

# Comparative Evaluation of Root Canal Working Length Determination with Three Methods: Conventional Radiography, Digital Radiography and Raypex6 Apex Locator: An Experimental Study

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## Abstract

**Introduction:** Determining working length had always been one of the most crucial factors in evaluating prognosis. Radiography as a gold standard way nowadays has some flaws like making a 3D object, image distortion, not measuring the exact location of apical foramen, and putting the patient in a direct X-ray exposure. Here, we compare these three ways in measuring working length of single canal teeth that are narrow. **Methods:** Initially thirty single canal teeth with narrow canals were selected. After preparing the access cavity, the teeth were mounted in alginate for measuring working length with an apex locator. After that, they mounted in chalk in order to determine the working length using conventional and digital radiographs. Finally, the teeth were removed from the mount and the exact working length assessed using a hand file to compare with the three mentioned methods. **Results:** This study showed that the mean measured working length of root canal therapy had a significant difference between the four methods ( $P=0.003$ ). Bonferroni post hoc test showed that the mean exact working length of root canal therapy was significantly lower than measured working length of root canal therapy by conventional radiography ( $P=0.002$ ), digital radiography ( $P=0.001$ ) and Raypex6 apex locator ( $P=0.01$ ). However, there was no significant difference between these three methods ( $P>0.05$ ).

**Conclusion:** The results of this study showed that the mean measured working length of root canal therapy had no significant difference between digital radiography, conventional radiography, and Raypex6 apex locator but these three methods had a significant difference with the exact teeth length.

**Keywords:** Digital radiography, Root canal therapy, Working length, Apex locator

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## Introduction

Determining working length (WL) had always been one of the most crucial factors in evaluating prognosis (1). One of the most pressing concerns of dentists is determining where is the endpoint of preparation and obturation in root canal therapy (RCT) (2). The working length is the distance between the coronal reference point and the endpoint of the root canal that obturation and preparation ends (3). According to the studies, apical constriction considered the endpoint of the root canal and the most desirable termination point for preparation and

obturation. Overextension from the apical constriction demonstrates a poor prognosis(4).

Prevalence of failure at canal working length determination is to the extent that filling the root canal more than 2mm from the radiographic apex or beyond the radiographic apex alongside file fracture and perforation is considered one of the most technical dental failures in root canal treatment. According to the American dental association, the importance of precise apical constriction determination is to the extent that filling the root canal beyond the radiographic apex indicates a technical failure, which can be due to the inaccuracy in working length determination(5).

Preparing the root canal beyond the radiographic apex can transmit microorganisms beyond the apical constriction, which threatens the process of healing periapical tissue. Although in the studies on overfilling with gutta-percha under an electron microscope have shown the possibility of bacterial biofilm(6). This biofilm prevents the immune system from overcoming the bacteria and facilitates their growth, and can cause a foreign body reaction(7).

There are several ways to determine the working length, including apex locators, conventional radiography, and digital radiography, each with its advantages and disadvantages(8, 9). Apex locators widely use besides radiography(10, 11). The best way to determine the working length is radiography(12-14).

Drawbacks of radiography include 2-dimensional shadows on a single film, elongation, shortening, image distortion, and patient exposure(15). Albeit, digital radiography has reduced many of the problems with benefits such as reduced radiation, chemical process removal, speed of obtaining the image, and computer storage(16).

Nevertheless, both conventional and digital graphs still have their disadvantages. Radiographs are unable to delineate the precise location of apical constriction, apical foramen, and CDJ(17, 18).

Apex locators are also contraindicated in patients using Pacemaker(19). It has long been accepted that apex locators should not be used alone and can only be used alongside radiography, which can improve the accuracy of working length determination (20, 21). Apex Locator also reduces the number of diagnostic radiographs to determine the working length, which naturally reduces the radiation dose to the patient(22).

However, in patients whose radiation dose might be harmful to obtain radiographs, an apex locator alone is

also recommended for root canal therapy(23). Studies have shown that the apical foramen does not always coincide with the radiographic apex and may be in a lateral position relative to it with a distance of 2 mm(24). Other studies have explicated that the apical constriction can be up to 1 mm away from the apical foramen(25). As a result, radiography is unable to locate the apical foramen in these cases(10).

Apex locator introduced by Suzuki in the 1940s(26). And in 1962, Sunada (27) proposed the idea of using the determination of electrical resistance between the oral mucous membrane and periodontal membrane to define the working length. First and second-generation apex locators in the presence of electrolytes in the root canal cannot accurately determine the working length(28). But third-generation apex locators with more powerful processors show more accurate performance despite electrolytes(29). This study aims to compare the accuracy of working length determination between conventional radiography, digital radiography, and the apex locator (Raypex6).

## Methods and Materials

Thirty single-rooted teeth selected based on inclusion and exclusion criteria. The inclusion criteria were as follows:

1. Single canal in single-rooted teeth
2. Teeth with no evidence of root caries
3. Teeth with no excessive curve of the root
4. teeth with no root fracture
5. The teeth with narrow root canal
6. Teeth with the completely formed apex

Exclusion criteria were as follows:

1. Teeth with root resorption
2. Teeth with root fracture before or during the operation
3. File fracture during the operation
4. Patency with file number #20 or more.

The extracted teeth vertically mounted in chalk and marked from number 1 to 30. The initial file inserted into canals based on tactile sense. Conventional and digital radiography taken with the parallel technique, if the file tip was more than 2 mm away from the radiographic apex, radiography repeated. Each conventional x-ray

image evaluated by an endodontist and a dental student by modifying the working length.

If there were more than 1 mm difference between the declared numbers for a tooth, Another endodontist estimated the working length. All three specialists calibrated to define the working length, and the same gauge used during the study. If the lengths reported by the student and the endodontist were less than 1 mm, the mean of the two numbers was recorded as the working length of the tooth according to conventional radiography. This process with Digital radiography repeated for all teeth, except that digital software was used instead of the gage.

For the in-vitro study on apex locator, the teeth embedded into alginate and the lip clip electrode of Raypex6

inserted into alginate neat the tooth. Then the working length estimated by the apex locator(30).

After determining the working length with all three methods, the teeth were extracted from alginate. By inserting file #15 into the canal, tip to tip with the apical foramen, the length of the file measured, and 1mm subtracted from the file length, and the actual tooth length obtained(25).

Lastly, we compared each of the three numbers obtained by conventional radiography, digital radiography, and Raypex6 apex locator for each tooth with the actual length of the teeth. All of these procedures are shown in Figures 1-3.

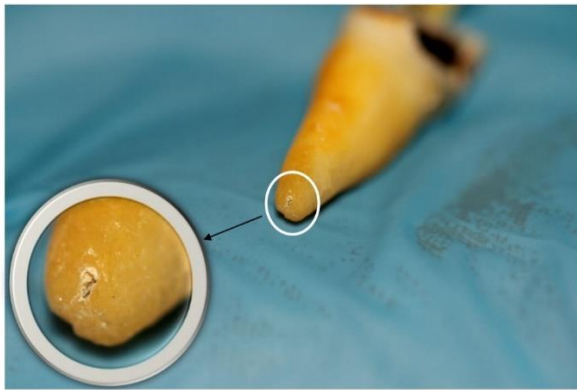


Figure 1: Method of determining the exact length of the teeth.

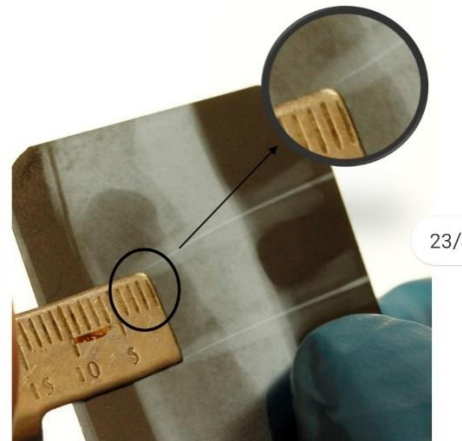


Figure 2: Determination of tooth length by conventional radiography



Figure 3: Image of digital radiographs on the screen and determine the length of operation on the computer

Conventional Radiography, Digital Radiography, and Apex Locator Raypex6 in millimeters. The outcomes explicated the mean measured the working length of the root canal had no significant difference between the digital radiography, conventional radiography, and Raypex6 apex locator. These three methods had a significant difference with the actual teeth length. (Table I)

Data were analyzed with Bonferroni post hoc test using SPSS version 22.

**Results**

The sample consisted of 30 single-canal teeth with narrow canals, and the working length measured by

Table I: Mean working length in millimeter

Method	Mean	Standard Deviation	P-value
Actual length	19.59	1.93	0.003
Conventional Radiography	20.18	1.91	
Digital Radiography	20.19	1.92	
Raypex6	20.11	2.02	

ANOVA test with repeated observations revealed that the mean working length of the root canal was significantly different between the four methods (P=0.003). Bonferroni post hoc test showed that the mean exact

working length of root canal therapy was significantly lower than the measured working length of root canal therapy by conventional radiography (P=0.002), digital radiography (P=0.001) , and Raypex6 apex locator (P=0.01). However, there was no significant difference between these three methods (P>0.05). (Table II)

Table II: Comparison of the mean working length of the root canal between two methods by Bonferroni post hoc test

Methods	P-value
actual length and conventional radiography	0.002
actual length and digital radiography	0.001
actual length and Raypex6	0.01
digital radiography and conventional radiography	0.97
conventional radiography and Raypex6	0.68
digital radiography and Raypex6	0.64

**Discussion**

Attaining success in Endodontic treatment depends on multiple factors, one of the most crucial factors is proper root canal preparation, also, keeping the periapical area as intact as possible by determining the exact working

length. The ultimate goal of root canal treatment is to fill three-dimensional coronal, apical, and lateral of the canal.

Incorrect measurements can cause overfilling, rupture of periapical tissues, and excessive pain after treatment(31). There are many ways to determine the working length, the most well-known methods are tactile sense,

radiography, the use of mean root lengths statistically and, apex locators. However, radiographic interpretation using the initial file is a common and accepted method of estimating the working length(32). The main problem of this method is the variety of anatomy in the apical area. Also, if apical constriction is not matching the radiographic apex, this method can cause over instrumentation and invasion of the periapical tissues(33). Furthermore, radiographic problems such as image distortion, anatomical structure interference, gag reflex, patient exposure -especially in pregnancy- should consider(34).

One of the most critical issues with root canal treatment is the limited amount of canal space, so the endpoint of operation should define precisely, so that not to damage the apical tissue while cleaning and shaping the root canal. Therefore determining the exact apical constriction is a significant clinical object(32). In various investigations, many scientists determined working length using Electronic apex locators. The results of studies showed that in most cases, there was no significant difference between apex locators. Electronic apex locators also can locate the possible perforation of root or pulp chamber floor, additional canals, position of calcified barrier in apexification(35).

The results of this study explicated the mean measured working length of the root canal had no significant difference between the digital radiography, conventional radiography, and Raypex6 apex locator. Nevertheless, these three methods had a significant difference with the actual teeth length. This significant difference indicates that none of the three methods used can estimate the exact working length.

Elayouti et al. (35) estimated the working length in 182 canals using apex locator Raypex4. The results showed that Apex Locator Raypex4 was reasonably capable of determining the root canal length.

In another study by Wrbas et al., 2007,(36) the accuracy of two apex locator models, Raypex5 and root ZX was compared. Twenty single-rooted hopeless teeth used to determine the working length, and then the initial file fixed with composite resin and teeth extracted. The results explained that Apex Locator devices were able to accurately determine the working length. There was no significant difference between Raypex5 and root ZX.

Vieyra et al. (37). in a 2011 study, evaluated 245 teeth for precision measurement of apex locator and radiologic methods during root canal therapy. The results of the study showed that apex locator devices are more accurate than radiographic methods in determining the working length and can reduce the risk of using tools in dentistry.

A study by Orosco et al (38), aimed to compare the accuracy of working length determination, with conventional and digital radiography. The results showed that the accuracy of conventional radiography was higher than digital radiography.

A further study by Kumar et al. (2016) aimed to compare the accuracy of the apex locator and conventional radiography in determining the working length of 41 primary hopeless teeth. The results also showed that there was no significant difference between the apex locator and the radiographic method(39). The differences in various studies are due to the diverse sample size and teeth evaluated in these studies and, the differences with this study are acceptable.

## Conclusion

The outcomes of this study explicated the mean measured the working length of the root canal had no significant difference between the digital radiography, conventional radiography, and Raypex6 apex locator. Notwithstanding, these three methods had a significant difference with the actual teeth length. This significant difference indicates that none of the three approaches used can measure the exact working length.

**Conflict of interest:** none.

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