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A COMPARATIVE EVALUATION OF ACCURACY OF THE ROOT ZX ELECTRONIC APEX LOCATOR IN THE PRESENCE OF DIFFERENT IRRIGANTS

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Abstract

Objective: The aim of this study is to evaluate the accuracy of Root ZX in determining working length in presence of 2% chlorhexidine and 5% sodium hypochlorite.

Material and Methods: Thirty extracted, single rooted, single canal human teeth were used. Teeth were decoronated at CEJ and actual canal length determined. Then working length measurements were obtained with Root ZX in presence of 2% chlorhexidine and 5% NaOCl. The working length obtained with Root ZX were compared with actual canal length and subjected to statistical analysis.

Results: No statistical significant difference was found between actual canal length and Root ZX measurements in presence of 2% chlorhexidine. Highly statistical difference was found between actual canal length and Root ZX measurements in presence of 5% of NaOCl, however all the measurements were within the clinically acceptable range of ±0.5mm.

Conclusion: The accuracy of EL measurement of Root ZX within±0.5 mm of AL was consistently high in the presence of 2% chlorhexidine and 5% sodium hypochlorite.

Clinical significance: This study signifies the efficacy of ROOT ZX (Third generation apex locator) as a dependable aid in endodontic working length.

Key words: Root ZX, working length, chlorhexidine, sodium hypochlorite.

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Introduction

The establishment of appropriate working length is one of the most critical steps in endodontic therapy. Cleansing, shaping and obturation of the root canal systems cannot be accomplished perfectly unless the working length is determined precisely.[1] Working length (WL) is the distance from a coronal reference point to a point at which the canal preparation and obturation should terminate.[2]

Establishing the working length at the apical constriction is considered ideal for endodontic treatment.[3] The apical constriction (minor apical diameter) is the narrowest apical portion of the root canal with a variety of morphological variations that make its identification unpredictable.[4]

Many methods have been put forward for determination of the working length but with varying degree of accuracy.[5] Traditional methods for establishing the working length include the use of radiography, anatomical averages and knowledge of the anatomy, tactile sensation and paper point technique.[6] However, the possibility of the radiographic distortion, operator measuring errors or use of an improper radiographic technique can lead to faulty readings.[5]

In order to overcome these drawbacks, electronic apex locators have been introduced to determine the working length and form an important adjunct to radiography.[7] The use of electronic devices to determine the WL was proposed first by Custer (1918)[8], and the first electronic apex locator (EAL) was developed following Suzuki's investigation of the electrical resistance properties of oral tissues (Suzuki 1942).[9] Sunada in 1962 adopted the principle reported by Suzuki and was the first to describe the detail of simple clinical device to measure working length in patients.[10]

All apex locators function by using the human body to complete an electrical circuit. One side of the apex locator's circuitry is connected to an endodontic instrument. The other side is connected to the patient's body, either by a contact to the patient's lip or by an electrode held in the patient's hand. The electrical circuit is complete when the endodontic instrument is advanced apically inside the root canal until it touches periodontal tissue. The display on the apex locator indicates that the apical area has been reached.[11,12]

The electrolytes in root canals are considered to be one of the main factors that affect the precision of measurements made by certain EALs (Fan et al. 2006, Özsezer et al. 2007).[13,14] Consequently, it is important to understand the effects of the different irrigants that are used in root canal treatment on the accuracy of measurements made by EALs.[15] The effect of

Table I. Group 1 (5% NAOCL)

Tooth number	Actual canal length AL (mm)	Electronically calculated working length EL with Root ZX(mm)	Score	Difference (AL-EL)
1.	15	15	0	0
2.	19	18.5	1	0.5
3.	16.5	16.5	0	0
4.	13.5	13.1	1	0.4
5.	17	17	0	0
6.	16	15.6	1	0.4
7.	14.5	14.2	1	0.3
8.	17	17	0	0
9.	14.5	14.5	0	0
10.	16.5	16	1	0.5
11.	15.5	15.5	0	0
12.	15	15	0	0
13.	14	14	0	0
14.	16	15.6	1	0.4
15.	12	12	0	0

Table II. Group 2 (2% CHX)

Tooth number	Actual canal length AL (mm)	Electronically calculated working length EL with Root ZX(mm)	Score	Difference (AL-EL)
1.	12	11.8	1	0.2
2.	15.5	15.5	0	0
3.	16.5	16.5	0	0
4.	19	19	0	0
5.	12.5	12.2	1	0.3
6.	16.5	16.5	0	0
7.	17	17	0	0
8.	11.5	11.5	0	0
9.	14	14	0	0
10.	13.5	13.5	0	0
11.	13	13	0	0
12.	13.5	13.5	0	0
13.	15	15	0	0
14.	16	16	0	0
15.	14.5	14.5	0	0

Table III Mean (SD) of AL and EL measurements with Root ZX in the presence of different irrigants.

Irrigants	Actual Length Mean (SD)	Electronic Length Root ZX Mean (SD)	Paired 't' value	P value	Difference
5.0% NaOCl	15.467 (1.695)	15.300 (1.639)	2.988	0.010*	0.1667 (0.2160)
2% CHX	14.667 (2.093)	14.633 (2.135)	1.435	0.173^{NS}	0.0333 (0.0899)
Unpaired 't' value	1.150	0.959			2.207
P value	0.260^{NS}	0.346^{NS}			0.036*

NS; p > 0.05; Not significant; *p<0.05; Significant different irrigants on the accuracy of EALs has been evaluated (Kaufman et al. 2002, Erdemir et al. 2007).[16,17]

However, few studies have focused on the influence of different irrigating solutions used along with electronic apex locator (Root ZX). Therefore, the purpose of this study was to compare the accuracy of electronic apex locator (Root ZX) in the presence of commonly used irrigating solutions (Sodium Hypochlorite and Chlorhexidine).

Materials and Methods:

Thirty, straight, single-rooted permanent human teeth with mature apices were selected for this study. The teeth were cleaned of calculus, soft tissues, and debris with hand instrumentation and stored in distilled water until used. Teeth with resorption, curvatures, open apices, or radiographically invisible canals were excluded from the study.

The teeth were decoronated at the level of cementoenamel junction with a diamond disc to allow access to the root canal and to provide a stable reference for all measurements. The coronal portion of each canal was preflared using sequential Gates Glidden drills #4, #3, and #2 (Mani Inc., Japan), irrigated with saline and pulp extirpated with a barbed broach.

Measurement of actual working length

Teeth were numbered 1–30 and the actual canal length (AL) was determined by introducing a size 10 or 15 k-file (Mani Inc., Japan) into the canal until its tip emerged through the major apical foramen. The long axis of the tooth was placed perpendicular to the line of sight and the tip of the file was positioned tangential to the major apical foramen. After carefully adjusting the silicone stopper to the reference point, the file was withdrawn from the root canal, and the distance between the file tip and silicone stopper was measured with a scale to the nearest 0.5 mm; 0.5 mm was subtracted from this length and recorded as AL.

To simulate the periodontium, this study used the in vitro model as designed by Donnelly.[18] A polystyrene container (30 ml) was filled with warmed gelatin solution and refrigerated for 2 hrs to set. The apical two thirds of the root was embedded in gelatin, and the tooth was stabilized to the lid of a container with auto-polymerizing resin. The lip electrode was also placed in gelatin through another opening in the lid.

Working model for electronic working length determination

The irrigants tested will be: 5% sodium hypochlorite (NaOCl) and 2% chlorhexidine gluconate (CHX) The irrigant to be tested was introduced into the canal with a 23-guage needle.

The EAL tested in this experiment was: Root ZX (J. Morita Mfg Corp., Japan). It was used according to manufacturer's instructions.[19] Depending on the size of the canal, #15 or #20 K-file (Mani Inc., Japan), was attached to the file holder and introduced into the canal. The meter's 0.5 mm reading was set between the “APEX” and “1” (factory setting) as indicated by a flashing bar and will be used for electronic measurements. The file was gently inserted into the root canal until the “APEX” signal will be displayed. The file was then gently retracted until the display showed a flashing image of the root canal and a flashing bar between APEX and 1 (0.5 reading). The silicone stopper on the file will be carefully adjusted to a reference point, and the file was withdrawn to measure the distance between the silicone stopper and the file tip and noted down. This was recorded as the electronically measured canal length (EL).

The electronically measured Working length (EL) was compared with the actual canal (AL) length measured conventionally and scores were attributed to the resulting values[20].

Comparison between the electronically measured Working length (EL) and the actual canal (AL). Score Situation
0 Working Length (WL) equal to gold standard
1 Working Length (WL) from 0.5 to 1mm shorter than gold standard

2 Working Length (WL) > 1mm shorter than gold standard

3 Working Length (WL) exceeds gold standard

The canal length was assessed for each tooth with individual irrigants. The results obtained (in millimeters) were recorded. The difference between the median of electronically measured length (EL) and the AL was calculated for each tooth in the presence of all irrigating solutions. The resulting difference in working length was noted down.

Results:

Table I and Table II show the actual working length obtained with conventional method and the electronically measured working length obtained with Root Zx using different irrigants (5% NaOCl & 2% Chlorohexidine). It also indicates the score given and the difference in working length obtained per tooth.

The mean values of actual canal length and electronically measured working length with Root ZX along with their differences for two groups are given in table III. Table III shows that the working length difference obtained by different groups of irrigants is statistically significant as P value = 0.036. It depicts that the difference in working length obtained with 5% NaOCl are significantly larger than those obtained with 2% Chlorohexidine.

Although statistically significant difference exists between the irrigants, the majority of the readings were within the acceptable range of ±0.5 mm for Root ZX.

The results indicate that Root ZX is accurate within ±0.5mm 100% of the time with two test irrigants.

Discussion

Establishment of the correct working length is an important stage in root canal treatment, because sufficient evidence suggests that instrumentation either beyond or too short of apex can adversely affect success.[21]

Historically, conventional radiography has been the primary means for determining the working length in endodontic therapy. However radiographs have inherent limitations like providing only two-dimensional images of three-dimensional objects.[22]

The EAL is a device used to accurately determine the location of the apical foramen. Kuttler[3] and Green[23] have shown that the apex coincides with the anatomical foramen no more than 50% of the time. This limits the usefulness of radiographs, even if the quality is excellent.[24] An excellent adjunct, therefore, is the use of an EAL. The first-generation EALs were resistance-based and the second-generation EALs were impedance-based apex locators.[5] The main shortcomings of these EALs included poor accuracy in the presence of fluids and pulp tissue, and the need for calibration.[25] The frequency-based third-generation EALs have more powerful microprocessors and are able to process mathematical quotient and algorithm calculations required to give accurate readings.[26]

Root ZX (J. Morita Mfg Corp., Kyoto, Japan) is a third-generation EAL that uses dual frequency and comparative impedance principle is based on the "ratio method" for measuring canal length. This method simultaneously measures the impedance values at two frequencies (8 and 0.4 kHz) and calculates a quotient of impedances. This quotient is expressed as a position of the file in the canal.[27] Root ZX requires no calibration, and can be used when the canal is filled with a strong electrolyte.[5]

The fourth-generation apex locators do not process the impedance information as a mathematical algorithm, but instead they take the resistance and capacitance measurements separately and compare them with a database to determine the distance to the apex of the root canal.[26]

However, only few investigations have been carried out to compare the electronic root canal length measurements with that of the actual root canal length. In this *in vitro* study electronic apex locator namely Root ZX was used to calculate the length of the root canal.

However, there is still a concern as to whether high electroconductive irrigants such as saline, anesthetic solution, and sodium hypochlorite can affect the of these new-generation EALs performance.[25]

The present study used an in vitro model as described by Donnelly to obtain accurate measurements. The advantages of the model were its simplicity, ease of use and the ability to have strict control over the tested experimental condition. A disadvantage of the model is its inability to fully simulate in vivo conditions.[18]

The use of irrigating solutions is an important aspect of endodontic treatment. Sodium hypochlorite (NaOCl) is the most popular irrigating solution. NaOCl ionizes in water into Na and the hypochlorite ion, OCl, establishing an equilibrium with hypochlorous acid (HOCl). At acidic and neutral pH, chlorine exists predominantly as HOCl, whereas at high pH of 9 and above, OCl predominates.[28] Hypochlorous acid is responsible for the antibacterial activity. NaOCl is commonly used in concentrations between 0.5% and 6%. It is a potent antimicrobial agent, killing most bacteria instantly on direct contact. It also effectively dissolves pulpal remnants and collagen, the main organic components of dentin. Hypochlorite is the only root-canal irrigant of those in general use that dissolves necrotic and vital organic tissue. It is difficult to imagine successful irrigation of the root canal without hypochlorite.[20]

Chlorhexidine gluconate (CHX) is widely used in disinfection in dentistry because of its good antimicrobial activity.[29] CHX is marketed as a water-based solution and as a gel (with Natrosol). Some studies have indicated that the CHX gel has a slightly better performance than the CHX liquid but the reasons for possible differences are not known.[30] CHX solutions in concentrations of 0.2–2% are considered toxicologically safe.[31] However, there is paucity of research regarding the accuracy of EAL in presence of Chlorhexidine.[32] It is imperative that the clinician should be confident of the fact that irrigating solution is not effecting the accurateness of the apex locator.[20]

The study confirms that, Root ZX is 100% accurate within 0.5 mm from the apical foramen. Thus, measurements attained within this tolerance are considered highly accurate. According to this study, statistically significant difference was found when measurements were done in canals irrigated with 5% sodium hypochlorite. The possible reason for this variation could be the higher electrical conductivity of sodium hypochlorite.

This study shows that Root ZX can reliably be used for determining the position of the apical foramen in the presence of above mentioned irrigating solutions.

Conclusion

It can be concluded that Root ZX can accurately determine the root canal length within ±0.5 mm from the apical constriction. Therefore it is clinically safe and accurate to use Root ZX with the two mentioned irrigating solutions in this study.

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