved to surpass conventional radiography in terms of quality, even with augmentation and measuring features. However, it is advantageous for its speed and reduced radiation doses. This breakthrough was possible because new hardware and software were available to analyse the metrical data generated by micro CT, allowing geometrical changes in prepared canals to be determined with increased detail [8, 9].

Determination of Working Length Using Electronic Apex Locators

Apex Locator:

Electronic apex locators (EALs) generate an electrical circuit using the human body. They have two sides, one attached to the endodontic file and the other to the patient's lip. When the point of the file comes into contact with the periodontal tissue, the electrical circuit is complete. These instruments are especially beneficial for individuals who have gag reflex problems or who are unable to tolerate radiography films or sensors [2, 3].

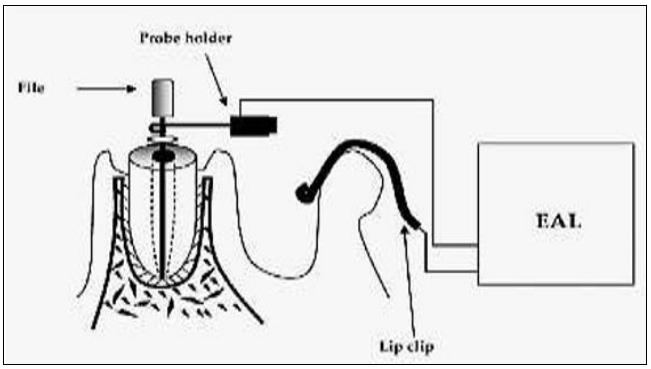

Fig 2: Circuit for determination of working length

Development of Electronic Apex Locator

Custer (1918) was the first to investigate an electronic approach for estimating root canal length [10]. Suzuki, in 1942, deduced that the constant value is caused by electronic resistance between the periodontal ligament and the oral mucosa [1, 10]. In 1962, Sunada designed the first electronic apex locator using Suzuki's theory [11].

Different generations of EALs have been designed since then to measure root canal length. Its primary advantage over radiography is that it can measure the length of the root canal to the end of the apical foramen as opposed to the radiographic apex [12].

Classification of Electronic Apex Locators

1st Generation Apex Locators (Resistance Type)

These are resistance based electronic apex locators. This measures the flow of direct current resistance, which is based on the idea that the resistance given by periodontal ligament and oral mucous membrane is 6.5 k [11]. In the presence of blood, pus, chelating agents, and irritants, these apex locators can produce false signals. The root canal meter was the first apex locator based on this approach [13]. The features of this generation apex locators are their ease of use, ability to identify perforations, compatibility with K files, auditory indication, and ability to be digitally read out.

The disadvantages of this generation include the fact that it requires a dry operating field to function accurately, requires good contact with the lip clip, requires calibration, and is unable to estimate beyond 2 mm.

Example:

1. Root canal meter (Onuki medical Co.tokyo, Japan).
2. Dentometer (Dahlinectromedicine, Copenhagen, Denmark).

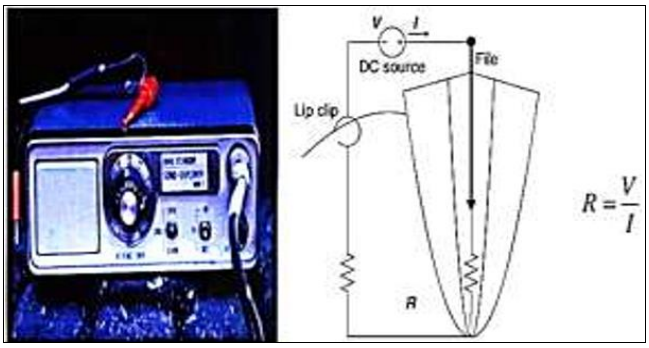

Fig 3: Root Canal Meter

2nd Generation Apex Locators (Impedance Type)

Because they operate on the principle of impedance, they are referred to as impedance apex locators. Endocater, Sono Explorer, Digipex, and Pio Apex Locator are examples of second generation apex locators [13]. It offers some advantages over the first generation. It operates on an analog method and does not require a lip clip. There has also been no report of patient sensitivity. One significant disadvantage is that the root canal must be devoid of electro-conductive elements in order to acquire an accurate measurement [14]. The Endo Analyzer (Analytic/ Endo, Orange, USA) is self-calibrating with a visual indicator, however accuracy reports have been inconsistent [1].

Examples: 1. Foramatron IV (Parkell Dental, Formingdale, New York, USA).

2. Digipex I, II, III (Mada Equipment Co., Carlstadt)

Fig 4: Endo Analyzer

3rd Generation of Apex Locators (Frequency Dependent Comparative Impedance Type)

These are nearly identical to second generation apex locators except that they employ various frequencies to estimate the distance from the canal's end, therefore the name frequency dependent apex locators. When the canal is well irrigated with an electrolyte such as saline or sodium hypochlorite, the apparatus produces reliable readings. It measures two impedances inside the canal at two different frequencies (8 kHz and 0.4 kHz). This device's downside is that it must be "reset" or "calibrated" for each canal [4]. Root ZX (J. Morita Japan) is a third-generation electronic apex locator that employs the dual-frequency and comparative impedance principles.

Example: 1. Root ZX (J.Morita, Tokyo, Japan)

2.Mini Apex Locator (Sybron Endo, Anaheim, CA, USA)

Fig 5: Root ZX

4th Generation of Apex Locators (Ratio Type)

These are ratio type apex locators that determine impedance at five frequencies. They compare the resistance and capacitance measurements to a database to compute the distance to the root canal apex. One significant disadvantage of fourth generation devices is that they only work in very dry or partially dried canals. It also becomes ineffective in heavy exudates or blood [5].

Examples: 1. Propex II (DentsplyMaillerfer, Ballaiques, Switzerland)

2. I-ROOT (E-Magic Finder)(S-DentiSEoul, South Korea)

Fig 6: a) Root ZX II b) Propex II

5th Generation of Apex Locators (Dual Frequency Ratio Type)

To address issues with prior generations of apex locators, a new measuring approach based on a comparison of data from the canal's electrical characteristics and additional mathematical processing was devised. As a result, fifth-generation apex locators (Dual Frequency Ratio Type) are presently in use.

The E-magic Finder line of 5th generation apex locators was introduced in 2003. It measures the circuit's capacitance and resistance individually. It is provided via a diagnostic table that contains file statistics. They have the highest level of precision in any root canal situation (dry, wet, bleeding, saline, EDTA, NaOCl) [15, 16]. When functioning in dry canals, devices using this technology have significant challenges.

The accuracy of electronic root canal length measuring varies with pulp and periapical condition during clinical procedure. The device features a digital readout, graphic illustration, and an auditory signal. To determine tooth vitality, the built-in pulp tester can be utilized [5].

Examples: 1. Apex Locator Joypex 5 (Henan, CBD Neihuan Road, Zhengzhou, China)

2. Raypex 5 (VDW, Munich, Germany)

Fig 7: E-Magic Finder

6th Generation of Apex Locators (Adaptive Apex Locators)

The long-term efficacy of 6th generation EALs has yet to be determined. One significant advantage of an adaptive apex locator is that it eliminates the need for canal drying and moistening [5]. Adaptive apex locators continuously define canal humidity and instantly adapt to dry or wet canal. This allows it to be used in dry or moist canals, as well as canals containing blood or exudates [17].

Advancements in Apex Locators

Combination of Apex Locators with Endodontic Handpiece

The incorporation of an apex locator with the endodontic slow-speed hand piece is the most recent breakthrough in modern dentistry. These have the following benefits:

1. As soon as the device is placed into the canal, the file begins to rotate automatically.
2. If the predetermined torque has been exceeded, the hand piece stops and reverses its rotation.
3. Whenever the file tip extends beyond the apex, the integrated apex locator stops the rotation and reverses it.

The Root ZX has been combined with a handpiece to measure canal length when a rotary file is used. This has been marketed as the Tri Auto ZX (J. Morita Co., Kyoto, Japan).

The nickel-titanium rotary instruments used in the handpiece rotate at 240 to 280 rpm. Depending on the severity and morphology of the root canal being treated, Kobayashi *et al*. indicated that "to get the best results, it may be necessary to use some hand instrumentation" in conjunction with the Tri Auto ZX.

The Tri Auto ZX has a reported accuracy of 95%, which is similar to the Root ZX. Alves *et al*. tested the Tri Auto ZX's ability to find the AF after root filling material was removed during root canal therapy *in vitro*. They discovered that the Tri Auto ZX was accurate to 0.5 mm in more than 80% of teeth after root filling removal.

The Dentaport ZX (J. Morita Co., Kyoto, Japan and J. Morita Mfg. Co., Irvine, California, USA) was recently introduced to the Japanese and US markets. The Dentaport ZX is made up of two parts: the Root ZX and the Tri Auto ZX. The handpiece employs nickel-titanium rotary instruments that rotate at speeds ranging from 50 to 800 rpm.

Other Apex-Locating Handpieces

1. Kobayashi *et al*. reported regarding the development of SOFY ZX (J. Morita Co., Kyoto, Japan), a new ultrasonic system that uses the Root ZX to electronically monitor the location of the file tip during all instrumentation processes. This device reduces the risk of overinstrumentation.
2. In Europe, the Endy 7000 (Ionyx SA, Blanquefort Cedex, France) is available.

Short Comings of Apex Locators

1. Canal shape, lack of patency, dentine debris accumulation, and calcifications can all influence precise working length calculation with electronic apex locators.
2. Because intact vital tissue, inflammatory exudates, and blood can conduct electric current and create inaccurate measurements, their presence should be minimised before accepting an apex reading [1, 4].

Apex Locators and Cardiac Pacemakers

Electric pulp testers, EALs, and electrosurgical equipment have the potential to interfere with cardiac pacemakers. Because there are different therapeutic purposes and types of pacemakers, the use of an electric pulp tester may have no effect on some.

A patient with a fixed-rate cardiac pacemaker who needed root canal therapy was described in a 1996. An EAL was employed after consulting with the patient's cardiologist. The patient had no harmful effects either immediately or later on.

Garofalo *et al*. reported in 2002 that four of five third generation EALs tested with a single cardiac pacemaker demonstrated proper pacing, with only one producing an erratic pace recording on an oscilloscope [18].

Wilson *et al*. recently investigated whether EALs, or electric pulp testers, interfere with the function of implanted cardiac pacemakers or cardioverter/defibrillators *in vitro*. They discovered no evidence of interference when using 3rd generation EALs or an electric pulp testing as described by patients with working, implanted cardiac devices. They came to the conclusion that EAL, or electric pulp tests, are safe to use in patients who have cardiac pacemakers or cardioverter/defibrillators.

Conclusion

The EAL device has drawn a lot of interest because it works on the basis of electrical impedance rather than visual inspection. When the apical portion of the canal system is hidden by anatomic structures such as impacted teeth, tori, the zygomatic arch, excessive bone density, overlapping roots, or shallow palatal vaults, EALs are very beneficial.

A comparison of the EAL readings with the radiograph will help practitioners achieve predictable results in the presence of metallic restorations, severely undermined caries, serous, purulent, or hemorrhagic exudates, or when there are cracks, root fractures, internal or external root resorption, wide-canal, or a wide-open apex.

In determining the endodontic working length, no single technique is completely satisfactory. Modern electronic apex locators can determine this position with higher than 90% accuracy, but they have significant limits. In most clinical scenarios, knowledge of apical anatomy, wise use of radiographs, and the use of electronic apex locators are user friendly, less time consuming, and more dependable. Although apex locators cannot replace radiography at this

point in time, they will undoubtedly serve as an efficient adjuvant.

References

1. Gordon MPJ, Chandler NP. Electronic Apex Locators. Review International Endodontic Journal. 2004; 37:425-437.
2. Katz A, Tamse A, Kaufman AY. Tooth length determination: A review. Oral Surg Oral Med Oral Pathol. 1991; 72:238-242.
3. Nekoofar, *et al*. The Fundamental Operating Principles of Electronic Root Canal Length Measuring Devices. International Endodontic Journal. 2006; 39:595-609.
4. Ebrahim AK, Wadachi R, Suda H. Electronic Apex Locators-A Review. J Med Dent Sci. 2007; 54:125-136.
5. Sonal Soi, Sumit Mohan, Vineet Vinayak, Prabhjot Kaur. Electronic Apex Locators. Journal of Dental Sciences & Oral Rehabilitation, 2013, 24-27.
6. Kobayashi C, Suda H. New electronic canal measuring device based on the ratio method. J Endod. 1994; 20:111-114.
7. Kuttler Y. Microscopic investigation of root apexes. J Am Dent Assoc. 1955; 50:544-552.
8. Bhatt Akansha, Gupta Vishesh, Rajkumar. Arora Ruchi B. Working Length Determination-The Soul of Root Canal Therapy: A Review.
9. Martinez-Lozano MA, Forner-Navarro L, Sanchez-Cortes JL, *et al*. Methodological considerations in the determination of working length. Int Endod J. 2001; 34:371-376.
10. Custer C. Exact methods for locating the apical foramen. J Nat Dent Assoc. 1918; 5:815-819.
11. Sunada I. New method for measuring the length of the root canal. J Dent Res. 1962; 41:375-387.
12. Kobayashi C. Electronic canal length measurement. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 1995; 79:226-231.
13. https://www.juniordentist.com/apex-locators-classification-uses-types.html
14. Krell KV Fouad AF. An *in Vitro* Comparison of Five Root Canal length measuring Instruments. Journal of Endodontics. 1989; 15:p557.
15. Salvcho Dimitrav, Dimitur Rashkev. Sixth Generation Adaptive Apex Locator. Journal of IMAB (annual proceeding scientific papers) Book 2, 2009.
16. Kovacevic M, Tamarut T. Influence of the Concentration of Ions and Foramen Diameter on the Accuracy of Electronic Root Canal Length Measurement-An Experimental Study. Journal of Endodontics. 1998; 24:346-351.
17. Ashish Kalhan, Ronak Choudhary, Shraddha Chokshi, Rupal Vaidya. Evolution of Apex Locators. The Journal of Ahmedabad Dental College and Hospital. 2010; 1 (1):4-7.
18. Garofalo RR, Ede EN, Dorn SO, *et al*. Effect of electronic apex locators on cardiac pacemaker function. J Endod. 2002; 28:831-833.