Acta Scientific Dental Sciences (ISSN: 2581-4893)

Volume 6 Issue 1 January 2022

Research Article

Comparative Evaluation of Using Cone Beam Computerized Tomography (CBCT) and Conventional Radiography Confirmed with Apex Locator for Working Length Determination in Curved Root Canals (Clinical Study)

Amal Hassan Mohamed[1]*, Geraldine Mohamed Ahmed[2], Ghada Borhan Abou Hussein[3] and Hamdy Adly Youssef[2]

[1]*Master Degree in Endodontics, Faculty of Dentistry, Cairo University, Egypt*

[2]*Professor of Endodontics, Faculty of Dentistry, Cairo University, Egypt*

[3]*Lecturer of Radiology, Faculty of Dentistry, Cairo University, Egypt*

***Corresponding Author:** Amal Hassan Mohamed, Master Degree in Endodontics, Faculty of Dentistry, Cairo University, Giza, Egypt.

Received: December 01, 2021

Published: December 30, 2021

Abstract

Introduction: For a successful endodontic treatment, removal of all pulp tissue and bacteria from the root canal is crucial. This cannot be performed without the proper determination of the working length of the canal. The working length of a tooth is between the coronal reference point and the end of the canal where preparation and obturation should stop. Several methods have been used for working length determination; tactile method, radiographic method, electronic method and 3D imaging.

Aim of the Study: to compare between CBCT and conventional radiography with apex locator in determination of working length in curved root canals.

Methods: 18 canals were included in this study. Working length in each root canal was determined by two methods; CBCT scan and conventional radiography confirmed with electronic apex locator (Root ZX).

Results: There was no statistically significant difference between the two methods (p value = 0.7). Conventional radiography confirmed with electronic apex locator (mean value = 21.05) CBCT scan method (mean value= 20.9).

Conclusion: No difference was found between using CBCT and conventional radiography with apex locator for working length determination. In curved root canals, it is recommended to use electronic apex locator in combination with conventional radiography without the need for CBCT.

Keywords: Working Length; Root Canal Length; Apex Locator; Electronic Method; Radiographic Method; CBCT;

Abbreviation

CBCT: Cone Beam Computerized Tomography; WL: Working Length; EAL: Electronic Apex Locator; AC: Apical Constriction; AF: Apical Foramen; FOV: Field of View

Introduction

For a successful endodontic treatment, removal of all pulp tissue and bacteria from the root canal is crucial. This cannot be performed without the proper determination of the working length of the canal.

The working length of a tooth is between the coronal reference point and the end of the canal where preparation and obturation should stop (Glossary of endodontic terms).

One of the most common methods to determine the canal working length is the radiographic method. The first introduction of electronic apex locator (EAL) was by Custer to measure the canal length by an electronic method (Khadse., *et al*. 2017). Old generations of EALs had the disadvantages of being affected by canal contents, but the third generation is the first generation to report ac-

curacy even in presence of fluids in the canal. Gordon and Chandler (2004).

The consistency of EAL appears to be affected by canal curvature. In straight channel (Palatal), consistent readings of EAL were more prevalent than curved canals (MB, ML). Inconsistent measurements are strongly linked to overextended preparation of the canal. Sadaf and Ahmad (2015).

New generations of electronic apex locator showed better results when compared with traditional radiography and Cone Beam Computed Tomography (CBCT) for working length determination. (Yadav., *et al*. 2020).

Cone beam computerized tomography (CBCT) systems are variation of traditional computed tomography (CT) systems, which moves around the patient and collect data using a cone-shaped Xray beam. The 3D Endo software was a handy tool to identify canal anatomy in three dimensions easily and quickly.

(Janner., *et al*. 2011) published the first study comparing the accuracy of working length measurements of previously obtained CBCT scans with standard periapical radiographs and an electronic apex finder, which have shown that in endodonticly treated teeth CBCT scans can be effective in combination with clinical measurements such as EAL to determine the endodontic working length.

According to the 2012 American Dental Association Council, dentists should only recommend CBCT imaging if they expect the diagnostic output to help patient care, enhance patient safety or significantly increase clinical outcomes.

Materials and Methods

Trial design

Comparative controlled clinical study.

Study setting

Participants selection was done from patients attending to department of Endodontics, Faculty of Dentistry, Cairo University, Egypt, for root canal treatment and had CBCT scans.

The patients were treated on the dental Units of the postgraduate clinic of the department (Dental units: Adec 200 U.S.A) and x-rays were taken by the digital sensor (FONA) and (X-ray machine: Belmont, japan) in the clinic.

CBCTs were taken in the CBCT Unit in the radiology department (PROMAX 3D, FINLAND), Faculty of Dentistry, Cairo University using Planmecca software. After the explanation of the treatment procedure, the patients were asked to sign a printed informed consent that explains the aim of the study.

Sample size

The aim of this study is to assess the degree of correlation between Cone beam computerized tomography (CBCT) and conventional radiography with apex locator for working length determination in curved root canals. Based on the previous paper by the correlation coefficient is r=0.90, using power 95% and 5% significance level 18 patients(images) is required. Sample size was calculated by PASS 2008 program.

Ethical consideration

The protocol for this parallel designed trial was reviewed and approved by the ECs [Ethics committee], Faculty of Dentistry, Cairo University, with respect to scientific content and compliance with applicable research and human subjects' regulations. Site-specific informed consent forms (Arabic language and English versions), participant education, recruitment materials, other requested documents and any subsequent modifications were also reviewed and approved by the ethical committee. The treatment procedures, aim of the study and possible side effects were thoroughly explained to all the participants.

Participants

Inclusion criteria

- Adult patients who had CBCT scans.
- Teeth with curved root canals indicated for root canal treatment.

Exclusion criteria

- Young and old age patients.
- Teeth with straight root canals.

Endodontic procedure

- Anesthesia: Patients were anesthetized by local anesthesia (Mepecaine-L, Alexandria Company for pharmaceuticals and Chemical Industries, Egypt).
- Access cavity: All caries was removed first and then the pulp chamber was accessed with sterile high speed carbide round bur and then removal of the roof by tapered stone with noncut-

ting end. Isolation of the tooth with a rubber dam then removal of any pulp tissue by a sharp spoon excavator, and irrigation with NaOCl.

- Working length determination: A CBCT was obtained before starting the procedure and the working length of the canal was determined and recorded.

After pulp extirpation from the canals by the help of small sized k-files and irrigation by NaOCl, to continue cleaning and shaping of the root canals to the full length, preflaring the canals was done then working length was determined by radiograph using size 10 k-file.

To confirm the radiographic working length with RootZX; J.Morita apex locator (Figure 1), the clip was placed on the lower lip of the patient and the electrode was attached to a size 10 k-file in the canal and a flashing red bar was noticed when the file reached the apical constriction.

Figure 1: Root ZX apex locator.

Cleaning, shaping and obturation of the canals

Cleaning and shaping of the canals to the previously estimated working length using files and copious amount of NaOCl irrigation. The canals were manually cleaned by stainless steel files till file #20 to full working length then M-Pro files were used at speed 300rpm and torque 150 gcm till master file #25(0.06) in molars (16 canals) and in premolars the master apical file was size 35 (2 canals).

Obturation of the canals was done using lateral condensation technique (Figure 2).

Figure 2: The canals are cleaned, shaped and obturated to the determined working length.

M-Pro 2018 system was used due to its high fracture resistance. Fitting of the master cone was checked and obturation of the canal was completed using lateral condensation technique and a final radiograph was obtained after obturation.

Outcomes

The outcome of this study is the working length of the curved canals which is determined using CBCT and during the procedure using Root ZX; J. Morita and conventional radiography and all the findings are recorded.

Statistical analysis

IBM® SPSS® Statistics Version 25 was used for statistical analysis. Numerical data were presented as mean. The data distribution was checked for normalty to see if it was normal using Kolmogorov Smirnov and Shapiro-Wilk tests. Parametric data were checked using independent t-test to compare between two groups. The significance level was set at $P \leq 0.05$.

Results and Discussion

Results

Results are reported here for canal length determined using:

- Conventional radiography confirmed with apex locator (conventional method)
- CBCT was done for 6 patients with18 curved root canals.

Working length was determined on CBCT using the view where root curvature could be seen; in 11 canals we could see the root curvatures on the sagittal view and in 7 canals the root curvatures were seen on the coronal view.

In 13 canals the difference between the two methods is less than 1mm. The largest difference (2.02 mm) was found in the distobuccal canal of lower first molar and the smallest difference (0.02mm) was found in the mesiolingual canal of lower first molar.

The outcome in this study is the length of the canal measured in millimeters using the two previously mentioned methods, the results recorded in (Table 1). No significant difference between the two methods (p value = 0.7) (Table 2).

In this study, in 11 cases the root curved mesiodistaly so the working length was measured on the sagittal view on CBCT (Figure 4). In 7 cases the root curved buccolingualy so the working length was measured on the coronal view on CBCT (Figure 5).

Discussion

Successful endodontic treatment mostly depends on the exact estimation of the root canal working length. The accurate measurement would ensure that the root canal is properly cleaned, shaped

Case no.	Working length by conventional method (conventional radiograph confirmed with apex locator)	Working length by CBCT
1	21	18.98
2	21	20.24
3	21	20.96
4	20	19.58
5	23	21.61
6	22	20.97
7	22	22.83
8	20	21.33
9	21	21.9
10	23	22.5
11	23	22.33
12	20	19.3
13	20	20.9
14	19	18.83
15	23	24.44
16	19	19.02
17	20	19.44
18	21	21.06

Table 1: Working lengths (in millimeters) measured by conventional method and CBCT.

	N	Mean	95% Confidence Interval for Mean		Minimum	Maximum	P value
			Lower Bound	Upper Bound			
Conventional Wl.	18	21.05	20.38	21.72	19	23	0.7
Wl. by CBCT	18	20.9	20.12	21.67	18.83	24.44	

Table 2: Means of lengths in millimeters in both methods.

Figure 3: Bar chart showing working length determined by two methods (CBCT and conventional method).

Figure 4: Mesiodistaly curved roots and working length measured on sagittal view.

Figure 5: Buccolingualy curved roots and working length measured on coronal view.

and sealed without remaining bacteria and inflammatory tissues, and that the obturation does not extend beyond the canal apex, violating periapical tissues.

Anatomy of the apical foramen shows many variations; it changes with age by deposition of dentin and cementum. The apical foramen may be located to one side of the anatomical apex, sometimes at distance up to 3 mm in 50-98% of roots (Kuttler 1955,Green 1956, Pineda and Kuttler 1972). Chandler (2004) [14].

The anatomical end of the root as visible on a radiograph is defined as the radiographic apex, whereas the apical foramen is the place where the canal departs the root surface near to the periodontal ligament. (American Association of Endodontists 1984). We should be aware of the distinction between the apical constriction (AC) and the apical foramen (AF), whereas the AF is the major apical aperture of the root canal; AC is defined as the narrowest apical region of the root canal.

The distance from the AC to the AF ranged from 0.4-1.2 mm, mainly in either dentine or CDJ, and less often in cementum. Several methods are used to determine the working length but it is not an easy task especially in curved canals. One of these methods, which has been used for many years, is conventional radiography but there are some limitations of using x-ray in working length determination.

Limitations of x-ray in working length determination:

- Two dimensional image for a three dimensional object.
- Too long or too short image according to the angle of the x-ray cone. Hence, radiographic length needs to be adjusted and confirmed by other means.
- In a double curved root, it cannot determine the correct working length so it needs a radiologist who can recognize it. These areas appear more radio-opaque, known as x-ray twice or double curved.
- Superimposition for which shift technique is recommended to separate between the overlapped structures.

Although radiography is the most commonly used method for working length determination, Clayton (2005) claimed that this method may be inaccurate [4]. When using conventional radiography the canal might be curved on the third dimension which is not shown on conventional radiography.

We used Root ZX apex locator in this study as it has become the gold standard against which all other apex locators are judged. Root ZX apex locator is one of the third generation apex locators. These apex locators had the upper hand over their predecessors in terms of accuracy and reliability. This generation uses two frequencies instead of a single one to measure the impedance in order to determine the working length.

To measure the impedance in the canal, the Root ZX apex locator simultaneously uses two distinct frequencies of 400 Hz and 8 kHz. The quotient value is then calculated by dividing the 8 kHz impedance value by the 400 Hz impedance value. When the quotient value is 0.67, the reading of minor diameter is shown. Singh and Kapoor (2019) [35].

Apex locator can be used as an excellent adjunct to confirm working length determined by radiography which is proved in several studies (ElAyouti., *et al*. 2002) [7], (Ravanshad., *et al*. 2010) [29], (Vieyra., *et al*. 2011) [39], (Mandlik., *et al*. 2013) [21], (Mittal., *et al*. 2015) [23], (Bhat., *et al*. 2017) [3], (Jafarzadeh 2017) [15], (Saatchi., *et al*. 2017) [30], (Tampelini., *et al*. 2017) [26], (Rathore., *et al*. 2020) [28].

Sadaf and Ahmed (2015) [31] made a Cross-Sectional study to evaluate consistency and exactness in root canals and their linkage with other clinical variables in the Electronic Apex Locator (EAL) root ZXII. They claimed that the curvature of the canal appears to influence the consistency of EAL.

But on the other hand (Saatchi., *et al*. 2017) [30] evaluated the link between the Root ZX apex locator accuracy and the root canal curvature and revealed that the root canal curvature did not affect Root ZX apex locator accuracy.

Cone-beam CT image manufacture (1) acquisition setup, (2) image detection, (3) image replacement and (4) image presentation are the four components of (CBCT) image generation (Scarfe W. C. and Farman A. G. 2008) [33].

Field of view (FOV) The dimensions of the scan volume or the FOV are essentially dependent on the size and form of the detector, the geometry of the beam projection and the capacity to collimate the beam. The primary x-ray beam collimation of the CBCT enables radiation to be restricted to the area of interest. For each patient therefore, an optimal FOV is chosen based on the suspected presentation of diseases and the area of interest. This feature is extremely desirable, though not accessible on all CBCT systems, as it provides dosage reductions by restricting irradiated fields to the FOV. Scarfe and Farman (2008).

CBCT scan could be reliably used for canal length determination in several studies (Janner., *et al*. 2011) [17], (Lucena., *et al*. 2014) [20] (De Morais., *et al*. 2016) [5], (Ustun., *et al*. 2016) [38] (Dutta 2017) [6], (Yilmaz., *et al*. 2017) [42] (Obeid., *et al*. 2018) [26] (Tchorz., *et al*. 2019) [37] (Rathore., *et al*. 2020) [28].

In this study we decided to work on curved canals where Sadaf and Ahmad (2015) [31] claimed that canal curvature may affect working length determination using electronic apex locator.

No significant difference was found between using CBCT and conventional radiography confirmed with Root ZX apex locator (p value = 0.7).

The present results shows no difference between the two methods. Which agrees with the results of (Janner., *et al*. 2011) [17], (De Morais., *et al*. 2016) [5], (Ustun., *et al*. 2016) [38], (Dutta., *et al*. 2017) [6], (Obeid., *et al*. 2018) [26], (Tchorz., *et al*. 2019) [37] and Faraj (2020) [8].

On the other hand, (Lucena., *et al*. 2014) [20] compared the accuracy of the determination of canal length using a Raypex 6(®) electronic apex finder and CBCT cone-beam computed tomography, Electronic measures were found to be more reliable than CBCT scans. (Yadav RK.., *et al*. 2020) [40] used the same apex locator and had the same conclusion.

(Yildirim., *et al*. 2017) [41] found that CBCT was the most precise approach for root canal evaluation when compared with the working length performance of the electronic apex locator (EAL) and radiography. Also CBCT was found to be the most accurate method when compared with conventional radiography according to (Adarsh., *et al*. 2018) [1].

The Council of Scientific Affairs of the American Dental Association encourages the adoption of measures to decrease radiation received during dental x-raying. Known as the ALARA principle, this comprises taking radiographs based on the patient's necessities (as determined by the clinician).

According to American Association of Endodontists recommendations, Endodontic usage of CBCT should be confined to the evaluation and treatment of difficult endodontic situations, for example:

- Identification of anomalies in the root canal system and root curvature determination.
- During and post-operative examination of issues of endodontic therapy, such as overextended root canal sealing material, split endodontic devices, calcified canal identifying and drill location.
- Diagnosis of periapical dental pathoses in patients who have contradictory or unspecific clinical signs and symptoms, who show poorly localised symptoms of an untreated or previously treated tooth, with no evidence of conventionally identified pathosis, and where roots or zones of the maxillofacial skeleton are being anatomically superimposed.
- Diagnosis of nonendodontic pathosis to assess the degree of the lesion and its effect on the structures surrounding it.
- Root fractures, luxation and/or removal of teeth and alveolar fractures, dentoalveolar trauma.
- Localization and distinction, with suitable treatments and predicting of the possible outcome, of external root resorption or invasive cervical resorption from other diseases.
- Case planning before surgery to accurately estimate the root apex/apices placement and to assess the proximity of surrounding anatomical structures.

Conclusion

Within limitations of this study, it could be concluded that: No difference between using CBCT and conventional radiography with apex locator for working length determination in curved root canals.

Within the limitations of this study it could be recommended that:

- Using conventional radiography with changing the horizontal angel for determination of the third dimension for accurate working length determination.
- Using electronic apex locator for confirmation of the working length determined by conventional radiography without the need for CBCT.
- CBCT can be used for verification of the treatment in curved canals or calcified canals and in failure cases.
- CBCT shouldn't be used as a standard method in straight canals and canals with normal anatomy.
- The operator should develop tactile sensation for detection of apical constriction of the root canal.

Acknowledgements

I would love to give all my gratitude and thanks to ALLAH for giving me the ability to complete this study successfully.

I would like to express my deepest appreciation and gratitude to Prof. Dr. Hamdy Adly Youssef, Professor of Endodontics, Faculty of Dentistry, Cairo University, for his valuable supervision, help and support in achieving this study. I am grateful to his respected personnel for allowing me to gain from his knowledge and expanded experience.

I would like to express my deep thanks to Prof. Dr. Geraldine Mohamed Ahmed, Professor of Endodontics, Faculty of Dentistry, Cairo University, for her constant encouragement, constant guidance and support. I am deeply indebted to her for opinions that were instrumental in completing this research.

I would like to express my deep thanks to Dr. Ghada Borhan Abou Hussein Lecturer of radiology, Faculty of Dentistry, Cairo University for her constant encouragement, constant guidance and support.

Conflict of Interest

I declare that this thesis has been composed solely by myself and there is no conflict of interest.

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