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An Insight Into Electronic Apex Locator

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Abstract: Prior to root canal treatment at least one undistorted radiograph is required to assess canal morphology. A correct working length with the help of Radiograph or Electronic Apex Locator is one of the critical factors for the success of Endodontic Treatment. Short measurements may leave parts of the Root Canal un-instrumented. On the other hand, over instrumentation with enlargement of the apical constriction may result in damage to peri radicular tissues. Therefore correct working length has a role in treatment success. Compared to Radiograph, Electronic Apex Locators reduces the number of radiographs and assists where radiograph method is difficult to access. This review of literature focusses on the insight into electronic apex locator. Search engines used are, PubMed and Google Scholar.

Keywords: Apex locators, root apex, working length, endodontic treatment.

1. **Introduction:**The removal of pulp tissue, necrotic material and microorganisms from the root canal is essential for endodontic success. This can only be achieved if the length of the tooth and the root canal is determined with accuracy.[1] This length is called as the working length(WL), which is defined as "the distance from a coronal reference point to the point at which canal preparation and obturation should terminate".[2]The outcome of treatment of roots with necrotic pulps and periapical lesions is influenced significantly by the apical level of the root filling. [3]Traditionally, conventional radiographs are used to determine the WL. However, radiographs are subject to distortion, magnification, interpretation variability, and lack of a two-dimensional representation of a three-dimensional object.[4]Radiograph is a technique

that provides information about the canal anatomy and surrounding tissues, but superimposition and anatomy interferences can be problematic and affect correct interpretation of the images.[5] The use of electronic devices became popular and numerous devices have been introduced to the market. The advantages of electronic apex locators (EALs) include reduction in radiation dosage and procedure time, both of which aid in maintaining patient cooperation.[6]The development of the electronic apex locator has helped make the assessment of working length more accurate and predictable.[7]The aim of this review is to have a deep and accurate understanding of electronic apex locators (EALs).It is generally accepted that root canal treatment procedures should be limited to within the root canal system. [8] To attain this objective the end- point of the root canal system, the canal terminus, should be detected as precisely as possible during preparation of the canal. Therefore, one of the main concerns in root canal treatment is to determine how far instruments should be advanced within the root canal and at what point the preparation and filling should terminate. [9]

Anatomical apical portion of root:

To appreciate fully the concept of working length, an understanding of apical anatomy is required. The anatomy of the apical foramen changes with age.A root canal had two main sections, a longer conical section in the coronal region consisting of dentine and a shorter funnel- shaped section consisting of cementum located in the apical portion The shape of this apical portion is considered to be an inverted cone (Fig. 1); its base being located at the major apical foramen. The apex of the inverted cone is the minor foramen that is often thought to coincide with the apical constriction regarded as being at or near the cemento-dentinal junction (CDJ).In other words, the most apical portion of the root canal system narrows from the opening of the major foramen, which is within cementum, to a constriction (minor foramen) before widening out in the main canal to produce an hour-glass shape (Fig. 1).[10]Theoretically, the CDJ is the appropriate apical limit for root canal treatment as at this point the area of contact between the peri radicular tissues and root canal filling material is likely to be minimal.[11] The term 'theoretically' is applied here because the CDJ is a histological site and it can only be detected in extracted teeth following sectioning; in the clinical situation it is impossible to identify its position. In addition, the CDJ is not a constant or consistent feature.In clinical practice, the minor apical foramen is a more consistent anatomical feature that can be regarded as being the narrowest portion of the canal system and thus the preferred landmark for the apical end-point for root canal treatment. [12]

Determining the root canal terminus

Various techniques have been used for determining the position of the canal terminus and thus measure the working length of root canals. The most popular method has been the use of radiographs. However, although it is generally accepted that the minor apical foramen and apical constriction is on average located 0.5–1.0 mm short of the radiographic apex.[12]There are wide variations in the relationship of these landmark that would result in under- or over-preparation of canals with an obvious impact on the position of the root filling. Thus, many studies have shown that canal lengths determined radiographically vary from actual root canal lengths by a considerable amount. The accuracy of radiographic methods of length determination depends on the radiographic technique that has been used. For example, Sheaffer et al.[13] revealed that higher density radiographs were more desirable for measuring working length. There is an ongoing need to reduce exposure to ionizing radiation whenever possible and it is difficult to locate its position using radiographs alone, even with multiplane

angles.[14]Hence, the innovations in root canal treatment has been the development and production of electronic devices for detecting the canal terminus.

Birth of electronic apex locators

An electronic method for root length determination was first investigated by Custer (1918). The idea was revisited by Suzuki in 1942 who studied the flow of direct current through the teeth of dogs. He registered consistent values in electrical resistance between an instrument in a root canal and an electrode on the oral mucous membrane and speculated that this would measure the canal length (Suzuki 1942).Sunada in 1962 took these principles and constructed a simple device that used direct current to measure the canal length. It worked on the principle of electrical resistance of the mucous membrane and periodontium registered 6.0 kΩ in any part of the periodontium irrespective of the type of teeth or the shape or age of the subjects. Using direct current caused instability with measurement, and polarization of the file tip altered the measurement.

In 1960 Gordon was the second to report the use of a clinical device for electrical measurement of root canal. It made a significant contribution to the evolution of apexlocators in North America with his reports on the Sono Explorer in 1970. Later, frequency measurements were taken through the feedback of an oscillator loop by calibration at periodontal pockets depth of each tooth.

A third generation EALs was developed by Kobayashi during 1980s. He used multiple channel impedance ratio based to measure the impedance of two different frequencies.

Functional principle of electronic apex locators

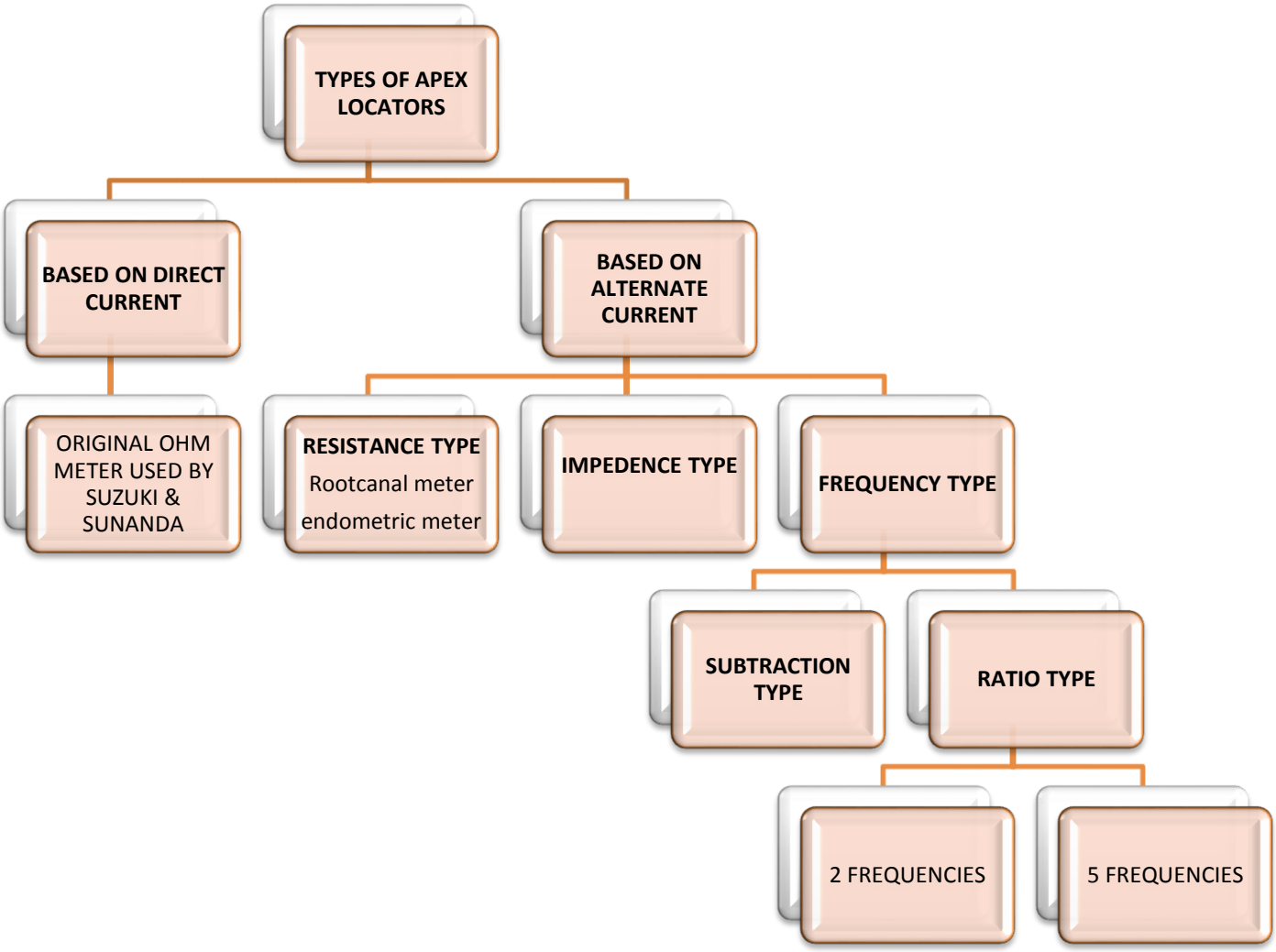
EALs functions by using the human body to complete an electrical circuit. One side of the apex locator's circuit subsequently connected to the oral mucosa through a lip clip and the other side to a file. (Fig. 2) When the file is placed into the root canal and advanced apically until its tip touches periodontal tissue at the apex, the electrical circuit is completed. The electrical resistance of the EALs and the resistance between the file and oral mucosa are now equal, which results in the device indicating that the apex has been reached.

When a circuit is complete (tissue is contacted by the tip of the file), resistance decreases markedly and current suddenly begins to flow. Depending upon the devices, this sudden current flow signaled by a beep, abuzzer, digital readout, flashing light or pointer on screen display. The electrical characteristic of the tooth structure are measured and exact position of the instrument in the tooth is determined.[15]

2. Classification

The classification of apex locators was given by Mc Donald (1992)[16] based on,

- **Type of current flow** (operating principle)



Classification according to generation:

1) **First Generation Electronic Apex locators - Resistance type apex locators:**These apex locators has a built in resistance value of 6.5 kilo Ohms. The apex locators are attached to the patient's lip on one side and the other side is attached to the file. The file is then advanced into the canal until it touches the periodontal tissue at the apex which then completes the circuit.These devices were found to be unreliable when compared with radiographs, with many of the readings being significantly longer or shorter than the accepted working length. **Eg.:** Root canal meter/ the endodontic meter (Onuki), Sono-explotet (satelec), Neosono-D, MC.

   Advantages are, 1) It's Easy to operate, 2) It uses K-type files, 3) Digital readout, 4) It can also be used to detect perforation and 4) It has a built in pulp tester.Disadvantages are, 1)It Requires a dry environment to give an accurate result, 2) Caries or defective restorations has an impact on accurate detection of working length, 3) It Require

calibrations 4) It Requires a lip clip with good contact 5) Perforations can give rise to false readings and 6) there is patient sensitivity.

2) **Second generation electronic apex locators-Impedance type apex locators:** Operate on the principle that there is electrical impedance across the walls of the root canal due to the presence of the transparent dentin. The tooth exhibits increasing electrical impedance across the walls of the root canal, which is greater apically than coronally. At the DCJ, the level of impedance drops dramatically. The unit detects the sudden change and indicates it on the analogue meter. To overcome the problem of a wet environment, insulated probes are utilized.Eg.: Endocator uses 400 kHz.

   Advantages are, 1) It can operate even in fluid environment, 2) There is no patient sensitivity 3) It has an analogue meter 4) It can also operate with root canal lubricants 5) It has no lip clipand 6) It can be used to detect perforations and bifurcated canals.Disadvantages are, 1) It requires calibration to function efficiently, 2) There is no digital readout, 3) It's difficult to operate and 4) Coated probes are required.

3) **Third generation electronic apex locators-Frequency dependent apex locators:** Operate very similarly to the impedance type except it uses multiple frequencies to determine the distance from the end of the canal. It measures the impedance of tooth at two different frequencies. In the coronal portion of the canal, the impedance difference between the frequencies is constant. As the file advanced apically, the difference in the impedance value begins to differ greatly with maximum differences at the apical area.Advantages are, 1) It's easy to operate and can also be used in fluid environment, 2) It can also operate with root canal lubricants and 3) It has a low voltage electrical output. Disadvantages being, 1) It must be calibrated at each canal 2) Its sensitive to canal fluid level and requires fully charged battery.

   Ratio method: The Root ZX devicedetermine the impedance at 2 frequencies 0.4 kHz & 8kHz and have built in electronic pulp tester.The built in pulp tester can be used to access tooth vitality

4) **Fourth generation electronic apex locators- Ratio type:** The Root ZX 11 and Rey-Pex 5 device determine the impedance at multiple frequencies and have built in electronic pulp tester.These devices not process the impedance information as a mathematical algorithm, but instead take the resistance and capacitance measurement and compare them with a database to determine the distance to the apex of the root canal.This generation uses two different frequencies namely 0.4 kHz and 8kHz alike to the current 3rdgeneration. Disadvantages are, they need to perform in relatively dry or in partially dried canals. Also in heavy exudates or blood it becomes inapplicable.

5) Fifth Generation Electronic Apex Locators – Dual Frequency Ratio Type: To cope with associated problems with previous generations of apex locators a new measuring method has been developed based on comparison of the data taken from the electrical characteristic of the canal and additional mathematical processing. And so the fifth generation apex locators (Dual Frequency Ratio Type) are now being used.It measures the capacitance and resistance of the circuit separately. It is supplied by diagnostic table that includes statistic of the file. This unit is an error free in any

conditions like wet (blood, irrigants) canals. 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.

6) **Sixth Generation Electronic Apex Locators- Adaptive Apex Locators:** The efficacy of 6^{th} generation EALs in long term use is yet to be established. A major advantage of adaptive apex locator is eliminating necessity of drying and moistening of the canal.Adaptive apex locators continuously define humidity of the canal and immediately adapts to dry or wet canal.Hence, it is feasible to be used in wet or dry canals and canals with blood or exudates.

Other applications of Electronic Apex Locators-

1. To detect root perforations to clinically acceptable limits.
2. Determine the location of root and pulpal floor perforations.
3. To detect horizontal fractures.
4. To confirm suspected periodontal or pulpal perforations during pinhole preparation.
5. Recognize any connection between the root canal& periodontal membrane such as root fracture and cracks.

Drawback associated with the use of apex locators

1. It is ineffective for teeth with incomplete root formation.
2. Though majority of present generation apex locators are not affected by endodontic irrigants within the root canal, dry canals shows reliable results during working length determination.
3. Intact vital tissue, inflammatory exudates and blood can conduct electric current and cause inaccurate readings so their presence should be minimized before accepting apex reading.
4. Canal shape, lack of patency, the accumulation of dentine debris and calcifications can affect accurate working length determination with electronic apex locators.
5. It has been suggested that prefacing of root canals as used in modern crown-down preparation techniques would increase the accuracy of reading.
6. Electronic apex locators have the potential to interfere with cardiac pacemakers. The manufacturer of electronic apex locators specifically warns against their use with patients with cardiac pacemaker. As there are many therapeutic uses and types of pacemakers some may not be influenced by apex locator use.

3. Conclusion

Modern electronic apex locator has played an excellent role in determining the working length which indirectly has an impact on the treatment success. EALs has an accuracy greater compared to others and it can also be used at angles where radiograph won't be able to be play the role. Like a coin with two sides, EALs also has some limitations like it can't be used

in patients on pacemaker or defibrillators, intact vital tissues and inflammatory exudate also has an impact on determining the working length.

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