Comparison of Working Length Determination Using Apex Locator and Conventional Radiography in Curved Canals–an In Vitro Study

Original Article

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Abstract

Introduction:
The exact measurement of the root canal length is of great importance in root canal therapy. Although determination of the root canal length through radiography is the most common method, recently electronic apex locators have been used to determine working length and decrease the number of radiographs. The purpose of this study was to compare the accuracy of an electronic apex locator (Root ZX) with conventional radiography to determine the working length (WL) of curved mandibular molars.

Materials and methods:
Thirty-five intact mandibular first molars with curve above 10^0 were selected. The access cavity was prepared and the root canal length was measured using apex locator and conventional radiography. Data were analyzed using the paired-sample t-test.

Results:
The working lengths measured by the apex locator were equal to the actual working lengths in 42.86%, 0.5–1 mm shorter in 31.43%, and 0.5 mm longer in 25.71%. The working lengths measured by radiography were equal to the actual working length in 51.14%, 0.5–1 mm shorter in 39.99%, and 0.5 mm longer in 2.86%. There was no significant difference between these two methods in the measurement of the working length ($p = 0.951$).

Conclusion:
The apex locator and conventional radiography were equally effective in determining the working length of the curved canals.

Key words:

•Radiography •Curved Canal Therapy •First Molar •

Introduction

An accurate estimation of the working length (WL) of the root canal during endodontic treatment is essential for biomechanical preparation, filling the root canal, and remaining inside the root canal system to reduce the risk of inadequate cleaning of root canals or damage to periapical tissues. The WL is the distance from a coronal reference point to the point at which canal preparation and obturation should terminate.[1]

Periapical radiography is the most common WL determination method. However, radiography is associated with some limitations. For example, children, patients with gag reflex, uncooperative dental-phobic patients, patients with trismus and trauma, mentally retarded patients, and pregnant women cannot tolerate radiographic sensor or film. Anatomical points, such as zygomatic arch, torus, increased bone density, overlapping roots, and shallow depth of maxillary vestibule make radiographic determination of the root canal length problematic. In addition, determination of the occurrence and site of root perforation, as well as vertical and horizontal fractures of the roots is difficult with radiography.[2]

On the other hand, radiography is sensitive in terms of exposure technique and interpretation, and may encounter distortion and magnification. The two-dimensional images of radiography do not provide a real depiction of an object. Due to the aforementioned limitations, the use of alternative methods is necessary.

In recent years, the use of apex locator to determine WL and root perforation has been largely considered.[3,4]

Electronical apex locators (EAL) can be very helpful in patients with structures or objects that obstruct the visualization of the apex, patients with gag reflex who cannot tolerate films, and patients with medical problems that prohibit the holding of a film or sensor.[5, 6] Some advantages of this method over radiography are its simplicity of application, speed of root canal length determination, absence of X-ray radiation, and reasonable cost. However, these devices are associated with some limitations, including immature (i.e., open apex) teeth.[7,8] They perform less efficiently when there is an extensive periapical lesion associated with severe bone destruction; in addition, some irrigation substances, blood, and pus may cause measurement error in these devices.[9,10] Another disadvantage of these devices is that they are incapable of detecting root curvatures.[11]

This study intended to compare the difference between conventional radiography and electronic apex locator (Root ZX mini) in determination of the length of curved canals.

Materials and Methods

In this in vitro study, 35 extracted human mandibular first molars with closed apices and curved mesiobuccal roots (more than 10 °), were examined. (Figure 1)

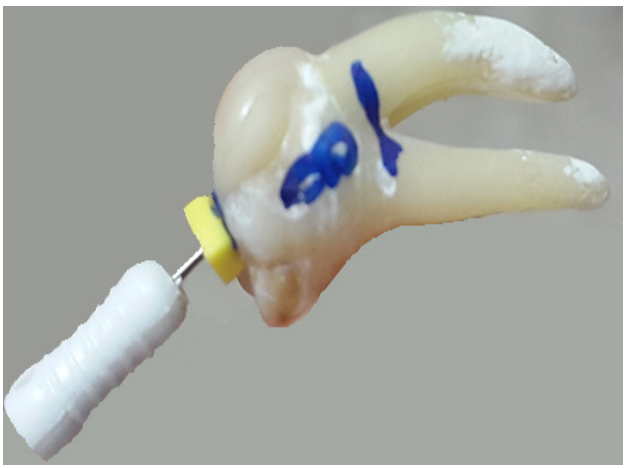

Figure 1. Actual working length determination

To determine the degree of curvature, periapical radiograph (PA) was first conducted, and then the degree of curvature was measured through radiography using the Schneider technique.[12]

Teeth were first immersed in sodium hypochlorite 5.25% for 15 min, and then the fibrous connective tissue, calculus, and bony processes were removed by scaling. The access cavity was prepared. To homogenize the methodology, only the mesiobuccal root canal of the mandibular first molar was used. A fixed occlusal index was determined for each canal, using nail polish, and this reproducible fixed reference was used in all measurements. The patency of the root canals was controlled, using a K-file size 10 (Mani, Japan). The K-file was also used to approximate the diameter of the apex. In addition, the apex diameter for mesiobuccal roots of mandibular molars was considered between size 10 and size 20 K-files. The lengths of canals were measured as follows:

•Measurement of the actual length of canals: A K-file size 10 was inserted into the canal apex

under the light and 3x magnifier. As soon as the file reached the apical foramen, the rubber stopper came into contact with the reference point and the file was removed from the canal. Then, 0.5 mm of the obtained length was reduced and [the rest was] measured with a digital caliper (LG, Japan) to obtain the actual WL, based on Kuttler's study.[13]

•Measurement of WL with Root ZX mini, and comparison of length determined by apex locator, radiographic length, and actual length: The root of each tooth was mounted in alginate (Zhermach, Italy). A wet metal rod was placed on the side of the teeth in contact with the lip clip to complete the electric circuit. To prepare the alginate model, an alginate-water solution (1:1) was used, according the manufacturer's instruction. After drying the canals, the normal saline solution was injected into the canals to wet them. Then, the access cavity was almost dried with cotton. The size 15 K-file was connected to a specific clamp on the device and directed towards the apex until its location (the site of contact with alginate) was determined.(Figure 2)

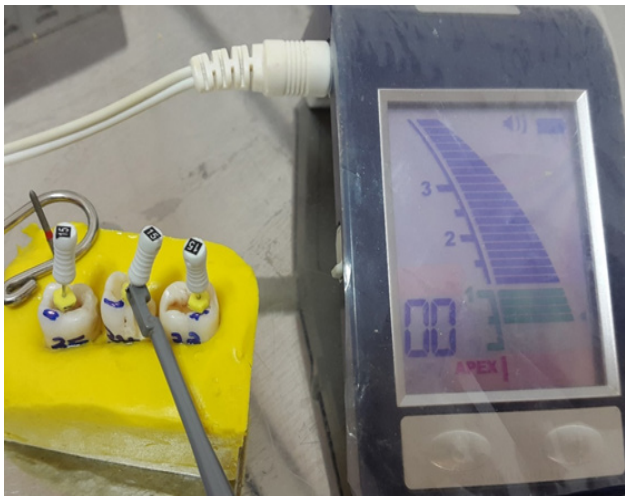

Figure 2. Determination of canal length with apex locator

After adjusting the file's rubber stopper to the stationary occlusal reference point of the canal, the file was removed and its length was measured, using a digital caliper with an accuracy of 0.01 mm. Immediately after determination of the root canal length, while apex locator and teeth were stationary in the alginate, the radiographic E film (Kodak, USA) was placed behind the teeth container and the size 15 K-file, the length of which was determined with apex locator, was fixed in the canal. The distances between the film and tooth and between the X-ray tube and tooth were 5 mm and 8 cm, respectively. The X-ray tube was positioned perpendicular to the buccal surface of the tooth. The radiation duration was 0.65 s with intensity of 7.5 mA and 65 KVP. The ratio of photographic developer and water in the solution was 3:1. Films were processed under standard and unchanged conditions. Films were immersed in the photographic developer for 20 s, and then in the photographic fixer for 60 s, and washed for 10 min. The temperatures of the photographic developer and fixer were measured before the developing and fixing stages, and all films were prepared at the same temperature. Radiography was performed by two endodontic specialists (under the same conditions in terms of the light and magnification).

In this descriptive-analytical study, data analysis was done according to the research objectives. Data were first fed to SPSS21, and normality of them was assessed using the one-sample Kolmogorov-Smirnov test. Data were analyzed using the paired-sample t-test.

Results

Among 35 mesiobuccal canals of mandibular first molars investigated in this study, the working lengths measured by apex locator were equal to the actual working lengths in 42.86%, 0.5–1 mm shorter in 31.43%, and 0.5 mm longer in 25.71%. In the measurement of the working length of 35 root canals with radiography, the working lengths measured by radiography were equal to the actual working length in 51.14%, 0.5–1 mm shorter in 39.99%, and 0.5 mm longer in 2.86%. (Table 1)

Table 1. Frequencies of the apex locators and radiographic methods in terms of accuracy

Accuracy	Apex locator per cent	Radiography percent
Difference greater than +1 mm	0	0
Difference between +0/5 mm to 1 mm	0	0
Difference between +0/01 mm to +0/5 mm	25.71%	2.86%
No difference	42.86%	57.14%
Difference between −0/01 mm to −0/5 mm	20%	34.28%
Difference between −0/5 mm to −1 mm	11.34%	5.71%
The difference of more than −1 mm	0	0

Table 2. Comparison of mean length measured using electronic apex locator and radiography with actual working length

	Number	Mean length	Standard Deviation	Difference relative to actual length	Paired t-test	p-value
Actual working length	35	19.71	1.477	0.081	1.138	0.263
Length of apex locator (electronic)	35	19.63	1.564			
Actual working length	35	19.71	19.71	0.112	2.788	0.917
Length of radiography	35	19.60	1.507			
Length of apex locator (electronic)	35	19.63	1.564	0.031	0.415	0.681
Length of radiography	35	19.60	1.507			

Discussion

The establishment of the apical limit of canal preparation is an important phase of root canal treatment. It is generally accepted that canal preparation and filling should be limited within the root canal.[14] Thus, accurate determination of the root canal working length is one of the most important steps in endodontic therapy.

The objective of this in vitro study was to evaluate the accuracy of an electronic apex locator in comparison with a conventional radiographic method. Based on the results obtained, the two methods for WL measurement had no significant differences.

The Root ZX electronic apex locator was used in this study because it presents higher precision and reliability in the measurements.[15,16]

However, it is important to emphasize that this device indicates the location of the apical foramen, which in most cases does not coincide with the radiographic apex. Nonetheless, after root canal working length determination using an apex locator, many dentists take a conventional or digital radiograph to confirm the measurement.[17]

In this study, alginate was used as a conductive material. Katz et al., proposed an alginate model.[3] Tinaz, Fuss, and Azabal also used alginate in their studies.[18-20] The underlying reason for using alginate is its good conductivity for EAL measurements; in addition, it appropriately supplies the equivalent electronic impedance to human periodontium.

Alginate is an appropriate substance with high elasticity and viscosity, and simple application. This substance does not interfere with radiography process. Relatively high strength and viscosity of alginate allows removing the substance from the apex and perforation with narrow diameter. Alginate can be kept wet for more than 45 hrs, to be used later. The application of alginate does not require specific instruments, which is in the previous proposed models.[20] In general, the problem of previous models with open apex is the probable movement of gelatin and PBS solution in the canal, leading to electronic length reading error.[21]

According to the findings of this study, there was no significant difference between the WL in mesiobuccal canals of mandibular first molars measured with electronic method and actual working length. In addition, there was no significant difference between the electronic method and radiography in this regard.

Root ZX mini could accurately diagnose the apex foramen in posterior teeth in 62.85% of cases. According to the findings of this study, Root ZX mini accurately determined the WL of curved canals of posterior teeth. This finding is consistent with the findings of Abdullah, Carneiro, Reddy and Malik; whereas they were inconsistent with the findings of Mittal, Khawaja and Yilmaz.[17,22-26]

Identical results between the two methods indicate that in curved first mandibular molars, radiographic and apex locator methods are both accurate and more curvature and less convergence of these channels during root canal therapy does not affect the accuracy of the apex locator. According to these findings, radiographic measurements were either shorter or equal to the actual WL, except in one case.

This finding was very consistent with

Reddy, Carneir, Khandewal, Sivadas, and Rekabi; whereas it was inconsistent with Mittal, Khawaja, and Yilmaz.[17,22-29]

Conclusion

Root ZX mini and radiography both are accurate in determining the WL of posterior teeth. In addition, no significant difference was observed between the electronic and radiographic methods with respect to the curved posterior teeth.

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