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Clinical Accuracy of Electronic Apex Locator in Measuring Working Length During Root Canal Treatment

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Abstracts

Obtaining a correct working length is critical to success of endodontic therapy. The procedure for establishment of working length should be performed using techniques that have been proven to give valuable and accurate results and methods that are practical and efficacious. The development of the electronic apex locator has helped to assess the working length more accurate and predictable. So, the objective of this in vivo-ex vivo study was to evaluate the clinical accuracy of electronic apex locator in measuring the working length of the root canal in vivo, and comparing the lengths so measured, to the actual working length, ex vivo and after extraction. Electronic apex locator C-Root-I VI (Foshan COXO Medical Instrument Co. China) was used to measure the working length in 100 root canals (one palatal canal and one buccal canal in fifty maxillary 1st premolar) in vivo before extraction, that were scheduled for orthodontic treatment in twenty-five patients.Teeth were then extracted and apical constrictions were identified by careful preparation of the apical 4 mm of all the roots. Actual working lengths were determined by adjusting an endodontic file in the root canal upto the constriction from the coronal reference point. Electronic working lengths obtained in vivo were then compared for coincidence with the actual lengths thus measured after extraction (ex vivo). The data were statistically analysed by a paired Student't' test and Pearson correlation-coefficient test. In 14 canals out of 100 electronic working lengths (EWL) truly coincided with actual working length (AWL). Eighty two canals out of 100, EWLs were ≤0.5 mm short in measurement than AWLs but the difference with AWL was statistically insignificant (p>0 .01). Only in 4 canals (4%) EWLs were either >0.5mm short or more than AWL, thereby fail to meet the criteria of acceptable range of coincidence (≤ 0.5 mm from the apical constriction). On reliability analysis, all (100%) electronic working length significantly correlate with the actual working length (r=0.971). Within a clinically acceptable range of ≤0.5 mm, C Root I apex locator device showed a high degree of success (96%) in determination of working length during root canal treatment.

Keywords: Electronic apex locator (EAL), Working length (WL), Root canal treatment, Vivo-ex vivo

Introduction

The features of proper root canal treatment procedures include the complete removal of infected pulp tissues, thorough canal cleaning, shaping, disinfection and three-dimensional filling.[1] To achieve this objective, the preparation terminus (working length) must be detected accurately and must be maintained during the process.[2] The apical constriction (AC) is recommended as the ideal end-point for the instrumentation and filling of the root canal system.[3]Available techniques to determine WL are: periodontal sensitivity, tactile sense, radiographic method and electronic methodbut till now none of these are completely perfect.[4] Radiography is the most commonly used diagnostic aid in endodontics, as described by

ingle.[5] However, accuracy in determining working length is difficult to achieve in this technique because radiography can, at best, give an estimate of histological structure (apical constriction) and although clinically desirable, averages used to define the apical constriction from the radiographic apex could lead to over or under filling.[6] Moreover, the variables in techniques, angulation and exposure distort this image and lead to error due to laterally situated foramina.[7] In addition, there is radiation hazard both to the patients and the dental personnel.[6] Furthermore, a radiograph provides a two dimensional image of a three dimensional structure which lacks of a real representation.[7] Dense bone and anatomical structures,the superimposition of the zygomatic arch has been shown to interfere radiographically and can make the radiographic visualization of root canal files unfeasible by obscuring the apex.[8]

The tactile perception being the oldest, because of the simplicity of the technique and its virtual effectiveness are factors that motivate a few clinicians in endodontic practice to still follow this technique. But this technique obviously depends on the sensitivity and experience of the operator,generally inaccurate in root canals with immature apex, excessive curvature and if the canal is constricted throughout its length.[6]

In general, the methods currently available for root canal length measurement, neither the manual nor the radiologic approaches allow precise localization of apical narrowing.[2]

The new generation of apex locator provides the operator with a digital read out, graphic illustration and an audible signal. It has been claimed that it can measure pulp space lengths accurately even in wet canalin presence of biological phenomena such as vital tissue, or conductive fluid like NaOCl, Nacl, EDTA solution etc .[9-11]

In vitro testing in dry and in presence of different electro conductive fluid, accuracy of apex locator revealed as low as 83%upto 100%.[12,13] But the clinical efficacy of EALs regarding its clinical accuracy is yet a matter of dispute. Since in vitro testing could give accuracy results higher than those obtainable in clinical practice. So, the present study was conducted to evaluate whether and how much the Electronic Apex Locator is clinically accurate in measuring the working length of root canal.

Materials and Method

The in vivo- ex vivo study was carried out in the Department of Orthodontia and Department of Conservative Dentistry & Endodontics, Bangabandhu Sheikh Mujib Medical University, Dhaka, Bangladesh.Methodology followed in this study was based on previous studies.[6,14,15]Human maxillary 1st premolar teeth with mature apices that werescheduled for extraction for orthodontic purposewas included as a study specimen. The teeth having metallic restorations, open apex or blunderbuss canal, root fractures, calcification in the pulp chamber or root canal, radiographically invisible canals, internal or external resorption as determined both clinically and radiographically or previously root canal treated teeth were excluded from the study.[6,7,15] Finally, the study was conducted on a total of one hundred root canals[15] (Fifty maxillary1st premolar teeth with one palatal and one buccal canal in each) those were used as study sample consecutively both for electronic working length determination in vivo then for actual working length measurement after extraction (ex vivo).

*Procedure:*After obtaining informed consent, access cavity prepared and pulp extirpated with a barbed broach. A univocal reference point was determined on the occlusal surface. The canals were irrigated using 1% sodium hypochlorite solution and finally flushed copiously with distilled water. The irrigant solution overflowed to the pulp chamber was soaked with small cotton ball.

*Electronic working length determination:*The 'lip clip/attachment' of the digital apex locator instrument (C-Root-I VI digital apex locator, Foshan COXO Medical Instrument Co. China) was attached to the patient's lower lip. A no. 15 K-file was taken and the unit's cable was clipped to its metal shank. The digital apex locator was turned on and the file was inserted slowly into the palatal canal.

During insertion of the file deep into the canal, when the apex locator gave the signal for the apical constriction (the flashing bar diagram reached at the level '0' digital display), the rubber stop was adjusted on the file shaft in such a way that it touched the reference point. The instrument was carefully withdrawn and the distance from the tip of the instrument to the rubber stop was measured using a graduated scale; the value was noted and registered as Electronic Working Length (EWL). Now electronic working length in buccal canal was measured similarly. Same protocol was followed for all the 100 root canals.

Actual working length determination: The teeth were extracted and the apical 4 mm of the root canal and the apical canal constriction were exposed by careful sectioning the root apices in a longitudinal direction; at first with a diamond bur, then the remaining thin layer of dentin with a probe. The apical constriction and the major foramen were identified under microscope at 16x magnification.[14] An endodontic file was carefully introduced into the canal upto the apical constriction, the rubber stop was adjusted so that it touched the reference point and was withdrawn. Distance from the apical constriction upto the coronal reference point was measured. All the obtained readings in 100 canals by this method were registered as Actual Working Length (AWL). Now the difference between the AWLs and EWLs were calculated. Levels of coincidence were assigned according to predetermined evaluation criteria (table I). Paired Student't' test was done to compare between AWLs and EWLs on different level of coincidence. Finally, different levels of coincidence as attained by EWLs were co-related with AWLsutilising Pearson correlation-coefficient test. A '*p*' value <0.0001 was considered significant.

Results

The results showed that in 14 canals out of 100(14%) Electronic working length (EWL) as measured clinically with C Root I Electronic apex locator truly coincided with the actual working length (AWL) (figure1). Eighty twocanals out of 100 (82%) EWL were ≤0.5 mm short in measurement than AWL (figure 2) but the difference with AWL was statistically insignificant (p >0.1). Only in 4 canals (4%) EWLs were either >0.5 mm short or more than 0.5mm AWL, thereby fail to meet the criteria of acceptable range of coincidence (≤0.5 mm from the apical constriction) but were within 1 mm from the apical constriction. So, all together (true coincidence and within clinically acceptable range) a higher percentage of EWLs (14%+82%=96%) under clinical conditions were either accurate or marginally short of AWL within a clinically acceptable range of ≤0.5mm.

Table I: The level of coincidence determined for the study

level of coincidence	Interpretation
1	**Exact coincidence:** Zero difference between the value obtained by electronic method and the value obtained using the Awl method.
2	**Acceptable coincidence:** 0.5 mm or less than 0.5 mm decrease in measurement (≤0.5 mm) when compared with that obtained using AWL method
3	**Non-acceptable coincidence:** more than 0.5 mm (>0.5 mm) short of the actual working length or more than the AWL

On reliability analysis, all (100%) EWL significantly correlates with the Actual Working Length (AWL) r = 0.971]. So, it couldbe assumed that Electronic Apex Locator like C

Root I can measure working length of root canal clinically with a high degree of accuracy (96%).

The various levels of coincidence obtained by the electronic Apex locator (C Root I) during clinical measurement of the root canals and reliability analysis at various levels vis-a-vis actual working length are tabulated (table II -V).

Table II: Interpretation of coincidence (n=100)

Coincidence	Number	Mean±SD	Range
Exact	14	0	
Acceptable (≤0.5 mm short in measurement than AWL)	82	-0.39±0.12	-0.50 to -0.20
Nonacceptable (>0.5 mm short or more than AWL)	4	-0.70±0.85	-1.50 to +0.50
Overall	100	-0.35±0.24	-1.50 to +0.50

Table III: Comparison between AWL and EWL (n=100)

	AWL (mm)	EWL (mm)	p value
Mean±SD	20.86±1.00	20.51±0.93	<0.001***
Range	18.50-23.00	18.50-22.50	

Paired Student's 't' test, *** = Significant
AWL = Actual working length; EWL = Electronic working length

Table IV: Comparison between AWL and EWL based on coincidence

	AWL (mm)	EWL (mm)	p value
Exact (n=14)	19.89±0.98	19.89±0.98	
Mean±SD	18.50-22.00	18.50-22.00	
Range			
Acceptable	21.01±0.90	20.62±0.90	>0.10ns
(n=82)	19.00-23.00	18.50-22.50	
Mean±SD			
Range			
Nonacceptable	21.25±1.19	20.55±0.64	<0.001*
(n=4)	19.50-22.00	20.00-21.20	**
Mean±SD			
Range			

Table V: Reliability analysis (AWL vs EWL)

Parameters	Correlation (r)	p value
Exact (n=14)	1.000	<0.001***
Acceptable (n=82)	0.991	<0.001***
Nonacceptable (n=4)	0.722	>0.10ns

Pearson correlation-coefficient test
ns = Not significant, *** = Significant

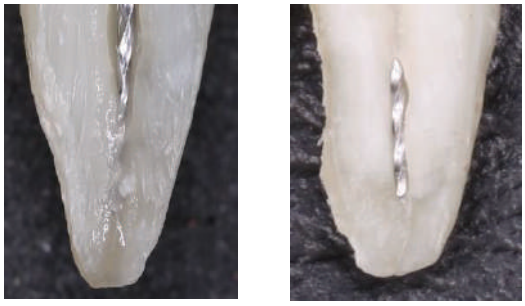

Figure 1: Electronic working length (EWL) truly coincided with the Actual working length (AWL)

Figure 2: Electronic working length (EWL) were ≤0.5 mm short in measurement than Actual working length (AWL)

Discussion

Findings of this study revealed that the electronic working lengths were only 14% coincident with actual working length. Using different brand apex locator and different evaluation criteria, other former in vivo studies resulted higher success rates than the present study.[6,7] The reason for getting a higher coincidence rate was probably due to difference in the process of determining the actual working length. Those resulted higher success rates than the present study in consideration of actual coincidence, often used the major foramen as a reference point. But in this study, it was explored that the minor apical foramina (apical constriction). However, the overall higher success rate (96%) in the present study may be due to using brand of apex locator, method used to compare the device and parameters used for comparison.

Hoer and Attin when determining the accuracy of apex locator set the target intervals 'apical constriction to major foramen'.[14] Finally, the position of the file tip in relation to target interval was recorded. If the file tip hit the target interval, the measurement was recorded as 'success', if not, it was recorded as 'non-success'. Thus, 82.4% file tips were found within the target interval 'apical constriction to major foramen'. In the present study, a total of 14% EWLs were either truly coincided with the target goal (just at the apical constriction) and 82% EWLs were within 0.5 mm from the apical constriction. If we would consider a target interval of 0.5 mm from the apical constriction a total of 96% could attained accuracy. Previous studies demonstrated that electronic apex locators (EALs) can determine canal length within 0.5 mm from the apical constriction in 84 -100% of canals.[16-19]

Though EWL in 4 canals out of 100, found to be within non acceptance range as per set criteria for the study; But if it is considered the previous study[2]where the target intervals were ±1 mm around the apical constriction or around the major foramen, even these values can be acceptable.[20,21]

Finally, overall reliability analysis for 100 canals showed that EWLs had a significant correlation co-efficient (r=0.971); while considering individual group, EWL in 82 canals being within acceptable range (±0.5), was also statistically co-relate with AWL (r= 0.991); having similarity with the study of Shanmugaraj et al,where an interclass co-relation co-efficient value was 0.99 between EWL and AWL.[7]

Conclusion

The results of the present study confirm that C Root I apex locator device showed a high degree of success (96%) to identify the apical constriction i,e, in determination of working length during root canal treatment within a clinically acceptable range of ≤0.5 mm.

It was tried to keep the canals lightly moistened, but it was crucial. During the process of clinical experiment, errors may occur, as in other types of apex locators, from patient's excessive hydration or dehydrations.

Based on previous study, it was inspected and evaluated apex and apical constriction at 16x magnification, but it is true that microscopic evaluation (SEM) of the apex and apical length should have been more accurate scientifically.[17]

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