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Comparison of working length determination using cone-beam computed tomography, electronic apex locator and periapical radiograph in teeth with periapical lesion: An in-vivo study

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***Abstract*---**Context: The accurate determination of working length (WL) has a major impact on the outcome of root canal treatment. Aim: The aim of present clinical study was to compare the accuracy of working length (WL) determination using Cone Beam Computed Tomography (CBCT), Periapical radiograph and Electronic apex locator in teeth with periapical lesion. Settings and Design: Randomised control trial. Materials and Method: This study was conducted on 30 patients with an initial diagnosis of a periapical lesion in teeth. The working length of the involved teeth was determined using three techniques. In all patients working length was first detected using an Electronic apex locator. Secondly, with periapical radiograph using Ingle's method and then from CBCT scans. The three measurements so obtained were tabulated and compared using statistical analysis. Statistical analysis used: Non-parametric paired T-tests were carried out. Results: The mean values for WL determination by electronic apex locator, periapical radiographs and CBCT images were 20.1833, 20.4667 and 20.7533 respectively. Statistical significant differences were found between the three methods. However, CBCT gave more precise readings. Conclusion: In Teeth with a large periapical lesion, working length determined using CBCT scan was most accurate and reliable as compared to a periapical radiograph and electronic apex locator.

***Keywords*---**periapical lesion, CBCT, working length, electronic apex locator.

Introduction

A better understanding of variations in the internal anatomy of root canals and obtaining the working length (WL) is a challenge for a contemporary endodontist. The accurate determination of working length (WL) has a major impact on the outcome of root canal treatment (Seltzer et al. 1963, Ricucci 1998, Ricucci&Langeland 1998) [1]. Working length is defined in the endodontic glossary as the distance from a coronal reference point to the point at which canal preparation and obturation should terminate. The apical constriction (AC) being the recommended end-point for canal preparation by several authors (Kuttler 1955, Ricucci & Langeland 1998, Gordon & Chandler 2004) [2]. Clinically, conventional radiography and electronic apex locators (EALs) are usually used to determine the working length (WL).

During radiographic imaging, the paralleling technique reduces the dimensional changes however, the ideal orientation of the x-ray tube are difficult to achieve. Changes in the angle between the radiographic film and the tooth have a significant effect on linear measures. Moreover, because the apical constriction cannot be detected radiographically, the radiographic WL is an estimation based on the average distance between the constriction and the major foramen. Thus, WL is often measured 0.5–1 mm short of the radiographic apex. Nevertheless, the major foramen does not always coincide with the anatomical apex, but may be located laterally (Kuttler 1955, Dummer et al. 1984, ElAyouti et al. 2002) [3]. The

principle of the apex locator was first reported by Suzuki and introduced to clinical practice by Sunada. It is based on the property that the electrical resistance between the periodontal membrane and the oral mucosa is constant and equals 6.5 KQ when the tip of the instrument reaches the foramen [4]. However, accurate readings cannot be obtained in cases of root resorption, periapical lesion, open apex or there is vital tissue or fluid in the canal. Its function is to detect an area between the minor and the major foramen, which represents the transition between the pulp and periodontal tissues, point of reference in which endodontic instrumentation and obturation should terminate preferentially. Electronic apex locators can be classified into various generations according to the following principles i.e. based on resistance, based upon impedance, based on frequency or comparative impedance, measures resistance and capacitance separately. The major disadvantage includes that in wet canals, canals with exudate or those with resorped apex the readings are not constant.

Cone-beam computed tomography (CBCT) is a contemporary radiological imaging system that produces undistorted images with a significantly lower-effective radiation dose than conventional computed tomography (CT) (Durack& Patel 2012) [5] Its contribution to diagnosis, the root canal anatomy, root fracture, periapical pathology, and internal/external root resorption is observed. This improved visualization of root canal morphology could increase the accuracy of WL measurements (Jeger et al. 2012) [6].

Most endodontists prefer a combination of electronic apex locators and radiographic methods to determine the WL. In the present study comparison of working length was done in teeth with periapical lesions as there is root resorption or exudate in canals which poses a challenge in the determination of working length. Very few studies are available which assess the role of CBCT in working length determination, especially in periapical lesion cases. Thus to overcome the limitations of EAL and radiographic technique the role of CBCT in WL determination must be explored in such cases. This clinical study aimed to compare the accuracy of WL determined by CBCT, electronic apex locators and periapical radiograph in patients with periapical lesions.

Materials and Methods

The present investigation included all those patients who were referred to the department of Conservative Dentistry and Endodontics at Sri Guru Ram das institute of dental sciences and research, Amritsar. On diagnosis, all those patients who had a large periapical lesion were sent for CBCT scan. Out of these only those patients who met the following inclusion and exclusion criteria were selected.

Inclusion criteria: Single rooted teeth (previously root canal treated or not) with a periapical lesion, teeth with radicular resorption, immature apex and periapical lesion, non-contributory medical history (American society of Anesthesiologist class 1 and 2).

Exclusion criteria: Tooth mobility greater than grade 1, multi-rooted tooth, root fracture, Non-restorable tooth.

A total of 30 patients with single-rooted involved teeth were selected for the study over 1 month.

Procedure: Pulpal anaesthesia using 2% lignocaine with 1:200000 adrenaline was achieved, rubber dam isolation was done and the access cavity was prepared, the necrosed tissue was removed and apical patency was obtained with #10 K File (Dentsply, Maillefer). Working length was determined by using three methods in all the cases.

Working Length Determination with Electronic apex locator:A #15 K-file (Dentsply, Maillefer) attached to the EAL (Woodpex v apex locator 5 th generation) device was then introduced into the root canal, and the lip hook of the EAL device was put onto the lip of the patient. Measurements taken with the apex locator were determined following the manufacturer's instructions. When the 0.0 signal was seen by the operator, the file was gently moved beyond the apex until the ''beyond apex'' signal appeared, at that point, the file was quickly withdrawn and stopped at the 0.0 point. Simultaneously, the rubber stop of the file was maintained in continuous contact with the incisal reference point of the tooth. The distance was recorded by using a digital calliper (Insize Mini digital calliper; Istanbul, Turkey).

Working length Determination with periapical radiograph: Initial length was measured from the preoperative radiograph taken before instrumentation. After subtracting 1 mm for safety allowance, a K-file was introduced up to the measured working length and an IOPA radiograph was exposed with a paralleling technique using an XCP film holder.

Imaging Procedures and Evaluation of WL Measurements on the CBCT Images: The CBCT (CS 3D Imaging v3.8.7 Carestream Health inc. internal version 3.8.7.0) images were obtained by using a voxel size of 0.125 mm, positioned parallel to the horizontal axis of the alveolar bone. A single experienced oral radiologist evaluated all CBCT images. The contrast and brightness of the images were adjusted by using the image-processing tool in the software to ensure optimal visualization. The CBCT slices were first reformatted to place the root canal of each analyzed tooth in a vertical position to visualize the incisal edge, pulp chamber, major foramen, and, if possible, the whole length of the canal in 1 single slice. To ensure standardized measurements, the root canal length was established in the CBCT images as the distance between the most incisal (or the most cuspidal) tooth edge in the projected midline of the pulp cavity and the major foramen.

After working length determination, the root canal was prepared using hand K files. All the teeth with periapical lesions had intracanal exudate. Therefore, the endodontic treatment was performed until the root canal was free of intracanal exudate or debris. Root canals were irrigated with 1% NaOCl during instrumentation followed by normal saline and final irrigation using 2 % Chlorhexidine. The root canals were then dried with paper points (DentsplyMaillefer). Intracanal dressing of calcium hydroxide mixed with chlorhexidine was placed. The patient was recalled after 2 weeks. If the canal was dry then an apical plug of bioactive material was made followed by obturation

with gutta-percha and a resin-based root canal sealer by using a cold lateral compaction technique. After the root canal obturation was completed, a radiograph of each case was taken for a final review of the teeth. The data collected were analysed using statistical software (SPSS 23.0 ver). Non-parametric paired T-tests were carried out to determine the working length comparison amongst the three methods.

Results

The mean values of WL obtained by using the electronic apex locator, the periapical radiographs and CBCT images were recorded and are presented in Table 1. The mean values obtained by electronic apex locator, periapical radiographs and CBCT images were 20.1833, 20.4667 and 20.7533 respectively. Upon statistical analysis, it was found that on comparison of working length between CBCT and radiograph mean difference was 0.2867(p value<0.001), between CBCT and Apex locator it was 0.5700 (p value<0.001), between radiograph and apex locator it was 0.2833 (p value<0.001). All these differences were statistically highly significant suggesting a lot of variation in working length determination using the three techniques.

Discussion

Accuracy in length determination is necessary to avoid damage to the apices of teeth and to the periapical tissues during instrumentation, thus providing better conditions for healing after endodontic treatment. Shortened working length may result in incomplete preparation and inadequate apical seal, resulting in the persistence of viable bacteria and their by-products leading to failure.

The most widely used method is taking periapical radiographs.Two dimensional periapical radiograph lack consistency and the interpretation variability associated with periapical radiograph due to altered root apex (root resorption, open apex) in periapical lesion cases (Basaiwala et al 2019)[7].The radiographs have some inherent disadvantages, like the possibilities of radiation exposure, time consumption, lack of clarity or definition, film placement, and film processing. Radiographs are technique-sensitive in both their exposure and interpretation. Dense bone and anatomical structures can make the visualization of root canal files impossible by obscuring the apex [4]. However, although the accepted place for apical constriction is between 0.5 to 1.0 mm from the radiographic apex, there are variations in the relationship from that point of reference which result in errors of instrumentation, and that obviously influence the position of endodontic filling.

The apex locators are accurate, easy, fast and reduce exposure to radiation. Artificial perforation can be recognized and it is the only method that can measure length to the apical foramen and not the radiographic apex. The disadvantages are that it requires a special device and accuracy is influenced by electrical condition of canal and secondly, the magnitude of the impedance of the canal is influenced by the electrolytes present inside the canal [8]. The apical root canal structure may be altered in teeth with necrotic pulp and periapical lesions or inflammatory apical root resorption [9]. This could affect the performance of

EALs when detecting the major foramen [10]. Inaccurate results can occur in teeth with a large apical foramen, root resorption and lesion cases in which exudates is present [11]

The CBCT scans have been popular in endodontics for both diagnosis and planning treatment. CBCT consists of a planar detector and a cone-shaped beam source that illuminates a complete volume. All data are obtained during a single rotation of the source-detector around the patient's head, which takes about 20 s. The result is a set of 2D images taken from different angles. These images are then reconstructed to form a 3D data set using a modification of the original cone-beam algorithm developed by Feldkamp [12].They provide results comparable with EALs for the determination of the endodontic WL[13]. CBCT scans were performed preoperatively, and a limited field of view was used. In accordance with the principle of as low as reasonably achievable. CBCT measurements were accurate as the real WL. Ability of CBCT scans to better locate the whole root canal and apical foramen by three dimensional information as compared to two dimensional periapical radiograph and there's no effect of intra canal exudate and resorbed root on working length measurements. The main disadvantages of CBCT imaging are inferior visualization and differentiation of soft tissue, scatter, streaking metal artifacts and a low specificity to objectively evaluate bone mineral density. One of the biggest disadvantages is the effect of patient motion on the resulting image sharpness [14].

In the present study, root canal length measurements were performed by using periapical radiograph, electronic apex locator and CBCT scans. All teeth had large periapical lesions, and according to the results, there were significant differences between the measurements. Upon stastical analysis it was found that mean difference between working length determined using CBCT and apex locator was 0.5700. The p value was <0.001; highly significant. The results of the EAL measurements in our study were affected by existing periapical inflammation, exudate present in canal and root resorption as there was conduction difference. CBCT scan better locate the whole root canal and apical foramen by three dimensional information and is not affected by intra canal exudate or resorbed roots.

Morais a et al (2016), compare the accuracy of working length (WL) determination using cone-beam computed tomography (CBCT), conventional periapical radiographies and electronic apex locator and found that working length determination using CBCT images was precise when compared to radiographic method and electronic apex locator[15].Usttun Y et al (2016), evaluated the endodontic working-length measurements in teeth with large periapical lesions and persistent intracanal exudate by using preexisting cone-beam computed tomography (CBCT) and concluded that measurement of the root canal length by using CBCT was as reliable as measurements that used apex locators[16].

In the present study, the mean difference in working length determination using electronic apex locator and radiograph was 0.2833. The p value was <0.001; highly significant results came out as periapical radiographs are two dimensional imaging which are not affected by intracanal exudate or resorbed root. Raghu et al (2010) evaluated the accuracy of working length determination of an electronic

apex locator (IPEX) on vital uninfected teeth and teeth with radiographic evidence of periapical lesions. In uninfected teeth, Electronic apex locator was found to be more reliable than Ingle's radiographic technique, but in case of teeth with radiographic evidence of periapical lesions, the radiographic method appeared to be relatively more dependable [17].

Ravanshad et al (2010), studied effect of working length measurement by Electronic Apex Locator and Radiograph on the adequacy of final working length and found that there was no statistically significant difference [18]. In the present study, the mean difference between periapical radiograph and CBCT was 0.2867. The p value was <0.001; highly significant. CBCT scans better locate the whole root canal and apical foramen by three dimensional information as compared to two dimensional periapical radiograph which are technique-sensitive in both their exposure and interpretation.

Yılmaz et al (2017) evaluated the accuracy of working length determination by using an electronic apex locator, periapical radiography, and cone-beam computed tomography. CBCT images obtained at different FOVs with voxel sizes less than 0.3 mm performed similarly and better than intraoral periapical radiography in the determination of endodontic working length measurement[19].Morais et al (2016), compared the accuracy of working length (WL) determination using cone-beam computed tomography (CBCT), conventional periapical radiographies and electronic apex locator and it was concluded that working length determination using CBCT images was precise when compared to radiographic method and electronic apex locator[15]. Sherrard et al. (2010) evaluated the accuracy and reliability of tooth length and root length measurements derived from CBCT volumetric data at 0.2, 0.3 and 0.4 mm voxel sizes. They found that the CBCT measurements were not significantly different from the actual lengths. CBCT scans provided most accurate and better anatomical and periapical view [16].

Conclusion

Based on the results of the present study it can be concluded that in teeth with a large periapical lesion, working length determined using CBCT scan was most accurate and reliable as compared to periapical radiograph and electronic apex locator.

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Table1 : Working Length with three methods

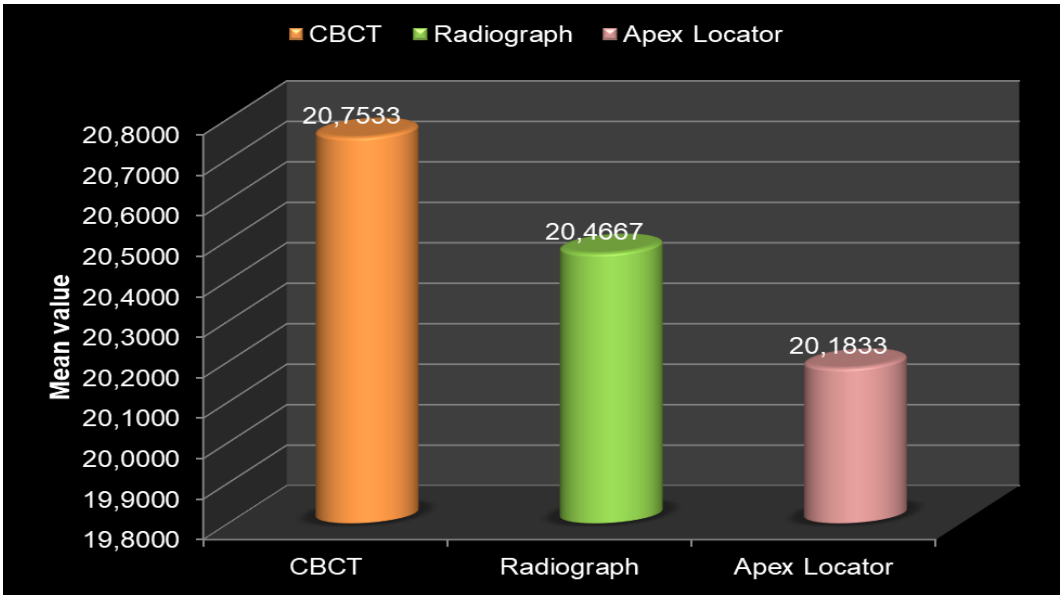
Method	Mean value	± SD	SEm
CBCT	20.7533	2.2976	0.4195
Radiograph	20.4667	2.2474	0.4103
Apex Locator	20.1833	2.2533	0.4114

SD: Standard Deviation; SEm: Standard Error of mean

Table 2: Comparison of Working Length with three methods

Comparison	Mean Difference	± SD	SEm	't' value#	P value#
CBCT vs Radiograph	0.2867	0.1907	0.0348	8.233	<0.001**
CBCT vs Apex Locator	0.5700	0.3949	0.0721	7.905	<0.001**
Radiograph vs Apex Locator	0.2833	0.3130	0.0572	4.958	<0.001**

SD: Standard Deviation; SEm: Standard Error of mean
#Student 't' test Paired: **p<0.001; Highly significant


CBCT
Radiograph
Apex Locator
Mean value
20,8000
20,7000
20,6000
20,5000
20,4000
20,3000
20,2000
20,1000
20,0000
19,9000
19,8000
20,7533
20,4667
20,1833
CBCT
Radiograph
Apex Locator