A comparative study of two different methods for determining the root canal working length

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Abstract

Introduction Success in endodontic treatment depends on various factors. Among the most important factors, appropriate preparation of the root canal system and keeping periapical region intact as much as possible could be mentioned. These are achieved by determining the penetration depth of the instruments into the canal i.e. the working length. Several methods are introduced for working length determination. The most popular techniques in this regard are the use of conventional radiography and electronic apex locators. A new type of apex locator is the Root ZX. The purpose of this study was to compare the accuracy rate of Root ZX apex locator with the conventional radiography.

Materials and Methods The working length of thirty extracted single rooted teeth were determined by means of Root ZX and conventional radiography then compared with the actual working lengths measured by the stereomicroscope.

Results The results showed there was statistically significant difference between the length determined by the Root ZX and stereomicroscope. In addition, the radiographic and stereomicroscopic working lengths had statistically significant differences as well. There was also significant difference between the lengths measured by the Root ZX and radiography.

Conclusion It is recommended to use the Root ZX and radiography both together to reach the most accurate working length.

Key words: Apex locator, Conventional radiography, Root ZX, Working length.

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Introduction

Many factors influence the success of root canal treatment. Among these factors an accurate and complete cleaning of the root canal system without disturbing the periapical integrity is of great importance (1). To reach this goal, the accurate working length of the root canal should be determined and the cleaning and shaping of the root canal system should be exactly performed up to this length. In other words, if the root canal treatment is done beyond the root canal working length or at a shorter length, the failure rate will be increased significantly. Thus, accurate determination of the root canal working length is one of the most important steps in endodontic therapy (1-3).

In order to determine the working length, many different methods and equipments have been introduced; from operator's tactile sense to complex devices such as electronic apex locators and radiography.

In this Study, the accuracy of the Root ZX apex locator and conventional radiography in determining the root canal working length are compared with each other to conclude whether the

Root ZX (considering its advantages) is an accurate alternative for conventional radiography or not (4-5).

Materials & Methods

Thirty extracted single-rooted teeth of any type were randomly selected. The teeth were completely carries-free and their roots had completely been formed. In order to omit the tissue remnants, the teeth were kept in 5% sodium hypochlorite solution for one week. Access cavities were prepared on each tooth using a high-speed handpiece and a diamond bur.

In order to preparing the teeth for measuring the working length by the Root ZX apex locator, the root of each tooth was inserted into a little empty bottle through its flexible plastic cap. Next to the tooth, a metal rod was also inserted to be attached with the lip chip of the Root ZX. In order to complete the electrical circuit, each bottle was filled up with a buffer solution which worked as an electrolyte. It contained 7gr of NaCl, 4.5gr of Na_2HPO_4 and 6.67gr of KH_2PO_4 in one liter of distilled water.

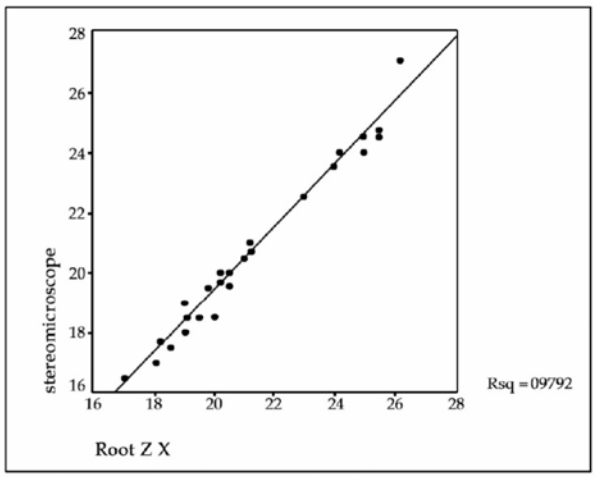
Following the Root ZX manufacturer's instructtions, the working length of each tooth was measured and recorded.

On the other hand to preparing the teeth for measuring the working length by conventional radiography, the root of each tooth was put in an acrylic block and appropriate file at the working length determined by the Root ZX was inserted into each root canal. Then, radiography was taken by setting the radiographic tube perpendicular to the buccal surface of each blocked tooth. After standard film processing, each radiograph was investigated by two endodontists. If the file tip was in 0.5mm distance from radiographic apex, the radiographic working length was equal to the working length measured by the Root ZX. If not, necessary corrections were done to determine the radiographic working length.

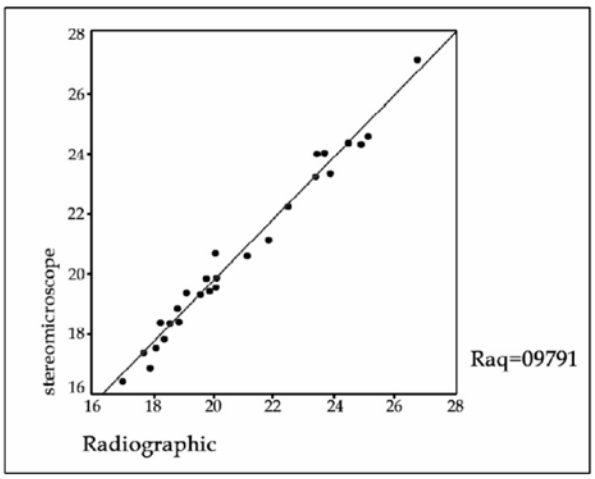
To prepare the teeth for measuring the working length by the microscope, each tooth was put under the SZH 10 stereomicroscope (Olympus, 50X Japan).While looking at the apex, the file was pushed through the root canal. As soon as the file tip reached the apical foramen, the file was removed from the canal and its length was measured. According to Kuttler's study, 0.5mm was subtracted from this length and the new length was considered as the actual working length for each tooth. Paired t test was used for data analysis.

Results

The findings of this study are summarized in table 1 and graphs 1-2.



Graph 1: Linear relation between Root ZX and stereomicroscopic working lengths



Graph 2: Linear relation between radiographic and stereomicroscopic working lengths

The difference between the measured working lengths by the Root ZX and by the stereomicroscope (actual working length) was statistically significant ($P<0.05$).

There was statistically significant difference between the working lengths measured by

Table 1

	Apically	Laterally	Sum
Actual (stereomicroscopic) length equal to Root ZX length (clinical error= ± 0.5mm)	9	8	17 (56.7%)
Actual length unequal to Root ZX length	8	5	13 (43.3%)
Sum	17	13	30

Table 2

	Apically	Laterally	Sum
Actual (stereomicroscopic) length equal to radiographic length (clinical error= ± 0.5mm)	16	11	27(90%)
Actual length unequal to radiographic length	1	2	3(10%)
Sum	17	13	30

conventional radiography and by the stereomicroscope (actual working length) (P<0.05).

The working lengths determined by the Root ZX and by conventional radiography were also compared with each other. Statistically significant difference was found between these working lengths, as well (P<0.05).

At the level of 5%, there are exists almost complete correlations between the Root ZX working and the stereomicroscope working lengths (R=0.990) using regression analysis and considering the Root ZX working lengths (R) as independent variables and the stereomicroscope working length(s) as dependent variable(s), the following linear relation can be described (graph 1): S= 0.04®-0.47.

The radiographic working lengths (Ra) and the stereomicroscopic working lengths (S) are also correlated at the level of 5%. (R=0.989). According to the regression analysis, the linear relation between them is (graph 2): S=/.0/5 (Ra) (Consider "Ra" as the independent variable and "S" as the dependent variable).

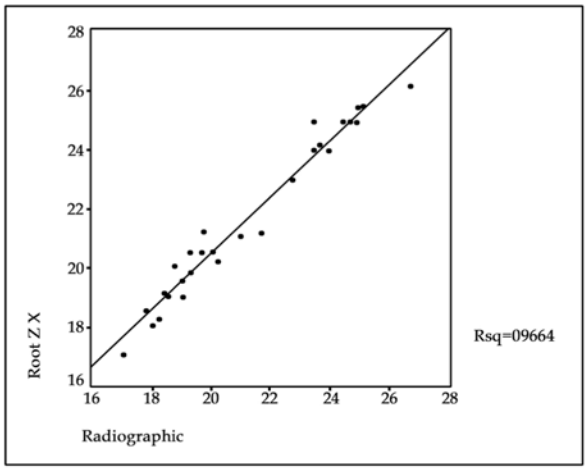
At the level of 5%, there are exists almost complete correlations between the Root ZX working length(R) and the radiographic working length (Ra) (R=0.983). Thus, the regression analysis provide us this linear relation between them (graph 3): Ra=/.008 (R) ("Ra" is the dependent variable and "R" is the independent variable).

The working lengths measured by the three methods are also correlated to each other (R=0.996). Considering the stereomicroscopic working length(S) as the independent variable, the following linear relation results from the regression analysis: S=0.51 (Ra) +0.53 (R)-1.16.

In addition, the chi-square analysis (Fisher's exact test), showed the following results:

Under stereomicroscopic investigation, it was evident that in 17 teeth, the apical foramen exactly opens at anatomic apex (apicaly). But in the remaining 13 teeth, the opening of the apical foramen is laterally to the anatomic apex. According to fisher's exact test, by accepting the clinical error of ±0.5 mm, the accuracy of the working length determination by radiography and by Root ZX, is not a function of apical foramen opening in relation to the anatomic apex (P>0.05).

Considering the clinical error of ±0.5mm, the accuracy of Root ZX in determining root canal working length is 56.7% and that of the conventional radiography is 90% (Table 1-2).



Graph 3: Linear relation between Root ZX and radiographic working lengths

Discussion

Working length is a determined length of the total root canal length at which all endodontic

procedures including cleaning, shaping and obturation are performed. Thus, the accurate determination of this length is crucial to the success of root canal treatment. The distance between a coronal reference point and a distinct point on the apical end of the root (i.e. apical constriction) is measured as the working length. Two major methods for working length determination are radiography and electronic apex locators. In this study, the advantages, disadvantages, accuracy and usefulness of the Root ZX apex locator are compared with the conventional radiography (5, 6).

The working lengths of 30 extracted single-rooted teeth are determined by the Root ZX and conventional radiography and then compared with the actual working length of each tooth measured by the stereomicroscope.

Compared to various methods used for working with the Root ZX in vitro, in this study a new and simple model is described. The ionic solution is a buffer solution which is easily mode, unlike the complex and expensive electrolytes in other studies (almost all of them consist of bactoagar or gelatin).

Observing the root canal end under the stereomicroscope is a simple method which does have some advantages: first, it is much less expensive; second, it needs less complicated equipment and last but not least, unlike using other types of microscopes, there is no need for keeping the teeth in acids to become soft and then cut them; So the anatomic details of the apical area remain intact.

In this study, we conclude that accepting the clinical error of ±0.5mm. The Root ZX is able to show the working length with the accuracy of 56.7%. In a similar study by Shabahang et al. (7) in 1996, the accuracy of the Root ZX was 96.2%. However, that study was done on vital teeth in vivo and the working length was not measured but the position of the apical foramen was determined. In addition, in Pagavino's study in 1998 (8), the accuracy of the Root ZX - with the same clinical error - was 82.75%. Again the teeth were vital and they used the scanning electron microscope. However, in 1998 Dunlap et al. (9) showed that there is no significant difference between the accuracy of the Root ZX in vital and nonvital teeth.

In 1999, Ibarrola et al. (10) claimed that canal preflaring results in better performance of the Root ZX, since the file reaches the apical foramen much better. Thus, it is probable that preflaring of the root canal has influence on the accuracy of the Root ZX.

We also found that the accuracy of the Root ZX is not a function of the position of the apical foramen opening. However, Pagavino et al. in 1998, stated that the Root ZX is more accurate if the apical foramen opens at the anatomic apex. This difference could derive from the different methods of these two studies as Pagavino used the SEM.

In our study, the accuracy of the conventional radiography (parallel method) was 90% (considering the clinical error of ±0.5mm). This high rate of accuracy may be related to the fact that the study was done in vitro. In clinic, there are many limitations for taking a radiography and consequently the accuracy of the radiography reduces: Parallel method cannot be used ideally, taking radiography in presence of rubber dam is difficult, sometimes the anatomic structures are superimposed on the radiograph and occasionally the patient is not cooperative (children, gag reflex).

To draw the final conclusion, both conventional radiography and the Root ZX are useful. The Root ZX can be used as an alternative in pregnant women. Besides that, if anatomic structures or the root position do not let us take accurate radiographs, the Root ZX is highly beneficial.

One can also estimate the working length by the Root ZX before taking the radiograph.

In spite of these advantages, the Root ZX should not be used as a single method for working length determination. It could cause several errors. The file attached to the Root ZX can enter an accessory or lateral canal instead of the main root canal. Only a radiograph can correct this error. In addition, the Root ZX solely measure the working length while a radiograph gives us a vast range of information about the shape and diameter of the root canal, anatomic

vicinities, bony lesions, etc. Thus, it is highly recommended that the conventional radiography and the Root ZX are used both together.

As there were strong correlations among methods of working length determination in our study, by considering linear relations between radio-graphic and/or Root ZX working length, stereomicroscope working length could be calculated.

For future studies, it is recommended that:

1. The Root ZX and radiography be compared in vivo.
2. Apical constriction is directly observed under SEM.
3. The RVG system is compared with the Root ZX and conventional radiography in order to find the best method for working length determination.

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