ELECTRONIC APEX LOCATOR:
A COMPREHENSIVE LITERATURE REVIEW

ABSTRACT

Accurate working length determination is a prerequisite for successful root canal treatment, reducing the chance of insufficient cleaning of the canal or of damaging the periapical tissues from over instrumentation. The use of an electronic apex locator has improved the accuracy of the working length measurement in clinical endodontics. Various electronic methods have been developed that use a variety of other principles to detect the canal terminus. Whilst the simplest devices measure resistance, other devices measure impedance using high frequency, two frequencies, or multiple frequencies. In addition, some systems use low frequency oscillation and/or a voltage gradient method to detect the canal terminus. The aim of this review was to have an insight into the fundamental operating principles of the different types of electronic systems that claim to measure canal length.

Keywords: apex locators, canal length, endodontics, root canal terminus.

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INTRODUCTION

Accurate working length determination is a prerequisite for successful root canal treatment, reducing the chance of insufficient cleaning of the

canal or of damaging the periapical tissues from over instrumentation1,2,3. Among clinicians, it is generally accepted that working length extends from the coronal portion of the root canal to the apical constriction. Various anatomic studies have determined the apical constriction to fall 0.5 to 1.0mm from the apical opening of the tooth, or major foramen4,5. Successful outcome of pulp space therapy is the prime concern of an endodontist for which one needs to restrict oneself to the confines of the apical constriction. The term constriction locators would there fore be more appropriate. An electronic apex locator is an electronic device used in endodontics to determine the position of the apical foramen and thus determine the length of the root canal space. The apex of the root has a specific resistance to electrical current, and this is measured using a pair of electrodes typically hooked into the lip and attached to an endodontic file. The electronic principle is relatively simple and is based on electrical resistance; when a circuit is complete (tissue is contacted by the tip of the file), resistance decreases markedly and current suddenly begins to flow. According to the device this event is signalled by a beep, a buzz, a flashing light, digital readouts, or a pointer on a dial. Electronic apex locators reduce the number of radiographs required and assist where radiographic methods create difficulty. The Neosono-copilot is a combination of an electronic apex locator and pulp tester and is the most recent innovation in apex location. This new generation of apex locator can measure pulp space lengths accurately even in the presence of conductive fluids. The device provides the operator with a digital read out, graphic illustration and an audible signal. The built in pulp tester can be used to assess tooth vitality and to ascertain proper and effective anaesthesia.

Why electronic apex location?

Advantages:

- Accurate
- Easy and Fast
- Reduction of exposure to radiation
- Perforations can be detected
- Can measure the pulp space exactly to the minor constriction.

The anatomy of the pulp space is very complex. To achieve success in endodontics, the variations in the internal anatomy should be thoroughly understood. A simple classification has been put forth by Vertucci to explain the various patterns of a pulp space. It is of immense importance to differentiate between Anatomical apex, Apical foramen and Apical constriction. An endodontic procedure must not extend beyond the constriction in conventional endodontic therapy.

Electronic apex locators:

The first generation apex locators -

Also known as resistance based apex locators, measure opposition to the flow of direct current or resistance. The Root Canal Meter (Onuki Medical Co., Tokyo, Japan) was developed in 1969. It used the resistance method and alternating current as a 150 Hz sine wave. Pain was often felt due to high currents in the original machine, so improvements were made and released as the Endodontic Meter and the Endodontic Meter S II (Onuki Medical Co.) which used a current of less than 5 μA . Other devices in the first generation include the Dentometer (Dahlin Electromedicine, Copenhagen, Denmark) and the Endo Radar (Elettronica Liarre, Imola, Italy). 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.6

The second generation apex locators-

Also known as impedance based apex locators, measure opposition to the flow of alternating current or impedance. Second generation apex locators were of the single frequency impedance type which used impedance measurements instead of resistance to measure location within the canal. Impedance is comprised of resistance and capacitance and has a sinusoidal amplitude trace. The property is utilized to measure distance in different canal 7conditions by using different frequencies. An increasing number of second generation apex locators were

designed and marketed, but all suffered similar problems of incorrect readings with electrolytes in the canals and also in dry canals.

The third generation apex locators:

Third generation apex locators are similar to the second generation except that they use multiple frequencies to determine the distance from the end of the canal. These units have more powerful microprocessors and are able to process the mathematical quotient and algorithm calculations required to give accurate readings. The Endex/Apit :The relative values of frequency response method detects the apical constriction by calculating the difference between two direct potentials picked up by filters when a 1 kHz rectilinear wave is applied to the canal. 8 This was described by Saito & Yamashita (1990) and the method was used to develop the Apit (also marketed as the Endex by Osada Electric Co., Tokyo, Japan), the original third generation apex locator (Frank & Torabinejad 1993).9 The Apit is able to measure lengths with electrolytes in the canal but needs to be calibrated in each canal .The main shortcoming of early apex locators (erroneous readings with electrolytes) 10 was overcome by Kobayashi et al. (1991) with the introduction of the ratio method and the subsequent development of the self-calibrating Root ZX (J. Morita, 11 Tokyo, Japan) (Kobayashi & Suda 1994).11 The ratio method works on the principle that two electric currents with different sine wave frequencies will have measurable impedances that can be measured and compared as a ratio regardless of the type of electrolyte in the canal. The capacitance of a root canal increases significantly at the apical constriction, and the quotient of the impedances reduces rapidly as the apical constriction is reached. Kobayashi & Suda (1994) showed that the ratio of different frequencies has definitive values, and that the ratio rate of change did not change with different electrolytes in the canal.

The fourth generation apex locators:

Bingo 1020/Ray-Pex 4 - The Bingo 1020 (Forum Engineering Technologies, Rishon Lezion, Israel) claims to be a fourth generation device and the unit uses two separate frequencies 400 Hz and 8 kHz similar to the current third generation units. The manufacturers claim that the combination of using only one frequency at a time and basing measurements on the root mean square values of the signals increases the measurement accuracy and the reliability of the device.12

The fifth generation apex locators:

5th generation apex locator was developed in 2003. It measures the capacitance and resistance of the circuit separately. It is supplied by diagnostic table that includes the statistics of the values at different positions to diagnose the position of the file. 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 (Kovacevic et al., 2006).13 So, pulp condition and periapical diseases should be considered to evaluate the relation between the pulp state and accuracy of electronic apex locators.

The sixth generation apex locators:

Adaptive Apex Locator overcomes as the disadvantages of the popular fourth generation apex locators which is low accuracy on working in wet canals, as well as the disadvantages of devices in the fifth generation, which is difficulty on working in dry canals and necessity of compulsory additional wetting. Adaptive Apex Locator continuously defines humidity of the canal and immediately adapts to dry or wet canal. 17,18,19This way it is possible to be used in dry and in additional wetted canals as well, canals with blood or exudates, canals with still not-extirpated pulp.20

Conclusion

The new era marks the beginning of a better future. Latest developments will continue in the field of endodontics. No individual technique is truly satisfactory in determining endodontic working length. The CDJ is a practical and anatomic termination point for the preparation and obturation of the root canal and this cannot be 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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