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Newer Generation Apex Locators - A Review

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Abstract: ***An apex locator is a dental electronic equipment used to detect the length of a root canal. This technology has revolutionized the way root canal treatments are performed, improving accuracy and reducing the risk of overfilling or perforation. Over the years, several generations of apex locators have been developed, each with their own unique features. In clinical endodontics, determining the exact position of this termination point has always been challenging. The working length was historically determined using conventional radiography until the development of modern electronic apex locators (EALs). EALs have received a lot of attention since they were first introduced over 50 years ago. The first - generation apex locators were introduced in the 1990s and used a low - frequency current to measure the resistance of the tissue. They were accurate but were affected by various factors like moisture and blood. There have been development since then which led to development of several generations of apex locators. Overall, with each new generation of apex locators, the accuracy and reliability of these devices have significantly improved, making root canal procedures faster, safer, and more efficient. This article reviews the working principles, advantages and disadvantages of newer generation apex locators.***

Keywords: Electronic apex locators, working length, apical foramen, root canals, endodontics

1. Introduction

For endodontics to be successful, the removal of pulp tissue, necrotic debris, and germs from root canal is crucial. This can only be accomplished if the tooth's length and the diameter of the root canal are accurately measured.[1]

Conventional radiographs have traditionally been used to determine working length.[1, 2]

Working length is the distance between the coronal reference point and the end point of canal preparation and obturation.3 Incorrect WL root canal determination can result in residual bacterial infection, which can cause a significant flaw in the root end area, loss of the apical seal, failure of the endodontic therapy, and serious flare - up isssues.[3]

Numerous methods, including tactile perception, radiography and electronic apex locators are regularly used to locate this crucial point.[4]

Apex locators with dual and multifrequency technology have been widely used to locate the apical foramen in a variety of canal conditions.[5, 17]

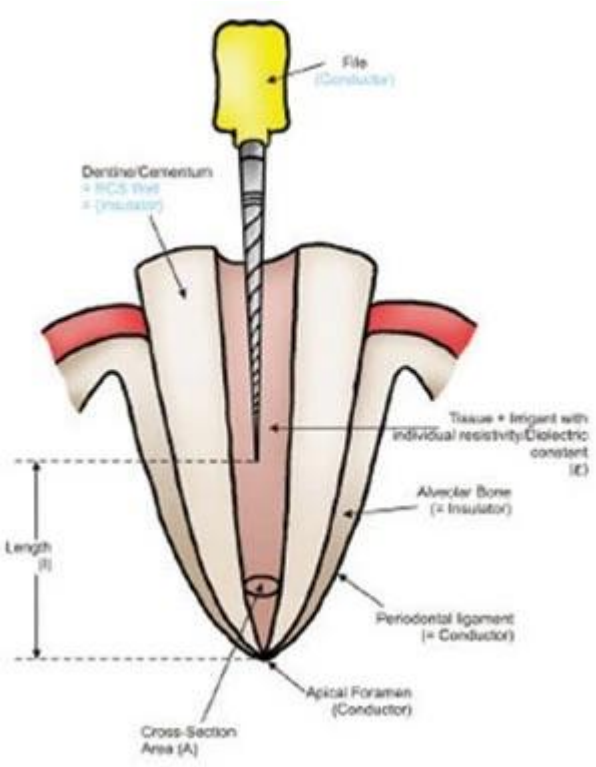
Adaptive devices that have a steady algorithm for measuring the working length of the root canal depending on the canal's moisture characteristics.[11]

2. History

Dr. Levitt Ellsworth Custer introduced the idea of using electricity to pinpoint the ends of root canals in dentistry in 1918. Additionally, he has written a book about dental electricity. Suzuki, who had been researching the direct current flow through dog teeth, went back to Custer's concepts and principles in 1942. He noticed constant electrical resistance values between an instrument in a root canal and an electrode on the oral mucous membrane, and he made the assumption that this would measure the length of the canal. Sunada used these ideas to create a straightforward instrument that measured the canal length using direct current[6, 14]. 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.[7, 15]

Classification of EAL

1st Generation Electronic Apex Locators (1stGEALs) (Resistance Type):



They are also known as resistance - based vertex locators because they measure resistance to DC flow or resistance. It was found to be less reliable compared to radiographs as the measurements were significant.

The root canal meter (Ohnuki Medical Co., Ltd.) was developed in 1969 and used the resistance method and 150Hz sinusoidal alternating current. Using currents below 5 μm was often painful.

Dentometer (Darin Electro Medicine, Denmark) and EndoRadar (Electronica Liarre, Italy) are also first generation electronic apex locators.

Demerits:
They were not very popular as they gave inaccurate readings in obstructed canals, wet canals, in defective restorations, in perforations and in patients with cardiac pace makers.[2]

Electronic apex locators of the second generation (2nd GEALs) (Impedance Type):
They are also known as impedance based apex locators. The idea behind second - generation apex locators is that the presence of translucent dentin causes an electrical impedance across the root canal wall. Electrical impedance across the root canal walls of the tooth increases, and this rise is larger apically than coronally. The amount of impedance drastically decreases at the cemento - dentinal junction.

Sono - Explorer (Hayashi Dental Supply, Japan) and Sono - Explorer M - III are the examples of second generation apex locators.

Demerits:
A major drawback of these apex locators was that electro - conductive materials gave inaccurate readings. To get an accurate measurement, the root canal must be clear of electroconductive substances. In addition, they required calibration and intricate calculations, coated probes in place of standard endodontic instruments, there was no digital readout, and they were highly challenging to use.[2]

Electronic Apex Locators of 3rd generation (3rd GEALs) (Frequency dependent comparative impedance Type):
With the exception of the fact that they use various frequencies to calculate the separation from the canal's terminus, they are comparable to second generation EALs. These devices have more potent microprocessors and can conduct the algorithm calculations and mathematical quotients needed to provide precise readings18. These devices are referred to as "Frequency Dependent" because the frequency and current flow can have a significant impact on a circuit's impedance.[2]

Ended was the first apex locator in this generation, but it required calibration for each canal before use. This problem was solved in Root ZX, which was introduced later. It did not require any calibration. The impedance of the canal is measured concurrently at two distinct frequencies of 400 Hz and 8 kHz. The result of dividing the impedance values of 400 Hz and 8 kHz is the quotient value. When the quotient value is 0.67, the reading of the minor diameter is displayed. These apex locators outperformed their forerunners in terms of precision and dependability.[8, 16]

AFA, Neosono Ultima EZ, Justy II, ProPex (Dentsply - Maillefer, Switzerland), Bingo 1020 (Forum Engineering Technologies), Elements - Diagnostic (Sybronendo), Raypex_5, (VDW, Munich, Germany) are the other third generation apex locators.[2, 8]

Demerits: [11, 12]

- It requires lip clip.
- chances of short circuit.
- Sensitive to canal fluid level

Electronic Apex Locators of 4th generation (4th generation EALs) (Ratio Type):

These are ratio - type or multiple frequency apex locators, which include an electric pulp tester built in and can measure impedance at five frequencies. Instead of using a mathematical method to analyse the impedance data, these devices use measurements of capacitance and resistance to compare against a database in order to calculate the distance to the root canal's apex.

They are promoted by Sybron Endo and consist of the ROOT ZX II and PROPEX II in addition to the AFA Apex Locator and Elements Diagnostic Unit. It makes use of a composite waveform made up of two signals, 0.5 and 4 kHz, which are then amplified and supplied to the patient circuit model after being translated from digital to analogue.[2]

This group also includes the Coltene Canal Pro Apex Locator. AC signals at two frequencies are used to accomplish the measurements in the Canal Pro apex locator. Other apex locators blend the frequencies instead of alternating them, which eliminates the requirement for signal filtering and gets rid of the noise produced by non ideal filters.[8]

Bingo 1020/Raypex (Forum Engineering technologies, Israel) said to be a fourth generation device. This unit uses two separate frequencies 400 Hz and 8 KHz similar to the current 3rd generation unit.[19]

Demerits: [11, 13]

They must work in relatively dry or partially dry canals. Additional drying may be required in some cases. In addition, they cannot be used if there is a lot of exudate or blood.

Electronic Apex Locators of 5th generation (5th GEALs) (Dual Frequency Ratio Type):

A novel measurement method was developed based on comparison and further mathematical processing of data retrieved from canal electrical properties to address the issues with previous generation apex locators. Apex locators of the fifth generation were introduced in 2003 as a part of the E - magic Finder series. Measure the circuit's capacitance and resistance separately. A diagnostic table with file statistics offers this service.20 In every root canal scenario (dry, wet, bleeding, saline, EDTA, NaOCl), they demonstrate the highest level of precision. The device offers a graphic illustration, a digital readout, and an auditory alert. The tooth viability can be checked with the built - in pulp tester.2

Demerits:

- Working in dry canals is challenging.
- Require additional wetting.

Electronic Apex Locators of 6th generation (6th GEALs) (Adaptive Apex Locators):

A major advantage of this Apex Locator is that the canal does not need to be dried or moistened. Adaptive Apex Locator continuously measures canal moisture and instantly adjusts to dry or wet canals. This allows it to be used in dry or wet canals, canals with blood or exudate. Their efficacy in long - term use has not yet been determined.2

Adaptive Apex Locators - Discussion

These adaptive apex locators offer graphic information on multicolor multimedia displays. A consistent algorithm for adjusting the method used for determining the working length of the root canal depending on the canal's moisture properties has been developed due to the extensive direct and juxtaposed investigations.[9]

This sixth generation apex locators was developed by Slavcho Dimitrov and DimiturRoshkev. This was done in order to ADAPT the method of measurement to the actual characteristics of the environment to measure. The factors they looked at included

- The number of frequencies to measure,
- The impulse properties of the various frequencies,
- Developing a mathematical transformation procedure for the canal's observed electrical properties
- Developing models of experimental simulation of various measurement environments (on testing devices);
- Establishing steady criteria that concern the moments when programmes adapt in accordance with the electro-mechanics of the canal; and
- Developing a method for determining the canal's moisture depending on where the measuring instrument's apex is located.
- Following this they conducted preliminary studies using 30 freshly extracted teeth.

Due to the modern technology, these apex locators are handy and fits in dentist's palm. Measurement mode provides graphical information displayed on a color multimedia display. At the physician's request, the adaptive apex locator retrieves audio information via either the familiar beeps typical of 5th generation apex locators or appropriate voice prompts.

The apex locator's display is divided into 2 sectors.

Information regarding the starting point of measuring while reaching the outermost and inner dentine structures is recorded at the stage of accessing the root canals with an endodontic device. The device signals that we are in contact with the dentine in the root canal, just before the apex zone. The zones that the instrument's tip has reached up until the apical zone are shown on the screen after a sound signal.

The device issues auditory information that repeats the data on the display

"two" — when the tip is in zone II, before the physiological narrowing
"one" — when the tip is in zone I before the physiological narrowing
"apex" — when the tip of the instrument is between the physiological narrowing and the anatomical foramen.
"over" — the tip has passed through the anatomical foramen.

The adaptive apex locator combines the advantages of the 4th and 5th generation measurement methods. This is made possible by the additional function of predetermining duct moisture. Accurate measurements, mathematical evaluations and determinations of canal moisture are performed within just one thousandth of a second of the canal instrument tip penetrating. Depending on the humidity being constantly measured, this device automatically adapts the measuring method to dry or wet conditions.[10]

3. Conclusion

In addition to eliminating the necessity to dry or moisten the canal, measurement with the adaptive apex locator allows for high levels of measurement precision to be achieved in the presence of blood, other fluids (such as sodium hypochlorite), or when manipulating dry canals. Since they are still relatively new, there is still a great deal of clinical research to be done and observations to be made.

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