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Evaluation of Accuracy of Two Frequency-Based Electronic Root Canal Length Measurement Devices – An Ex Vivo Study.

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Abstract: *The location of apical constriction is paramount for a successful endodontic therapy. Electronic apex locators operate on the basis of conductance of electricity through hollow tube. Useful when the apical portion of the canal is obscured by anatomic structures, such as impacted teeth, tori, the zygomatic arch, excessive bone density, overlapping roots, or shallow palatal vaults. Electronic apex locators reduce the radiation dose and treatment time. The Frequency Dependent Apex Locators are based on the principle that there is a maximum difference of impedance between electrodes depending on the frequencies used. The major advantages with these apex locators are that they operate in an electroconductive environment in the presence of pus, and pulpal tissue remnants. The aim of this study was to compare the accuracy of dual frequency based electronic apex locators under clinical conditions. This study was done on 40 single rooted non carious teeth designated for extraction for orthodontic or periodontal reasons. After access opening and pulp extirpation, working length was measured using both apex locators alternatively using K file. The file was luted in the canal using GIC. The tooth was then extracted. Group I comprises of the tooth with the working length measured Neosono Copilot and in Group II is that of ROOT ZX. The apical third of each specimen were then viewed in Stereo microscope under 30 x magnifications. The distance from file tip to minor diameter was measured for each apex locator. The values obtained were analysed statistically by Paired Sample't' test. The results showed that the working length measurements by both apex locators were not statistically different. The use of Electronic Apex Locators is a reliable method of determining root canal length. The measurement made by both devices where not different statistically. The results show that the electronic root canal length measurement device is an adjunct to endodontic practice.*

Keywords: *Working Length, Apex Locators, Root ZX, Neosono Copilot.*

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I. Introduction

The precise location of the apex of root canal is a prerequisite for a successful endodontic therapy. Working length is defined in the endodontic Glossary as "the distance from a coronal reference point to the point at which canal preparation and obturation should terminate".[1] According to Kuttler, the narrowest diameter of the canal is definitely not at the site of exiting of the canal from the tooth but usually occurs within the dentin, just prior to the initial layers of cementum.[2] The minor diameter is the narrowest part of the canal with the smallest diameter of blood supply, thus creating the smallest wound site and best healing condition. The minor diameter represents the transition between the pulpal and the periodontal tissue, located in the range of 0.5 to 1.0 mm from the external foramen or major diameter on the root surface.[2]The position of the minor diameter is altered by many factors.

An improper working length established either beyond or short of the minor diameter may cause apical perforation and overfilling of the root canal system or may lead to inadequate debridement and underfilling of the canal respectively. Radiograph method of working length determination is acceptable, but cannot accurately determine the apical constriction.[3] Electronic method of measuring the root canals overcomes some of deficiencies of radiographic method such as when the apical portion of the canal is obscured by anatomic structures, like impacted teeth, tori, the zygomatic arch, excessive bone density, overlapping roots, or shallow palatal vaults. Also using electronic apex locators helps in minimizing radiation.[4]

Among the various types of apex locators Frequency Dependent Apex Locators is widely used. These apex locators have the ability to operate in an electroconductive environment inside the canal such as presence of pus, blood, and pulpal tissue remnants.[5, 3]

The aim of this study was to compare the accuracy of frequency based Electronic Root Canal Length Measurement Devices– Root ZX and Neosono Co-pilot in working length determination under clinical conditions.

II. Materials And Methodology

A total of 40 single rooted noncarious teeth with completely formed apices confirmed with a radiograph that are indicated for extraction due to periodontal or orthodontic reasons were selected for the study. An informed written consent from each patient and approved by the institutional ethical committee. The coronal half of the clinical crowns was flattened to create a coronal reference point. Access opening and pulp extripation was done under local anesthesia and rubber dam isolation. The coronal portion of the canal was preflared using Gates Glidden drills, sizes 2 to 4. The canal was irrigated with 3% sodium hypochlorite solution. K-file with a silicone stop was used to measure the working-length in moist canal using the two Electronic Apex Locators alternatively according to the manufacturer's instructions. In Group-I the working length is measured with Root ZX and Neosonocopilot. The file is inserted till the reading indicates apex reached.The file was then cemented at the working length measured by Neosono co-pilot using a Glass Ionomer Type-I cement. In case of Group II the file was cemented at the working length measured by Root ZX. The file is cut at the handle using carborandum disk at low speed.Withthefilescementedinpositionthe teeth were extracted and placed in 5.25% sodium hypochlorite for 15 min to dissolve blood and tissue remnants. The samples were stored in 0.2% thymol solution until sectioning of apical third. Under a low magnification the apical 4 mm of the root was shaved using a finishing diamond until the file could be seen through a thin layer of dentin. The last layer was then carefully removed using a #15 B.P. blade. Each specimen was viewed at 30x original magnification. The distance (d_1-Neosono Copilot and d_2-Root ZX) from the file tip to the minor diameter was measured using the optometric lens of the stereomicroscope. The working length measured by the two Electronic Apex Locator groups were compared and statistically analyzed using a paired samples t test to determine the accuracy of each Electronic Apex Locators in relation to the minor diameter.

III. Results

A total of 40 teeth for each of the two groups were used for the study. All the measurement was recorded in millimetres.Table 1 shows the descriptive statistics for the both groups. From table 1, it can be seen that according to the paired sample t test, there is no statistically significance difference between the two groups ($p<0.01$).The values obtained for each group were then categorized into five ranges. The percentage for all the five categories was tabulated (Table 2) and graphically represented (Graph 1). The range of values lies between -1.0 mm to +1.0 mm with 0.5 mm increment. These values correspond to the position of file in relation to minor diameter. The value +1.0mm denotes the file is located beyond the minor diameter. While the value -1.0mm denotes the file located short of the minor diameter.Number of cases falling in each category is noted and the percentage of cases calculated for each category. The Root ZX located the minor diameter to within ±0.5mm in 90% of cases. The NeosonoCopilot located the minor diameter to within ±0.5mm in 85% of cases.

IV. Discussion

The ability to determine the working length accurately is a challenging task in endodontic therapy.[6] However, of the methods currently available for root canal length measurement, neither the tactile method nor the radiographic method allows precise location of apical termination point. In the radiographic approach, the working length is measured from the position of the radiographic apex. This does not coincide with apical constriction nor even with the apical foramen, but depends on a series of factors like tooth inclination, film position, length of thebeam, vertical & horizontal cone angulations. Nevertheless, the main inconvenience is that both the approaches are entirely subjective and not reproducible.[4, 6]

Root canals are surrounded by dentine and cementum which act like insulators to electric current. Minor apical foramen is like a small hole in with conductive materials that are electrically connected to the periodontal ligament which can act as a conductor of electric current.[7] The value of resistive material of the canal (dentine, tissue, fluid depends on the length, cross-sectional area and the resistivity of the materials. The structure of the root canal also has capacitive characteristics. As an endodontic file placed inside the canal acts as one side of a capacitor while the periodontal ligament being the other plate.[7] Anatomy of the canal, presence of tissue, fluid, and tooth structure itself form a complicated resistive and capacitive elements.[8]To measure and predict such a complex electrical network, multiple frequency alternating current and a algorithm was used. The third generation (frequency dependent) apex locators are based on frequency (Root ZX) and frequency (Neosono Copilot) which are able to locate the point of maximum root canal narrowing. The apex locators

measure the maximum difference in impedance between the dual frequencies used. The devices detect the apical narrowing by change in impedance of the probing electrode (or file) to tissue fluids.[9]When a file tip is located away from the minor diameter, the impedance in the canal is negligible, but when the file reaches the immediate vicinity of the minor diameter, the magnitude of the impedance of the canal suddenly increases. As the file tip contacts the periapical tissue (tissue fluids), such as the periodontal ligament, the impedance value rapidly decreases, indicating that the file is beyond the minor diameter. Since the impedance of a given circuit may be substantially influenced by the frequency of the current flow, these devices have been called "frequency dependent" apex locators.[4, 10]

The measurement of working length by the electronic apex locators is affected by various factors such as inflammation, blood, pus, types of irrigants.[12] Hence, the present study was planned as an ex vivo study to compare frequency based apex locators under clinical conditions.Several factors have been proposed to affect the accuracy of electronic root canal length measurement devices. They are presence of electroconductive substances in the root canal, diameter of the apical foramen, canal shape, shape and volume of the measurement probe.[13]The accuracy of resistance-based and impedance-based apex locators are affected by the canal contents as the devices measure the resistance or impedance using single frequency DC and AC current respectively. Whereas the canal contents has no influence on the measurement made by frequency-based apex locators. The basis for this is the basic circuitry that has been incorporated in each device. The Root ZX uses two frequencies of alternating current and calculates the quotient of the impedance values. This quotient is a constant that is not affected by various canal contents.[14] The Neosono Copilot on the other hand is designed to work in a "WET" mode to be used when the canal is not totally dry. The type and size of the apical diameter has significant influence on the measurement. Huang stated that when the size of the apical foramen is increased beyond 0.2mm the electronic apex locators tend to locate the minor diameter coronally resulting in shorter working length measurement.[13] Stein et al also concluded that as the width of the major foramen increased the distance between file tip and the foramen increased. Immature or "Blunderbuss" apices tend to give shorter measurements electronically due to the instruments not touching the apical dentinal walls. In this study the Root ZX located the minor diameter shorter in 2.5% of cases and NeosonoCopilot in 5% of cases. These results may be due to enlarged apical foramen that results in impedance values to decrease prematurely as it contacts the periapical tissues.[16]

Wu et al has indicated that, as apical foramen size decreases the electronic root canal measurement devices tend to record longer readings.[17]This may probably be due to the fact that the devices have been calibrated for average size of the apical foramen. In this study the NeosonoCopilot recorded the working length to be longer in 10% of cases while in 7.5% of cases were longer in case of Root ZX. The variations between the apex locators may be due to the fact that the design of the particular apex locator, and the algorithm used.

V. Conclusion

From the results of the present study, it may be concluded,

1. The use of Electronic Apex Locators is a reliable method of determining root canal length.
2. The measurement made by both devices where not different statistically.
3. The results show that the electronic root canal length measurement device is an adjunct to endodontic practice.

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Legends

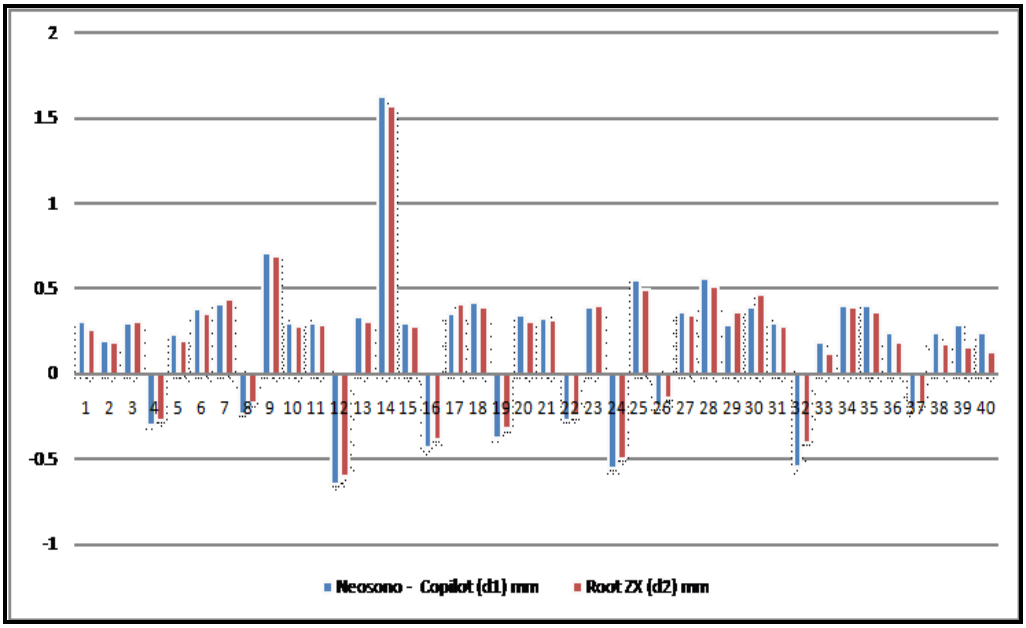
Table 1: Comparison of accuracy in location of minor diameter
Table 2: Percentage of both groups in different categories
Graph 1: Percentage of both groups in different categories

Table 1

Device	Mean (mm)	Maximum (mm)	Minimum (mm)	Standard Deviation	't' value
Root ZX	+0.19	+1.57	-0.60	0.462	0.677
Neosono Copilot	+0.20	+1.63	-0.65	0.472	

Table 2

Distance From Minor Diameter (mm)	Neosono Copilot		Root ZX	
	n=40	Percentage%	n=40	Percentage%
-1.0 to -0.5	2	5	1	2.5
-0.5 to 0.0	8	20	9	22.5
0.0 to 0.5	26	65	27	67.5
0.5 to 1.0	3	7.5	2	5
1.0	1	2.5	1	2.5



Graph 1

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