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EVALUATION OF CONE-BEAM COMPUTED TOMOGRAPHY AND APEX LOCATOR IN ENDODONTIC WORKING LENGTH DETERMINATION

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ABSTRACT

BACKGROUND: The success in the endodontic outcome relies mostly on the correct determination of the apex. The findings may aid by which method endodontic working length determination is more accurate between cone beam C.T and apex locators.
STUDY OBJECTIVE: The study aim was to evaluate the working length accuracy detection utilizing cone-beam computed tomography (CBCT) and electronic apex locator (EAL).
MATERIALS AND METHODS: 32 extracted mandibular premolars and molars were scanned using CBCT. The measurements were gained from the reference point coronally to the apex were measured utilizing OnDemand3D software then by using iPex II apex locator.
RESULTS: No statistically significant difference between EAL working length and actual length while there was a statistically significant difference between CBCT working length and actual working length.
CONCLUSION: The working length detection by apex locator was found to be more accurate than the working length detection by CBCT.
KEYWORDS: Cone beam computed tomography, Electronic apex locator, Working length, accuracy, Endodontic
RUNNING TITLE: Is CBCT working length detection accurate as EAL.

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INTRODUCTION

Appropriate determination of the working length is an important step for the endodontists. Periapical injury or lack of disinfection may result from over or under instrumentation (1). The end point for endodontic treatment is the constriction of the apex, which is often from 0.5 to 1 mm short from the foramen of the apex (2).

The most common procedures for measuring the working length (WL) are periapical radiograph and apex locators (EALs). EALs was found to be more accurate and reliable (3). Two-dimensional (2D) structure of conventional radiography may lead to difficult WL determination in some features as buccolingual plane (BL), curvature, lateral exit of the foramen, distortion, anatomical superimposition and difficulty in detection of the landmark (4).

The Combination between radiographic techniques and EALs to detect the accurate root canal length is usually used in endodontic outcome (5). Several technologies have been updated for the detection of the accurate length for root canal instrumentation and obturation. Endodontic treatment has become more successful, with less stress for endodontists, and with higher accuracy. Utilizing EALs was found to decrease the needs for more radiographs (6).

Cone-beam computed tomographic is a radiological technique that allows correct anatomic data in 3 dimensions to diagnose and to plan for the treatment before endodontic intervention (7). CBCT scans may be utilised to get more precise WL measures, allowing for the use of pre-existing data (8). Tools of measurements provided by CBCT applications is important for estimating the working length in scans.

Cone-beam computed tomographic has drawbacks: it subjects the patients to higher amounts of radiation than intra-oral radiograph; beam hardening and scattering can reduce image quality when there is structure with high density in the area of interest; and it is more expensive (9).

The current study's goal was to evaluate working length detection accuracy utilizing CBCT and EAL when compared to the actual length of the teeth (gold standard technique) (10). The null hypothesis of our research was that there will be no statistically significant difference between the CBCT software and the apex locator in working length detection.

MATERIALS AND METHODS

The study was accomplished after getting the Committee of Research Ethics approval, Faculty of Dentistry, Alexandria University (IRB No. 001056 – IORG 0008839).

Sample size was based on 95% level of confidence to find differences in accuracy of working length determination between CBCT and electronic EAL. The minimum sample size calculation was 29 teeth, raised to 32 teeth for making up the errors of laboratory processing (11).

Extracted teeth collection was done from the clinics of oral surgery department, Faculty of Dentistry, Alexandria University in period from 2022 to 2023. Teeth extraction was indicated according to the individual needs of the patient. The extracted teeth were left voluntarily by the patients. This study involved 32 teeth, which met the inclusions and exclusions criteria.

The study was conducted on a sample consisted of extracted 16 mandibular premolar teeth with single canal and extracted 16 mandibular molar teeth with one distal canal that were scanned by CBCT for working length prediction then after endodontic access the working length was measured using apex locator (N=32).

a) The following criteria of inclusion were applied:

- Single roots with patent canal.
- Mature roots with closed apex.

b) The following exclusion criteria were adopted:

- Teeth with previous endodontic access cavity preparations.
- Teeth with previous filling material.
- Teeth showing signs of root resorption.

The following steps were done for every tooth after the buccal cusps for premolar and molar teeth were flattened to form the reference point and all processes of preparations of the teeth were done to follow the methodology.

CBCT Measurements

All CBCT scans were done using CBCT machine (Green X CT, Vatech, Hwaseong, Republic of Korea) with the same specifications, the field of view was 4×4 cm. Voxel size used was 50 micron. The current of the tube was 8 mA with 90 kVp kilovoltage. Optimum acquisition parameters were chosen for working length determination by CBCT scans that were required field of view 4×4 cm for enhancing the quality of the image by decreasing radiation scattering (12).

Size of voxel used was 50 micron to enhance spatial resolution (13). The current of the tube was increased to 8 mA for less noise of the image and decreasing artifacts proposed by Gaêta Araujo et al. (14) they found that the use of 8 mA current of the tube produced lesser artifacts than 4 mA current. A 90 kVp kilo-voltage was selected to reduce the artifacts, thus raising the kilo-voltage will raise the photons' energies leading them to be less filtered by high density materials (15).

Cone-beam computed tomography scan for measuring the length of teeth was done by placing and fixing them in empty sockets of dry human mandible, pink base plate wax with thickness 3 mm was placed on the bone surfaces of the mandible for soft tissue simulation **(Figure 1)** (16). The measurements were gained from the reference in the coronal point to the foramen of the apex and were calculated utilizing OnDemand 3D software (Cybermed, Seoul, Korea) **(Figure 2)**. Working length was measured in both sagittal and coronal scans and then the mean was calculated to ensure the correct working length even there is a curvature.

Actual Measurements:

The actual endodontic working length of teeth calculation by the insertion of a #15 K-file into the root canal till its tip appeared through the foramen of the apex. Magnifying glass with magnification 2.5 X was utilized to see the file tip (17) **(Figure 3)**. The file tip must be flushed with the anatomical apex then measure the file length and subtracting 1mm to calculate actual working length.

Apex locator measurement

Teeth were fixed in alginate model then #15 K-file was inserted into the canal. The file touch probe was connected to the file and then the clip of the lip was connected to the alginate by using apex locator (iPex II, NSK, Tokyo, Japan) ((17) **(Figure 4)**.

Statistical analysis

The normality of distribution was checked by the mean measurements of the working length for actual length, EAL and CBCT. Comparison between actual length and the other methods was done by F test (ANOVA) with repeated measures and by p-value with statistical significance level at p-value < 0.05. Post hoc analysis test (Bonferroni) was performed to differ between each technique. Interclass correlation coefficient was done for intra and inter examiner reliability. Analyzing the data was done by Statistical sciences program SPSS (20.0) software.

Figure (1): Pink wax was placed on the mandible to simulate soft tissue during CBCT image acquisition.

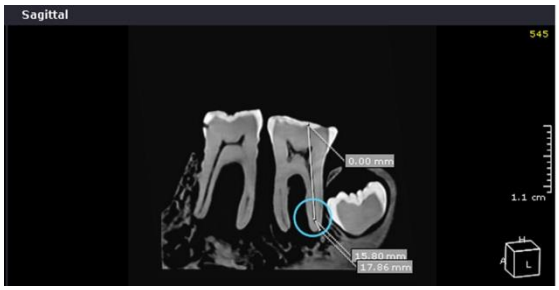

Figure (2): Using on demand software to measure the working length of the distal canal of mandibular molar in sagittal section.

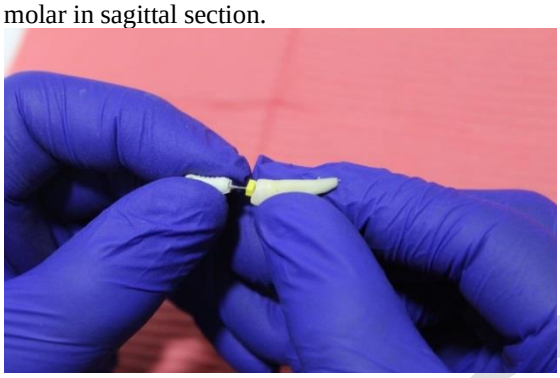

Figure (3): Actual working length was measured after File #15 k-file was inserted into the canal until its tip appeared through the apical foramen

Figure (4): EAL working length was measured after File #15 k-file was inserted into the canal. File touch probe was connected to #15 k-file and the lip clip was connected to the alginate.

RESULTS

The mean measurements of the working length by actual length, EAL and CBCT were 18.53, 18.75, and 18.13, respectively. It showed that the difference was statistically significant between the 3 techniques ($p < 0.05$). Post hoc analysis was performed to differ between each technique **(Table 1)**. CBCT showed 31.25% correct estimation of the working length while by EAL showed 56.25% correct estimation when compared to the actual working length with margin of error ± 0.5mm **(Table 2).**

This Analysis revealed that there was no statistically significant difference between actual length and EAL ($p_1 = 0.455$). But, a significant statistical difference was found between actual length and CBCT method ($p_1 = 0.007$).

EAL showed higher accuracy in estimating endodontic working length than CBCT with actual working length as a gold standard.

Reliability assessment

Assessment on the technique of calibrating was calculated between the 3 observers (two experienced radiologists and an endodontist). Intra-examiner agreement calculated by intra-class correlation coefficient by the examination of 10% of identified teeth and then by re-examination of them after 2 weeks. Inter-examiner and intra-examiner tests of reliability were measured then statistical analysis by intra-class correlation coefficient from 0.83 to 0.96 range, concluding agreement with very good results between observers and over time **(Table 3).**

Table 1: Comparison between the three studied methods according to working length (n = 32)

	Actual length	**EAL length**	**CBCT length**	**F**	**p**
Working length (mm)	18.53 ± 0.82	18.75 ± 0.77	18.13 ± 0.81	4.992*	0.009*
p_1		0.455	0.007*		

SD: **Standard deviation**

Data was expressed using Mean ± SD.

F: F test (ANOVA) with repeated measures, Sig. bet. periods was done using **Post Hoc Test(Bonferroni).**

p: p value for comparing between the studied groups.

p_1: p value for comparing between **Actual length** and each other methods.

*: Statistically significant at $p \leq 0.05$.

Table 2: Comparison between the percentage of working length estimation for CBCT and EAL.

Method of endodontic working length measurement	**Correct estimation %**
CBCT length	31.25
EAL length	56.25

Table 3: Inter and intra-observer reliability

		Actual length	**CBCT**	**EAL**
		Intra-class correlation coefficient		
Inter-observer reliability	Observer 1 with observer 2	0.91	0.83	0.89
	Observer 1 with observer 3	0.96	0.94	0.93
	Observer 2 with observer 3	0.87	0.83	0.84
Intra-observer reliability	Observer 1	0.95	0.86	0.92
	Observer 2	0.87	0.86	0.86
	Observer 3	0.92	0.83	0.84

DISCUSSION

One of the important factors in the endodontic field is selecting the best technique can be used to calculate the working length in accurate method by which root canal shaping, cleaning and filling should be ended (1). The most common procedures for measuring the working length (WL) are periapical radiographs and EALs. EALs are more accurate and predictable than radiography (3).

EAL is an important tool for measuring the working length during endodontic treatment, with accuracy reports from 55% to 93% (18, 19). Electronic measurements are selected as a clinically effective tool for detecting WL (20). Cone-beam computed tomography was showed to the dental community to overcome the drawbacks of periapical radiograph (21). It shows 3D orientation of teeth without anatomical structures superimposition.

The results of this study showed no statistically significant difference between EAL endodontic working length and actual endodontic working length. This result agreed with Kumar et al. (22) who evaluated EAL and actual length in measuring endodontic working length.

On the same way with Mello-Moura et al. (23) who compared 5 techniques for canal length measurements in the anterior deciduous teeth. In agreement with current study Wolgin et al. (24), Nguyen et al. (25) and Van pham et al. (26) showed that EAL detections were the ideal technique for canal length measurement.

In the current study, it was concluded that estimation of the working length gained by the EAL was near to the actual working length detection. This findings was also in accordance with many reports in literature as Katz et al. (27), Kielbassa et al. (28), Subramaniam et al. (29) and Sahni et al. (30),reporting that electronic calculation were near to the actual endodontic working length than calculations gained by radiograph.

On the other hand, the present study showed the difference in accuracy between EAL and CBCT in working length determination when compared to the actual tooth length and this was in line with the study that was done by Lucena et al. (31) showing that the EAL accuracy was higher than the calculations gained from CBCT.

On the contrary, this disagrees with the study by Jeger et al. (8) reporting that CBCT may be used for the detection of the accurate length of the teeth using different software for CBCT calculations. Moreover, that disagreed with Mrasori et al. (32), de Morais et al. (33), Janner et al. (34), Üstün et al. (35) and Eslinger et al. (36) who compared the accuracy of tooth length determination between EALs and CBCT, reporting that the accuracy of both methods was the same with no statistically significant differences between both methods. This difference with our study might be due to the use of different voxel sizes and other parameters during CBCT imaging or due to the use of different CBCT machines.

As limitation of the results to the current study, a certain CBCT device and EAL was used. Also the current study was limited to mandibular premolars and molars. So, further investigations are required using maxillary premolars and molars with utilizing different EALs, CBCT devices, software and acquisition parameters

CONCLUSIONS

Diagnostic accuracy of working length measurements and estimation the accuracy of EAL was higher than CBCT. So no need for routine request of CBCT to measure working length as EAL is more accurate with less radiation.

CONFLICT OF INTEREST

The authors declares no economic or personal benefit conflicts.

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