Effect of canal dryness and flaring on the accuracy of two electronic apex locators

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ABSTRACT

Background: This in vitro study evaluated the effect of canal dryness and flaring on the accuracy of two electronic apex locators for working length (WL) determination.

Materials and methods: Sixty extracted teeth were used, after access opening was done, the occlusal surface was flattened to create stable reference point. The teeth were randomly divided into two equal main groups of flared and unflared group each one of 30 teeth. The flaring was done with Gates Glidden drills. The two main groups were further subdivided into two subgroups: dry canal and wet canal using 5.25% sodium hypochlorite groups, Electronic WL of each sample was determined using both Root ZX and i-Root apex locator. Consequently, histologic WL was determined by shaving the apical 4mm of the root longitudinally and the tip of # 15 K-file was adjusted to the apical constriction under stereomicroscope at a magnification 20X, then the file removed carefully and the length was recorded using digital caliper. The data had been collected from two independent examiners and statistically analyzed using Student's t-test.

Results: The results showed differences between flared and unflared canal, wet and dry, Root ZX and i-Root apex locators, however the differences between them were statistically not significant, in which ($P \geq 0.5$) for all situations.

Conclusion: dryness of the canal, coronal flaring had little effect on the accuracy of electronic apex locators (EALs).

Key words: Apex locator, working length, dryness, flaring. (J Bagh Coll Dentistry 2013; 25(3):1-7).

INTRODUCTION

Accurate determination of working length is essential factor for successful endodontic treatment[1]. The apical constriction, when viewed under histological cross-sectioning, is the narrowest part of the root canal, and preparation to this mark is thought to result in optimal healing conditions[2].

It is generally accepted that working length extends from the coronal reference point to the apical constriction. Various anatomic studies have determined the apical constriction to fall 0.5 to 1.0 mm from the apical opening of the tooth, or major foramen [3]. This measurement is necessary to ensure complete removal of all pulp tissue and necrotic material from within the root canal, but also to prevent extrusion of filling material into surrounding periapical tissue which can behave as an irritant factors[2].

The radiograph is one of the traditional method for the determination of the root canal length and Seltzer et al[4]were the first to report greater success in terminating cleaning and obturating the root canal system just short 1mm of the radiographic apex, rather than overfilling or underfilling.

It is difficult to achieve accuracy of canal length by radiograph, because the apical constriction (AC) cannot be identified in radiograph, and variables in technique, angulations and exposure distort this image and lead to errors [5]

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The electronic method eliminates many of the problems associated with radiographic measurements. The most important advantage of apex locator over radiography is that it can measure the length of the root canal to the apical constriction, not to the radiographic apex [6]. Advances in technology have led to the development of EALs that determine the minor diameter position using the “ratio method”. This method allows for simultaneous measurement of impedance at two or more frequencies, a quotient of impedance is then calculated which is expressed as a position of file in the canal [7].

However, there are few researches on the effect of combined various clinical factors together on the accuracy of EALs. The aims of the study was to evaluate the effect of flaring and dryness on the accuracy of two types of electronic apex locators

MATERIALS AND METHODS

Sample Collection

A total number of 60 extracted teeth were used in this study. Distal canal of mandibular first and second molars, and single canal maxillary second premolar, mandibular premolars and palatal canal of maxillary first and second molars were included in the study from the collected teeth. The external tissue debris, calculus, soft tissue and the clotted blood were removed with scaler and tooth brush under running tap water; any metallic restoration was removed with the use of high speed turbine handpiece to avoid interferences with apex locator's reading. The teeth were then inspected for any sign of root fracture and

evidence of complete root formation under sereomicroscope (Motic ST-39 Series) at a magnification of 20X. Fractured or cracked roots and roots with immature apices were discarded. All of the roots were stored in a special container containing 0.9% normal saline solution until the required numbers of samples were collected. The normal saline was changed every day to keep the teeth fresh until use.

Teeth Preparation

The access opening was done for the collected teeth using a #2 round diamond bur and followed by tapered fissure diamond burs (Dentsply Maillefer, Ballaigus, Switzerland) in high-speed turbine hand-piece with water coolant. The occlusal surface of the teeth were also reduced and ground with a diamond grinding wheel (Dentsply Maillefer, Ballaigus, Switzerland) to create a flat surface for stable reference points. Any remaining caries and metallic restoration were removed to avoid leakage of electrical current. The pulp tissue was extirpated using small size barbed broaches , one for each canal.The patency of the apical foramen was checked using the stainless steel K-file (size # 10) (Maillefer Instruments, Ballaigues, Switzerland), in such away that the file must reach the apical terminus and appear from the root apex slightly and tightly (just seen) in combination with 1 ml of normal saline solution via disposable syringe and a 27 gauge Endo-EZE irrigation needle (Endo-EZE, Ultradent Products, inc., USA) . Any root that did not fulfill this criterion (i.e. K-file not appears from the apex) had been discarded and not included in the study. The canal was irrigated again with normal saline (1 ml via disposable syringe) and dried with paper points.

Sample Grouping

The teeth were divided into four groups randomly: each group of fifteen teeth. The groups were consisted of the following:

- Group 1: Electronic working length was determined for the teeth with flaring in dry canal (15 teeth).
- Group 2: Electronic working length was determined for the teeth with flaring in wet canal by using sodium hypochlorite 5.25% (15 teeth).
- Group 3: Electronic working length was determined for the teeth without flaring in dry canal. (15 teeth).
- Group 4: Electronic working length was determined for the teeth without flaring in wet canal by using sodium hypochloride 5.25% (15 teeth).

Flaring was done for groups 1 and 2 by using Gates Glidden drills #2, #3, #4, and #5 (Antaeos, Germany) to the coronal two third of the root in low-speed conventional contra-angle hand piece (W&H, Trend, Austria). The junction between apical and middle third of the root was calculated by measuring the root from the cemento-enamel junction to the apex of the root and the value was divided by three. Crown length (from the coronal reference point at the flattened occlusal surface to the cemento-enamel junction) also measured which was added to the coronal and middle third length of the root, the value which is represented the length from the coronal reference point to the junction of the middle and apical third of the root which is called flaring length.

The length which was obtained by removal of crown length from the flaring length was divided by four, that each subsequent Gates Glidden drills was entered by crown length plus this value the same as for crown down technique.

The canal was irrigated with 1 ml of normal saline between each Gates Glidden drill and after completion of flaring by a 27- gauge Endo-EZE irrigation needle that inserted to the 1/3of the root length and then the canal was dried.

Stabilization of the teeth

To measure the canal length with electronic apex locators, all the samples and lip clip of the apex locator were mounted in an alginate model especially developed to test apex locators, because alginate is a good medium for conducting electricity and its electrical impedance mimic that of human periodontium [8].

Alginate (Blue-print, de Trey, Surrey, UK) was mixed according to the manufacturer's instructions and packed in a mold of plastic box with dimensions 240x25x25mm (WxDxH) (custom-made by the researcher) which was marked at each 20 mm by number which correspond to the sample's number that was labeled on the test tube, immediately the corresponding teeth were embedded within the alginate to the level of cervical line, alginate was leaved for 5 minutes to set completely. The lip clip of the apex locater was inserted into the alginate and all measurements were made in an interval of 30 minutes [9].

For the first group after flaring the teeth were irrigated with 3 ml of normal saline by irrigation needle that inserted to the 1/3 of the root length and the canal then was dried, and the electronic working length measurement was taken immediately after complete dryness.

The dryness was done with size #35 paper points followed by smaller paper points until size # 20 paper point was reached and inserted 1 mm short to the tooth length (i.e. from the coronal reference point to the tip of the root), to determine

the presence of moisture in the canal, four subsequent paper points of size # 20 were used and then the tip of the fifth absorbent point was drawn along the surface of the rubber dam. If the point is moist, it will leave a mark as it removes the powder from the dam, and this procedure was repeated until paper points no longer streak the dam [10]. Electronic working length measurement was taken after complete dryness.

For the second group after flaring was done the teeth were irrigated with 3 ml of sodium hypochlorite 5.25% by an irrigation needle that inserted to the 1/3 of the root length and overflowing sodium hypochlorite from the access opening that contact with the alginate and excess sodium hypochlorite in the pulp chamber was removed by the use of cotton pellet, then electronic working length measurement was taken.Sodium hypochlorite was obtained by withdrawing the plunger of the syringe when the hub is immersed into freshly opened Clorox bottle which contain 5.25% NaOCl without any dilution of the solution.

For the third group, the canal was not flared, the teeth were only irrigated with 3 ml of normal saline by an irrigation needle that inserted to the 1/3 of the root length and the canal then was dried. The dryness was done as prescribed in first group, electronic working length measurement was taken after complete dryness [10]. And finally for fourth (unflared) group after irrigation with 3 ml of sodium hypochlorite 5.25% by a 27- gauge Endo-EZE irrigation needle that inserted to the 1/3 of the root length and overflowing sodium hypochlorite from the access opening that contact with the alginate and excess sodium hypochlorite in the pulp chamber was removed by the use of cotton pellet, then electronic working length measurement was taken.

Electronic working length determination

After mounting the samples and the lip clip of the apex locator, the working length measurements was performed using both Root ZX (J. Morita, Japan) and the i-Root (S-Denti Co., South Korea) apex locators. Both electronic apex locators were adjusted to 0.5 mm accuracy to the apical foramen, and they were used according to their manufacturer's recommendations. With each electronic apex locators, the file holder of the apex locator was attached to size 15 K-file (Dentsply, Malliefer) and inserted into the root canal that was prepared just before electronic working length measurements were taken which include dryness of the canal or irrigating it with NaOCl.

The file was advanced slowly until the apex was reached and passed on the display of the apex locator, then the file withdrawn slowly until the display showed the apex or 0.5, then the rubber stopper adjusted to the reference point and the file removed, and measured with a digital caliper that have accuracy of 0.01 mm and the reading was recorded for each one of the apex locators. All measurements were repeated 3 times for each sample and the average was taken as the final measurement and recorded.

Histological working length (Real working length) determination

After electronic measurement of working length, histologic working length was determined by the following procedure, apical 4mm of the root was shaved using diamond taper fissure bur on high speed handpiece with water cooling, the shaving was done along the long axis of each root in the apical third until file could be seen through a very thin layer of dentin, the procedure was done very carefully, a very thin layer of dentine was removed each time and checked before another layer to be removed. As the file inside the root canal became visible through a thin residual dentine layer, this was manually removed with a sharp probe and the root canal was longitudinally exposed, any tooth that the lumen of the canal has been damaged during sectioning procedure was discarded and a new sample was taken [11]. Each canal was examined by a two observers under a stereomicroscope (Motic ST-39 Series) at a magnification of 20X, using an ISO 15 K-file (Dentsply, Malliefer) which was inserted into the canal until the tip of the file reached the apical constriction (figure 1), then the rubber stopper adjusted at the coronal reference point and the file was removed carefully in a way that the position of rubber stopper not changed until the length was recorded using digital caliper[12].

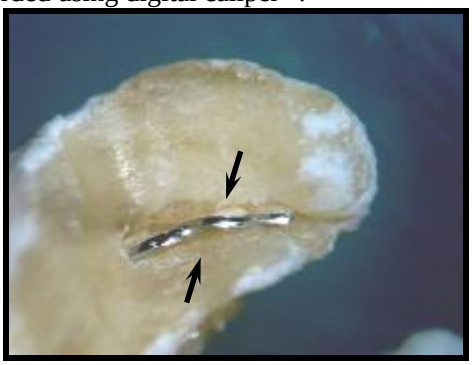

Figure 1: File reaching the apical constriction under stereomicroscope

Data collection

The working length has been recorded for each sample and the data colleted and entered into PC Pentium 4 using Microsoft Office Excel Professional 2003 version 11.0, the mean for the

two operator's reading was determined for histologic WL then the accuracy ratio for each samples were determined by dividing the electronic WL by histologic WL and multiplied by hundred according to the following equation: **Accuracy ratio = (Electronic WL / Histologic WL) * 100**

Values less than 100 meaning that the electronic WL was shorter than the histologic WL (apical constriction), while values more than 100 meaning that electronic WL was longer than histologic WL (apical constriction). While if 100 was obtained meaning that electronic WL was exactly at the apical constriction (electronic WL and histologic WL were the same).

Statistical Analysis

The collected data was analyzed using SPSS version 15 for Windows (SPSS, Chicago, Illinois, USA), using:

1: Descriptive statistics which include Means, Standard deviations and tables and bar charts.

2: Inferential statistics by using Paired t-test to compare between each corresponding pair of groups for each treatment.

RESULTS

Table (1) refers to the comparison of the accuracy ratio of the Root ZX and i-Root in flared (wet and dry) canal and unflared (wet and dry) canal groups; each including 30 teeth (15 wet and 15 dry) . The mean accuracy ratio of Root ZX for flared canal and unflared canal groups was (99.75±0.87) and (99.53±3.23) respectively, and there was statistically no significant difference at $p \geq 0.05$ between flared canal and unflared canal groups using Root ZX apex locator ($p = 0.66$). While the mean accuracy ratio of i-Root for flared canal and unflared canal groups was (99.47±1.05) and (99.29±3.21) respectively, and there was statistically no significant difference at $p \geq 0.05$ between flared canal and unflared canal groups using i-Root apex locator ($p = 0.72$).

Table 1. Mean accuracy ratio of Root ZX and i-Root in flared (wet and dry) canals and unflared (wet and dry) canal groups

Devices	Procedures	No. of samples	Mean accuracy ratio	Difference from histological WL	SD	p- value
Root ZX	Flared (wet and dry) canals	30	99.75	0.25	0.87	0.66
	Unflared (wet and dry) canals	30	99.53	0.47	3.23	
i-Root	Flared (wet and dry) canal s	30	99.47	0.53	1.05	0.72
	Unflared (wet and dry) canals	30	99.29	0.71	3.21	

The effect of canal dryness on the accuracy of apex locators

Table (2) shows comparison of the mean accuracy ratio for both apex locators in dry (flared and unflared) canal and wet (flared and unflared) canal groups. For Root ZX apex locator the dry canal group consist of 30 teeth (15 flared and 15 unflared) with mean accuracy ratio of (100.07±0.81) and the wet canal group consists of 30 teeth (15flared and 15unflared) with mean accuracy ratio of (99.73±1.30). There was statistically no significant difference at $P \geq 0.05$ between dry canal and wet canal groups regarding Root ZX apex locator ($P = 0.20$), and for i-Root apex locator the dry canal group consist of 30 teeth (15flared and15 unflared) with mean accuracy ratio of (99.81±0.87) and the wet canal group consists of 30 teeth (15flared and15unflared) with mean accuracy ratio of (99.47±1.40). There was statistically no significant difference at $P \geq 0.05$ between dry canal and wet canal groups regarding i-Root apex locator ($P = 0.23$).

Table 2. Mean accuracy ratio Root ZX and i-Root apex locators in dry (flared and unflared) canal and wet (flared and unflared) canal groups

Devices	Procedure	Accuracy with ±0.5 to the apical constriction	Mean accuracy ratio	Difference from histological WL	SD	p- value
Root ZX	Dry (flared and unflared) canals (30)	100%	100.07	0.07	0.81	0.20
	Wet (flared and unflared) canals (30)	91.66%	99.73	027	1.30	
i-Root	Dry (flared and unflared) canals (30)	96.66%	99.81	019	0.87	0.23
	Wet (flared and unflared) canals (30)	91.66%	99.47	0.53	1.40	

Table (3) shows the accuracy of both apex locators in comparison with histologic WL. In which 60 teeth tested by all methods, that the mean and the difference from histological WL for Root ZX were (19.94±2.05) mm, and (0.02) mm respectively, there was statistically no significant difference at $p \geq 0.05$ between the accuracy of Root ZX apex locator and histologic WL (P = 0.92). In the same way the mean and the difference from histological WL for i-Root were (19.88±2.05) mm, and (0.08) mm respectively, there was statistically no significant difference at $p \geq 0.05$ between the accuracy of i-Root apex locator and histologic WL (P = 0.79).

Table 3. Accuracy of Both apex locators compared with Histologic WL

Methods	No.	Mean (mm)	Difference from histological WL (mm)	SD	P-Value
Root ZX	60	19.94	0.02	2.05	0.92
Histologic WL	60	19.96		2.00	
i-Root	60	19.88	0.08	2.05	0.79
Histologic WL	60	19.96		2.00	

DISCUSSION

There are problems with studies for determining the accuracy of apex locators in vitro due to lack of standardization of samples and techniques. In this study, extracted human teeth were used to enhance the reliability of the investigation by duplicating the clinical situation. An attempt was made to make the samples of teeth comparable by selecting roots with single patent root canals, to minimize anatomical variation and allow standardization and to avoid the problems of multiple canals. Despite these attempts, natural anatomical variation among the teeth was still a factor, but it was hoped that randomly assigning the teeth to experimental groups and examining each group as a whole rather than looking at individual teeth would give a fair comparison between the groups.

In vitro studies on apex locators make use of electro-conductive materials in which the teeth are embedded, thus allowing closure of the electrical circuit, and simulate the clinical conditions[13]. Different embedding media are used like agar solution or gel, suggested by Czerw et al[14], gelalginate presented by Katz et al, [5] and Kaufman and Katz [15] also saline solution proposed by Huang [16] or a sponge soaked with saline solution [17]. When various embedding media were compared alginate provided the most coherent results [18].Its easy achievement and preparation combined with its low cost make it the medium of choice for use in this situation, many studies used alginate as an electroconductive medium [15,19].

The working length should be determined in relation to the apical constriction according to the guidelines of the European Society of Endodontics [20].The apical constriction could be determined with sufficient accuracy with the light microscope. Some investigations have determined the accuracy of measurement of EALs However, only a few investigations on the accuracy of EALs compared the root canal measurement with the actual root canal length (histologic working length) [21].

In present study evaluation of the reliability of the apex locators was done in relation to the ±0.5 mm to the apical restriction that is considered as the strictest acceptable range thus, measurements

attained within this tolerance are considered highly accurate [22].

Effect of flaring on the accuracy of ELAs

The accuracy of Root ZX and i-Root apex locators regarding the flaring procedure in present study indicates that despite a very little difference between the flared and unflared groups in EWL measurement, there was statistically no significant difference between them . This finding is also in agreement with the results achieved by Tinaz et al, (2002) who found little difference in accuracy of Root ZX with flaring procedure. However, other similar studies reveaedl that flaring procedure increased the accuracy of electronic apex locator with statistically significant difference [23,24]. Because, flaring of the root canals as used in modern crown-down preparation techniques would increase the accuracy of readings which allow the working length file to reach the apical foramen more consistently as it was found to be true for tactile sensation [25]. In contrast to these findings, some researchers stated that coronal flaring did not ensure better or more precise electronic working length measurement[9] .Interestingly, other researchers found that flaring slightly increased the accuracy of the Root ZX but at the same time decrease the accuracy of the Apex Finder AFA model 7005 and the Bingo 1020. [19] Therefore, the canal patency appears to be more important, as dentine debris may disrupt the electrical resistance between the inside of the canal and the periodontal ligament. Constant recapitulation and irrigation ensures accurate electronic length readings during instrumentation [25].

The effect of canal dryness on the accuracy of apex locators

The accuracy of Root ZX and i-Root apex locators regarding dryness of the canal in current study indicates that despite a little difference between the dry and wet groups in EWL measurement there was statistically no significant difference between them. This result is confirmed by the results attained by Kang and Kim, [26] who used seven different apex locators under various conditions using different irrigation solutions, with the greatest tendency to under record the canal length. They were more accurate in the absence of irrigants (i.e. in the dry condition). This may be due to that the dryness provide lower conductive condition in the apical region which leads to more accurate WL determination by EALs (i.e. presence of wetness will lead to increase in electrical conductivity), although, the difference in the accuracies of these electronic apex locators caused by different canal condition were not statistically significant. In spite of that, other researchers found that the difference between wet and dry canals was statistically significant [9,21]. Furthermore, two other researchers examined the difference in sensitivity between wet and dry canals and found no significant difference between wet and dry canal for WL determination[27] .On the contrary, other studies showed that statistically significant differences were found among different canal contents. In the presence of saline (wet) measurements were closer to the apical constriction. While, those carried out in dry canals were shorter [15]. It was concluded that the accuracy of EALs were negatively influenced by presence of wetness inside the canal, because dryness provide low conductive condition in the apical region although the difference was statistically not significant

Within the limitations of this in vitro study, the following conclusion can be withdrawn; coronal flaring, dryness of the canal has little effect on the accuracy of EALs and their effects were not significant.

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