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THE ACCURACY OF USING CBCT IN WORKING LENGTH DETERMINATION VERSUS ELECTRONIC APEX LOCATOR (AN IN-VIVO STUDY)

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ABSTRACT

Introduction: Working length determination consider a critical importance for a successful endodontic outcome. Various techniques employed to ascertain the working length involve tactile sensation, electronic apex locator, conventional radiography, as well as cone beam computed tomography (CBCT).

Aim: To evaluate the accuracy of tooth length measurements utilizing electronic apex locator and CBCT scans to the physical tooth length.

Methods: The research involved 10 individuals, after detailed explanation of our study design had been provided, 4 patients refused and patients agreed were 6 patients with total 17 teeth included in the study, 5 lower central incisors, 7 lower lateral incisors and 5 lower canines teeth. All the patients had received a CBCT. Scans were evaluated by an experienced technician, who wasn't involved in any steps of the study.

Results: A statistically significant distinction was observed among the measurements obtained from both EALs and the actual tooth length but lower than those given by electronic apex locator with both software systems used. However, there is an advantage of sidexis software system over the galaxis software system. In addition to that, there was significant variation among the measurements obtained from the CBCT scans and the EALs.

Conclusion: EALs was more reliable tool for WL determination in comparison to physical method. CBCT less accurate than apex locator for endodontic length determination within the limitation of this physical method. Static navigation software more accurate in working length determination than regular viewing CBCT software.

KEYWORDS: cone-beam computed tomography; Electronic apex locator; Working length.

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INTRODUCTION

Teeth with irreversible pulpitis can have their apical periodontits healed with precise endodontic treatment, while teeth with infected, necrotic pulp spaces can have their apical periodontits prevented. [1]

Success is the expected outcome after root canal treatment including eliminate the pain; relieve symptoms of infection and spread of it, saving the tooth, restoring normal function.

Proper root canal treatment classifies into proper diagnosis and preoperative assessment, access cavity preparation, cleaning and shaping of the canal, obturation and restoring the tooth.

One of the most crucial parts of root canal treatment is cleaning and shaping the canal; if this part is flawed, the endodontic treatment will fail. Another critical part is determining the correct working length of the canal; endodontic success requires an accurate working length determination of the root canal. [2]

A working length is the distance from a coronal reference point to the point at which the canal preparation and obturation should cease. This definition is found in the endodontic lexicon. [3]

When the working length is too long, it can lead to problems like root canal overinstrumentation and filling, pain, a longer healing period, and a lower success rate for endodontic treatments. On the other hand, when the working length is too short, it can cause problems like underfilling the root canal, an incomplete apical seal, and apical leakage, which can support the existence of bacteria and delay the healing of periradicular lesions.

Multiple techniques are employed to ascertain the precise working length in endodontics. The manual tactile sensation is the oldest and most often used method for determining the working length. However, it requires a learning curve to develop skill. Conventional intraoral imaging is a frequently used method for determining working length. However, it has its own limitations, such as replicating three-dimensional objects in two dimensions and the potential for size and shape distortion. More recently, digital intraoral imaging has been introduced, which is reported to be superior in terms of operator convenience and reducing individuals' radiation exposure. [4]

Electronic method also used in determining working length of the canal using apex locators which is accurate, fast and decreases the need for X-rays. However, it needs special equipment, and its measurements may be affected by the canal's electric conditions.

CBCT was developed to avoid the problems caused by conventional x-ray, allowing viewing objects in 3-D, thus eliminating any chance of superimpositions. This diagnostic device is highly effective in providing high-resolution images with a small field of view, while keeping the radiation dose low. It is specifically designed for endodontic applications, such as diagnosis, treatment guidance, and post-treatment evaluation. Its use in endodontics has been proven to be essential in visualizing the root canal system, particularly in challenging cases.

To harness the power of CBCT scan, different softwares should be used to act as a bridge between the raw data captured by the CBCT scanner and actionable diagnostic insights, these softwares packages vary in features and capabilities.

Nevertheless, can CBCT be employed independently to ascertain the working length of the roots? Can it surpass or exceed the capability of apex locators in determining tooth length?

In this study; the aim was comparing the accuracy of working length determination using multiple softwares of CBCT which are sidexis and galaxis versus electronic apex locator and physically.

Our null hypothesis was that there is no difference in accuracy among the measurements obtained from the electronic apex locator and the CBCT scans with different softwares.

AIM OF THE WORK

The aim of the study was to compare the accuracy of working length (WL) determination using multiple software of cone-beam computed tomography (CBCT) versus electronic apex locator and physically.

MATERIALS AND METHODS

Materials and Devices

TABLE (1) Materials name and manufacturer used in the study

Item	Manufacturer
Root ZX II apex locator	J. Moritta-Takaguro-Hayashi-Kumiyama-Kyoto-Japan
K-files	MANI,INC-Ltd-utsunomiya-TOCHIGI-Japan
Endodontic excavator	Dentsply- Switzer
Local anesthesia	Artinibsa-Inibsa-Llica de vall-Barchelona-Spain
Round burs	MANI,INC-Ltd-utsunomiya-TOCHIGI-Japan
Cone beam machine (imaging device) Xg-3D	Sirona-densply-North Carolina-USA

Methods

Sample selection

The research protocol received approval from the ethical committee of the Faculty of Dentistry at Ain Shams University. The approval code number was FDASU-RecIM022101. It included 10 patients from the oral surgery clinic in the Faculty of Dentistry, Ain Shams University. After detailed explanation of our study design had been provided, 4 patients refused to participate and patients agreed were 6 patients with total 17 teeth included in the study, 5 lower central incisors, 7 lower lateral incisors and 5 lower canines teeth, all patients have signed an informed consent document.

The selected patients need to extract their anterior teeth for many reasons some of them because the teeth mobility were severe and can't use while eating and some of them need to construct an over-denture which the extraction of their anteriors was in their prosthodontics plan.

The Inclusion criteria of the patient included in this study were: All of them were in good health, the teeth selected to this study were lower anterior teeth, sound teeth with only one canal nearly straight with maximum angle ±10º. While the exclusion criteria of this research were: Diseased patients, Pregnant female patients and children not involved in the research, Teeth with caries or any curved root or with severe apical resorpative defects, Teeth with large metallic restorations, Abnormal root anatomy and previously endodontically treated teeth.

All have signed an informed consent document before starting the process of the research.

The study was conducted from November 2022 to February 2023 including patients referred to the oral surgery clinic as they had at least one lower anterior tooth indicated for extraction visible in the field of view. All the patients had received a CBCT scan independent of the present study. All the scans were evaluated by an experienced technician in Ain-Shams University, who wasn't involved in any further steps of the study.

Sample preparation

Patients involved in this trail were properly diagnosed and insured that they are under the inclusion criteria of the study; all of the patients have been imaged with CBCT to evaluate the working length as well be discussed in the evaluation of samples.

First of all, all the process of the study were explained to the patients before starting any procedure, Medical and dental history taken as they are a vital part in the study to increase the awareness of any diseases and medication that may interfere with the procedure.

Then all of them rinsed their mouth with mouthwash to decrease the effect of the bacterial loads, and after this they properly anesthetized with local anesthesia infiltration injection which was 4% concentration articaine 1.8 ml with adrenaline 1:100,000, they injected with needle inserted gently into the mucosal tissues, with slow injection to decrease the pressure and the patient's discomfort, then waiting 1-2 minutes observing the size of numbness.

After this the patient informed about rubber dam application to ensure that they are comfortably seated during the dental procedure, the rubber dam sheet was initially marked to identify it's positioning in the mouth and holes are punched into the sheet to correspond to the teeth that are to be isolated.

The clamp used was universal double bowed anterior clamp #210 and the frame was metallic, the rubber dam, clamp and frame were carried to the patient's mouth for placement, then liquid dam used to make sure proper isolation was obtained and the reading with apex locator will not be affected with any solution in the mouth.

After ensuring the patient was properly anesthetized, Access cavity preparation was performed using size 2 round bur. Deroofing was completed with a safe end diamond stone[1]. All coronal pulp tissues were removed using an endodontic excavator. Then working length was calculated utilizing an electronic apex locator.

Methods of working length evaluation of samples

The methods of evaluation of the working length included in this study were**:** Apex locator. CBCT with different softwares which were: Sidexis and Galaxis. Working length determination physically by inserting file inside the canal

Measurement of CBCT image

Prior to the scan, the patient was instructed to eliminate any metallic items, accessories, or spectacles if worn, as these can disrupt the imaging process.

The machine is activated and the spinning component, comprised of the x-ray source and receptor, is adjusted to the initial position.[(7)]

The patient is positioned in the CBCT machine and instructed to maintain a stationary posture, with their face supported by a little shelf in front. Subsequently, the patient is required to apply slight pressure on a mouthpiece in order to stabilize the head throughout the scan, and to retract the tongue while the scan is being conducted. During the scanning process, precise patient positioning is crucial as the quality of the image is directly affected by it. Subsequently, the CBCT system rotates completely around the patient, covering a full 360 degrees.[(22)]

The data was reconstructed with 1mm thick slices at an interval of 0.5 millimeter. Basic was 8cmx8cm and minimal FOV was 5cmx5cm and with high resolution image.

Sidexis software

First Sidexis software used to measure the root canal working length. First the contrast in addition to the saturation of images were adjusted by utilizing sharpen tool and contrast tool from the diagnosis section to ensure optimal visualization, and the degree of sharpness and contrast and the parameter adjusted were constant in all image taken.

After ensure optimal visualization the root canal was placed in vertical position using the rotate tool to visualize whenever possible the whole length of the root in one slice.

Canal length was determined by using the create length measurement tool, from the diagnosis section in sidexis software system where the measurement lines were traced in the cross-section view from the reference point in occlusal plane following the canal center to its terminus in 8 points follow the curve of the root not in straight line. Figure (1)

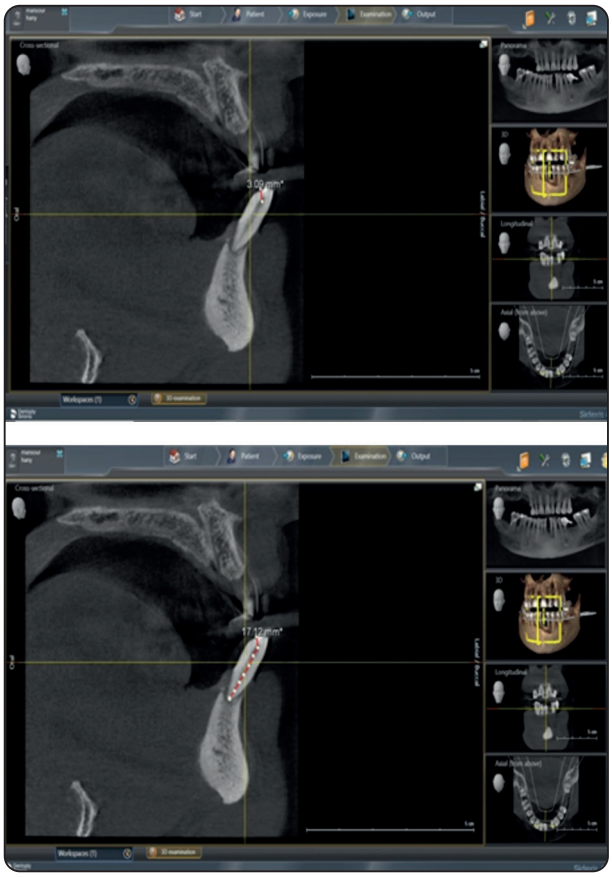


Fig. (1) Showing working length measurement with sidexis software.

After measuring the root canal working length using sidexis software system, another software system which is galaxis was used. Figure (2)

Galaxis software

When opening the software system first the contrast the saturation of the image adjusted to ensure optimal visualization. Figure (2)

Then from the tools the implant icon chosen then click on generic icon to choose which tooth needs to measure its working length and to determine the occlusal diameter, apical diameter and the length of the implant and then place the implant of the root canal to determine the working length.

Then implant aligned view selected and the canal length was determined utilizing the distance tool which is measure along path tool where the measurement lines were traced from

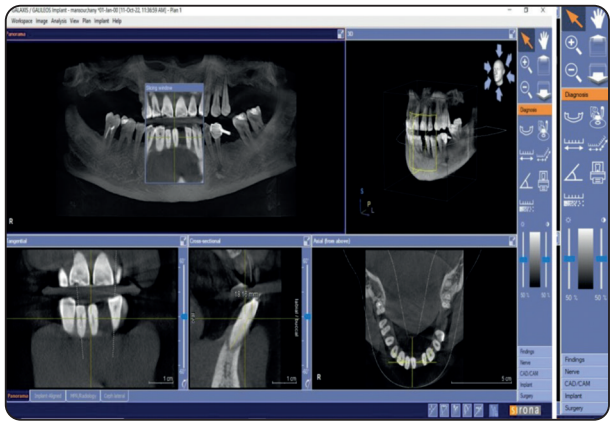


Fig. (2) Showing front screen and tools in galaxis software

Electronic root canal length measurements

Working length determination was done by apex locator performing all the measurements according to the manufacturer instructions of EALs.

After access cavity preparation, irrigation, and rubber dam placement, the canal should be dried very well with paper points to avoid fault reading by apex locator, Suction is used to ensure the canal is free of NaOCl, saliva, and water from the oral cavity, Then proper isolation of the operated tooth is required with rubber dam kit after this K file size 15 used, On the other hand it was very important to make sure that apex locator has a decent charge or it may not be accurate.

Before use, it was essential to calibrate the apex locator, So manufacturer's guidelines followed to ensure the device is accurately measuring the apex position. Regular calibration was necessary to maintain the device's accuracy, In order to confirm the file clip and measuring wire makes good contact, the wire was tested connecting before each use.[14]

The file clip attached with K-file and lip clip attached to the patient's cheeks, the file was placed into the root canal while keeping eyes on the locator, the file advanced apically until its tip touched periodontal tissue and exceeded the apex, the electrical circuit then was completed. After this the file

withdrawn slowly until it reached to 0.0 mark and constant audible tone produced by the apex locator.

If the readings were unclear, a few more readings taken to be sure the file was in the right position.

Then the silicon stopper on the file was then set to the reference points that were defined in agreement with the reference points used in CBCT measurements as the cusp tip.

Subsequently, the file is withdrawn and the gap between the rubber stopper and the tip of the file is assessed using a millimeter endodontic ruler. Each canal is measured three times and the average result is reported.

Physical tooth measurement

Once the working length was established by the apex locator & CBCT, individuals were directed to the maxillofacial department at Ain-shams University for tooth extraction.

Surgeron extract the teeth in atrumatic technique to decrease pain and discomfort to the individual and to avoid any crack or broken fragment may occur to the teeth included in the study, then the patients have taken the instruction after the extraction form the surgeon.

After the extraction, teeth were cleaned to remove any deposits. The teeth cleaned using soap and water to remove any blood or other residue from the teeth, and then rinsing them with in NaOCl for 15 minutes.[18]

After the electronic measurements were taken, the physical tooth length was estimated by inserting a K-file of the same size into the canals and withdrawing it 0.5mm to a shorter distance from the apical foramen when the file tip was visible through the main foramen.

After the incisal reference point was selected for both the EAL as well as CBCT measurements, the rubber stopper of the K-file was adjusted, and the file was withdrawn from the canal. Next, an endodontic ruler is used to measure the distance among the rubber stopper and the file tip. The millimeter value is recorded as the actual tooth length. Then temporary restoration placed in the access and the patients referred to maxillofacial department for extraction.

Statistical Analysis

Numerical data was shown utilizing standard deviation, maximum and minimum values, and 95 percent confidence intervals. Data distribution was tested for normality using the Shapiro-Wilk test. We examined them by repeated-measures ANOVA with a Bonferroni post hoc test after confirming a normal distribution. Statistical analysis was conducted utilizing R, a Windows statistical analysis application, version 4.1.3, with a significance level of $p < 0.05$.

RESULTS

A power analysis was designed to have adequate power to apply a statistical test of the null hypothesis that there would be no difference in measurements made with different modalities. By adopting an alpha level of (0.05), a beta of (0.2) (i.e., power=80%), and an effect size (f) of (0.147) calculated based on the results of a previous study*; the total required sample size (n) was found to be (76) samples. Sample size calculation was performed using R statistical analysis software version 4.4.1 for Windows.

Descriptive statistics:

Descriptive statistics of working length (mm) for different groups were presented in table (2).

* Pham, Van-Khoa, and Tran-Lan-Khue Pham. "Root canal length estimated by cone-beam computed tomography at different slice thicknesses, dedicated endodontic software, or measured by an electronic apex locator." Scientific Reports 12.1 (2022): 6531.

TABLE (2) Descriptive statistics of working length (mm) for different groups

Method	Mean	95% confidence interval		SD	Min	Max
		Lower	Upper			
Physical length	19.34	18.17	20.50	2.45	14.20	23.30
Sidexis	20.08	18.89	21.28	2.52	14.82	24.07
Galaxis	20.11	18.93	21.30	2.49	14.85	24.19
Apex locator	19.66	18.47	20.84	2.49	14.60	23.80

For physcial length, the mean was (19.34) ±2,45, standard deviation was (2.45), minimum value was (14.20), and the maximum value was (23.30). For Sidexis software, the mean was (20.08) with 95% confidence interval of (18.89:21.28), standard deviation was (2.52), minimum value was (14.82), and the maximum value was (24.07). For Galaxis software, the mean was (20.11) with 95% confidence interval of (18.93:21.30), standard deviation was (2.49), minimum value was (14.85), and the maximum value was (24.19). While for apex locator readings, the mean was (19.66) with 95% confidence interval of (18.47:20.84), standard deviation was (2.49), minimum value was (14.60), and the maximum value was (23.80).

Difference in working length

Table 3 displays the results of the intergroup comparison as well as the mean and standard deviation of the working length (mm).

There was a significant disparity in the values observed among the groups. The highest value was found in readings acquired by Galaxis software (20.11±2.49), followed by Sidexis softare (20.08±2.52), then apex locator readings (19.66± 2.49), while physical working lengths (19.34±2.45) had the lowest mean value. Post hoc pairwise comparisons revealed that both Sidexis and Galaxis readings revealed significantly higher values in comparison to the other readings. Furthermore, they demonstrated that the apex locator measurements were significantly bigger than the real lengths.

TABLE (3) Intergroup comparison, mean and standard deviation values of working length (mm)

Working length (mm) (mean±SD)				p-value
Physical length	**Sidexis**	**Galaxis**	**Apex locator**	
19.34±2.45^{A}	20.08±2.52^{C}	20.11±2.49^{C}	19.66±2.49^{B}	**<0.001***

Means with different superscript letters within the same horizontal row are significantly different *; significant ($p \leq 0.05$) ns; non-significant ($p>0.05$)

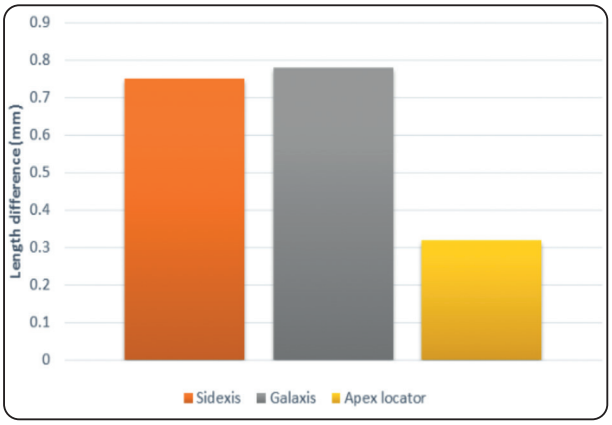
Difference form from physical length

The table (4) displayed intergroup comparisons of the standard deviation and mean values for the divergence from the actual length in millimeters.

There was a significant variation among values found in different groups. The highest difference was found with Galaxis software (0.78±0.13), followed by Sidexis (0.75±0.17), while the lowest difference was found in apex locator measurements (0.32±0.14). Post hoc pairwise comparisons showed the difference found with apex locator readings to be significantly lower than both CBCT softwares.

TABLE (4) Intergroup comparison, mean and standard deviation values of difference from physical length (mm)

Difference from actual length (mm) (mean±SD)			p-value
Sidexis	Galaxis	Apex locator	
0.75±0.17^{A}	0.78±0.13^{A}	0.32±0.14^{B}	<0.001*



Bar chart showing average working length difference (mm)

DISCUSSION

Accurate measurement of tooth length is crucial in root canal therapy, as it plays a vital role in achieving successful outcomes. Determining the working length precisely is a key part in the three essential components of successful endodontic treatment: eliminating microbes, preparing the canal properly, and achieving a tight seal during obturation. [5]

The accurate determination of the working length is crucial for identifying and maintaining the biological length of the root canal system. Any error in determining the working length can significantly impact the success rate of endodontic treatment. Inadequate measurements can lead to under instrumentation, resulting in incomplete cleaning and shaping of the canal. This, in turn, can leave tissues and debris in the apical segment, leading to under filling of the root canal and incomplete apical seal. As a consequence, there may be apical leakage, which supports the presence of viable bacteria and contributes to the development of a peri-radicular lesion. [6]

On the other hand, long measurements result from proper determination of working length which cause over instrumentation leading to damage of the periodontal tissues, or potentially cause an infection or cyst development from the placement of irritating materials beyond the apex, perforation through apical constriction, or patient discomfort and all of these outcomes resulting in lowering the success the rate of root canal treatment. [6]

Several techniques have been employed to ascertain the precise working length in endodontics. The manual tactile feeling, which is the oldest and most widely used method for determining working length, requires a significant amount of practice to develop skill. However, this technique is now considered outdated and there is very few published research that support its use in determining working length. [7] Identifying the root canal constriction is challenging since there may be other constrictions

present, such as coronal constriction or multiple apical constrictions. Due to the anatomical variability in the position, size, tooth type, and age of apical constriction, the measurement of working length is not reliable. [71]

Tactile sensation is also dependent on the patient's painful reaction when the K-file reaches working length and hits the periodontium; however, any approach that relies on the patient's painful response is not optimal. [9]

One frequent method of determining working length using conventional radiography is not without its limitations. The anatomy of the root canal, the working length, and the apical tissues around it can all be better understood with the help of radiographs. However, due to anatomical differences or projection inaccuracies, root canal length can only be accurately determined radiographically. Furthermore, radiation poses a risk to both individuals and dental staff. [10] Errors in radiographic interpretation could be caused by the observers' biases. In addition, children's lack of cooperation and restricted access to the mouth make it challenging to position the film, making it difficult to acquire a diagnostic radiograph.

Periapical radiographs have limitations as they are two-dimensional representations of three-dimensional objects. The working length is determined radiographically by placing the tip of a file at a specific distance, often 0.5 millimeter from the radiographic apex. The method's accuracy is compromised due to the fact that the measurement of 0.5 mm is taken from the radiographic apex of the root, rather than the apical foramen of the canal. Also distortion of image (elongation or shortening) due to improper angulation or difficulty to maintain parallelism between the cone and the intraoral film, it is also known that the accepted end point of endodontic filling is 0.5-1 mm from the radiographic apex and this may lead to inaccuracies due to difference in the reference point of the tooth from radiographs and intra-orally. [11]

Electronic apex locator was developed to allow for more accurate tooth length determination thus improving the success rate of endodontic treatment and decrease the need for ionizing radiation. The use of electronic apex locator in endodontics has been proven to be of great value in tooth length determination and has been proven to be more accurate than the traditional periapical radiograph. They are considered reliable methods for working length determination depending on the idea that the electrical conductivity of the periapical tissues differs from that of the intra-canal pulp tissue. [8]

Using Electronic apex locator is better than periapical radiograph [12-14] as it can be used in pregnant women or in patients with gagging reflex. However electronic apex locator may still have their limitations as their accuracy is affected by the electric conditions of the canals, presence of large metallic restorations that can cause a short circuit, open apices.

Another imaging device developed which is CBCT that provides 3D images thus eliminating any structures superimposition and has proven to be valuable in pre-endodontic treatment planning. Compared to classical 3D imaging such as Computed Tomography (CT), the radiation dose is smaller [15], Sidexis and Galaxis were the software that used in this study.

Sidexis software is developed by Dentsply-Sirona as x-ray software that promotes clinical efficiency and provides the tools needed to evaluate the clinical situation and diagnosis, and it allows selecting the image that needed for diagnosis and display these selected images side by side in a single light box for a clear and efficient overview of the situation. It's also equipped with tools dashboards that allow applying filters, annotations and a number of other applications to optimize the diagnosis. The needed aspects that should be clarified before dealing with the patients are PC hardware, Devices put to practical use and Sidexis updates. On the other hands Galaxis is software

for a dental practice developed by Dentsply-Sirona that enables the preparation of three-dimensional volume reconstructions of the maxillofacial region.

Thus, our aim was to compare the accuracy of tooth length measurements obtained from CBCT scans with two different softwares; sidexis and galaxis, with those obtained from the electronic apex locator and comparing the result with the physical working length that measured after the extraction of the tooth. The absence of a variance in accuracy among the EAL and CBCT scan evaluations was our null hypothesis.

Previous multiple studies compared the accuracy of electronic apex locator and CBCT in determining the tooth length, but they compared the accuracy of electronic apex locator in vivo with only one software system of CBCT. In our study we decided to test the electronic apex locator in vivo environment which is the actual environment that the electronic apex locator normally operates in and comparing the result with two different software system of CBCT which are Sidexis and Galaxis.

Although the anatomical variations in mandibular anterior teeth but they are selected in our study because they mostly affected periodontally and commonly used to construct the over denture, and any of the mandibular anterior teeth with two canals were excluded.

All the CBCT scans that were used in our study were involved in an interdisciplinary treatment planning for our patients to avoid unnecessary exposure to ionizing radiation and done by experienced technician in Ain-Shams University, Pre-operative CBCT scans done before the teeth extraction to stimulate the clinical situation as imaging scan [16]. CBCT scans were taken at a voxel size of 0.01 mm which allow for better image quality with high resolution and improve the ability to trace the root canal.

Before starting to prepare the access, patient properly anaesthetized with local anesthesia infiltration injection which was 4% concentration articaine 1.8 ml with adrenaline 1:100,000, because of its great biological safety, excellent local infiltration, as well as low toxicity. In addition to decreasing pain, it has a better success rate with dental infiltration anesthetic [17].

During electronic length determination proper isolation was done using properly applied rubber dam sheet as leakage of saliva may alters the canals electric conditions.

Sodium hypochlorite was used in irrigation of the canal as it consider the most common irrigant use in root canal treatment because it has an anti-bacterial effect, tissue dissolving capacity [18,19]. It used in all canals as an irrigant to equalize its effect on the electronic apex locator [20], the canal condition whether wet or dry and the type of used irrigant could affect the measurements of the apex locator.

Callibration done before using apex locator, the manufactures guidelines followed to make sure the apex locator is accurately measuring the apex position to keep it working well[21], and after the working length determined using the apex locator the patient referred to maxillofacial department to extract the teeth with atrumatic extraction technique to avoid any cracks or fracture to the teeth lead to incorrect readings, and then working length determined in the extracted teeth by the physical way.

A statistically significant distinction in the capacity of CBCT and EALs to determine tooth length was discovered after collecting and evaluating data from the apex locator and CBCT results contrasted with physical tooth length measurement ($P<0.00$). Since the electronic apex locator proved to be the most precise tool, thus rejecting our null hypothesis.

This is in agreement with ***Lucena et al.***[22] who conducted an investigation comparing the precision of determining the working length (WL) using the Raypex 6 electronic apex locator and CBCT. The researchers utilized the Raypex 6 to measure the working length (WL) at both the constriction and apex marks in a dry environment. Subsequently, they

determined the disparities between the electronic apex locator, CBCT readings, and the actual length (AL). The researchers discovered that the electronic measurements were more dependable than CBCT scans for determining the working length (WL).

In this study physical method used in determining the working length by using K-file size 15 and placing it in the root canal 0.5mm shorter than the apex, and this method is more practical in cleaning and shaping, Also ***Shanmugarajet al.***[23] agree with our study who measured the working length with multiple technique; tactile sensation, coneventional radiograph, apex locator and comparing the results with the physical working length, They found that the result of the apex locator was most accurate to that of the physical method and concluded that the exact location of working length with respect to CDJ can be determined only by histological method.

Similarity ***Shibin et al.***[24] performed a trial comparing the application of radiographic and EAL methods for determining WL in primary teeth. They also assessed the accuracy of these methods utilizing BCT. The study showed that EAL is more precise than the traditional radiographic technique for measuring WL in primary teeth. Additionally, it minimizes the superfluous exposure to radiation, therefore promoting child compliance during the treatment process.

This probably due to the same methodology between two techniques; physical method and apex locator, working length determined in both technique by measuring the length of the file inside the canal whose undergo straightening effect.

Conversely, the results of our study are in disagreement with **Liang et al**., [32] found that CBCT-based root canal lengths are accurate when compared to measuring the working length with file 10 after extraction of the tooth. However, routine root canal treatment alone shouldn't be an indication for requesting a CBCT scan and EALs should be relied upon tooth length determination as for the American association of Endodontic regarding the use of CBCT. Also ***Connert et al.*** [25] found that CBCT image of 0.2mm voxel size could accurately determine WL. Likewise, ***Aktan et al***. [26] found that CBCT with the smallest voxel size and highest resolution yielded more accurate WL determination. This probably because CBCT device measure the working length of the root canal from the reference point to the apex, while the apex locator determine the working length of the root canal through an object inserted which is the K-file as the method used in the physical measurement and this explain why the measurement resulted from apex locator and physical method are close to each other rather than CBCT.

The physical method used in this study done because it is the more practical way in cleaning and shaping, And the working length determination in both physical method and apex locator were by inserting the file inside the canal from reference point selected to 0.5 mm shorter than the apex, same technique with the same file made the results of both methods more reliable to each other's, because the file inserted in the canal in both technique undergo straightening effect while in CBCT, working length determined without insertion of file but using software system tracing the distance from the reference point selected to the apex, so no inserted file used and no straightening effect occurred, and it wasn't the same technique like in the physical methods, and it most probably that the result of CBCT will match the result of the physical method if the working length determined through inserting a file inside the canal and measuring the length of the file inside the canal from the reference point selected to 0.5mm shorter than apex, or comparing the CBCT result with the physical method but with splitting the tooth and measuring the distance of the working length without the need of using a file.

Regarding the accuracy of CBCT measurements with sidexis software system there was a significant distinction in the ability of CBCT scans and in determining the tooth length as the significant variation was $P<0.001$

On the other side regarding the accuracy of CBCT measurements with galaxis software system also there was significant disparity in the ability of CBCT scans and in determining the tooth length as the significance difference was P<0.001

The results of sidexis software and galaxis software were nearby to each other and both of them showed significant difference than the physical working length, and in comparing between both software systems we found that sidexis system was more accurate to the physical working length than galaxis software system, although the number of points used to tracing the working length in both system are same, so number of points wasn't variable but sidexis software was more accurate and this is probably because it is a static navigation software which is better than viewing software.

CONCLUSION

In this control clinical study, it was found that Electronic Apex Locator was more reliable tool for working length determination in comparison to physical method by inserting file inside the canal. Also, we found that Cone beam Computed Tomography was less accurate than apex locator for endodontic length determination within the limitation of this physical method. Regarding to the software used in this study we found that static navigation software was more accurate in working length determination than regular viewing CBCT software.

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