

COMPARATIVE ROLE OF RADIOGRAPHS AND ELECTRONIC APEX LOCATOR IN WORKING LENGTH DETERMINATION

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ABSTRACT

The objective of this study was to correlate the measurements of radiographic and electronic methods of working length determination with the directly observed visual length of root canals. It was a Quasi experimental intervention study carried out over a period of one year in the Department of Operative Dentistry, Lahore Medical and Dental College, Lahore. 100 patients who were advised extraction of their premolar teeth with 119 canals were selected by convenience sampling. The Root ZX[®] apex locator was used to measure the root canal length. Reference points were marked and a working length radiograph was also taken. The tooth was extracted. The actual length of the root canal was then determined using the same files and points of reference. Independent samples t-test was applied to compare the actual working length with the length measured by radiograph and electronic apex locator. The Root ZX was 94.1% accurate to within 0.5mm of the apical constriction as compared to 50.4% accuracy given by radiographs.

Key words: working length (WL), electronic apex locators (EAL), radiographs, apical constriction (AC).

INTRODUCTION

Determination of an accurate working length is one of the most critical steps of endodontic treatment. The cleaning, shaping and obturation of the root canal system cannot be accomplished accurately unless the working length is determined precisely.¹⁻³ 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.”⁴

Failure to accurately determine the length of the tooth may lead to either incomplete cleaning and apical leakage or apical perforation and overfilling with increased incidence of postoperative pain.^{5,6} Reports on postoperative pain indicate an increase when canals are filed and filled to the radiographic apex as compared to within the body of the canal.^{7,8} Custer⁹ was the first to report the use of electric current to determine working length. Suzuki¹⁰ determined that the electrical resistance between the periodontal ligament and the oral mucosa was of a constant value of 6.5 kilo-ohms and this can be used to measure the exact apical constriction where the canal terminates at the periodontal ligament.

Precise location of root apex is a problem which causes countless endodontic failures. In practice the

apex locator has given good endodontic results. This study was carried out to compare the radiographic estimation of working length with the electronic method. The results were compared with the direct measurement of canal length after extraction of the tooth. No such study has been carried out in Pakistan.

METHODOLOGY

This quasi experimental study was carried on 100 adult patients of both sexes aged 12-55 years requiring extraction of their maxillary and mandibular premolar teeth for prosthetic, periodontal, orthodontic purposes. Teeth selected had fully formed apices. Both symptomatic and asymptomatic teeth were selected.

The patients were selected by convenience sampling from the Dental OPD of Lahore Medical and Dental College, Lahore from August 2004 to July 2005.

Informed consent was obtained from the patients. Standardized preoperative radiographic analysis of the tooth's periodontal and pulpal status was carried out in every case. All the relevant dental information was recorded on a Proforma.

Tooth to be opened was anaesthetized. Access cavity was prepared using the 702 U bur followed by a

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No. 4 round bur in a contra-angle high speed hand-piece. The number of canals and whether the pulp was vital or necrotic upon entering the pulp chamber was recorded. The pulp tissue was removed with #15 and #20 Hedstrom file. The canals were irrigated copiously with 2.5% NaOCl. The root canal length was clinically determined with the Root ZX apex locator. The Root ZX assembly included an electrode that holds the file and a contrary electrode hooked in the corner of the mouth. The unit was turned on. A K-type file attached to the file holder and inserted into the canal. The audible alarm began to beep slowly when the meter reached 2. At the 0.5mm reading the tip of the file was at the apical constriction and the sound of the alarm changed. The file was then advanced further by slow clockwise turn until the word APEX began to flash. At this time the alarm changed to a single sustained beep. After the apex was reached the file was turned by slow counter-clockwise movement until the meter read 0.5mm again. The canal's working length was measured. Reference points were marked on the tooth crown with a felt pen to facilitate accurate reinsertion of the files after extraction of the tooth.

A standardized radiograph, with file in the canal, was taken to determine the working length. The parallel cone technique was used. The tooth was then extracted.

The actual length of the tooth was determined using the same files and points of reference. Magnifying glasses ($\times 2$) were used to determine the actual length of each tooth. This was measured by inserting the file until it emerged with its minor diameter at the end of the root. This root canal length minus 1mm was recorded metrically on a millimeter scale as the "working length" (assumed to be clinically important length).

Data analysis was computer based. SPSS version 10 was used for the analysis. Independent samples t-test was applied to compare the actual working length with length measured by radiograph and electronic apex locator. The influence of age, status of the pulp and preoperative pain on working length determination was also evaluated using the same test. The level of statistical significance was established at p value ≤ 0.05 .

RESULTS

100 premolar teeth with 119 root canals from 100 patients were included in the study. The mean working length measurements by radiographic and electronic methods were longer than the actual working length of the root canal. The mean distance from the apical constriction was 0.18mm in the electronic measurement and 0.39mm in the radiographic measurement (Tables 1 & 2). Both were statistically significant (≤ 0.01) but the electronic apex locator measurement was consistently more accurate (t -value = 4.84) ($r = 0.974$) than the radiographic (t -value = 5.01) ($r = 0.893$) measurement. The difference between the measurements by electronic apex locator and radiographs was statistically significant ($p < 0.01$) and ($r = 0.872$).

In total, the Root ZX measurements were at the working length 57.1% of the time. The results showed 94.1% accuracy within ± 0.5 mm of the working length and 97.5% accuracy within 1.0mm of the working length. The measurements in case of radiographs were at the working length 33.6% of the time. The results showed 50.4% accuracy within ± 0.5 mm of the working length and 80.6% accuracy within 1.0mm of the working length.

Statistical analysis showed significant result ($p \leq 0.01$) in the 40 years and above age group. The mean

TABLE 1: COMPARISON OF ACTUAL WORKING LENGTH WITH LENGTH MEASURED BY RADIOGRAPHIC PROCEDURE AND ELECTRONIC APEX LOCATOR

Working length of root canal	Mean	S.D.	Mean of diff.	S.D. of diff.	Student t test
Comparison of Radiographic Length and Actual length					
Actual length	19.53	1.79	0.39	0.85	t -value = 5.01
Radiographic length	19.91	1.87			p -value < 0.01
Comparison of Electronic Apex Locator length and Actual length					
Actual length	19.53	1.79	0.18	0.41	t -value = 4.84
					p -value < 0.01

TABLE 2: CORRELATION OF ACTUAL WORKING LENGTH WITH LENGTH MEASURED BY ELECTRONIC APEX LOCATOR AND BY RADIOGRAPHS

Correlation	(n)	Length measured by Electronic Apex Locator (r)	p-value	Length measured by Radiographic (r)	p-value
Actual working length(mm)	119	0.974	< 0.01	0.893	< 0.01
Length measured by Electronic Apex Locator	119			0.872	< 0.01

TABLE 3: COMPARISON OF MEASUREMENTS IN PATIENTS ABOVE 40 YEARS, NONVITAL TEETH AND SYMPTOMATIC TEETH

Patients 40 years and above				
Method	(n)	Mean of diff.	S.D. of diff.	Student <i>t</i> test
Radiographic Length	59	0.50	0.94	<i>t</i> -value = 3.04
Electronic Apex Locator length	59	0.10	0.37	<i>p</i> -value < 0.01
Nonvital teeth				
Radiographic Length	61	0.46	0.83	<i>t</i> -value = 0.36
Electronic Apex Locator length	61	0.15	0.36	<i>p</i> -value < 0.01
Symptomatic teeth				
Radiographic Length	60	0.50	0.73	<i>t</i> -value = 3.63
Electronic Apex Locator length	60	0.13	0.30	<i>p</i> -value < 0.01

distance from the apical constriction was 0.10mm in the electronic apex locator group and 0.50mm in the radiographic group (Table 3). The electronic apex locator gave more accurate results than radiographs in non-vital teeth and the results were statistically significant (Table 3). The results were statistically significant ($p \leq 0.01$) in symptomatic teeth. The electronic apex locator showed better results as compared to radiographs (Table 3)

DISCUSSION

Tooth length determination is a crucial step in endodontic treatment. It is the general opinion among the dental profession that the preparation of the root canal should ideally be carried out to the CDJ or the apical constriction. In this study the root canal length determined by the electronic apex locator and radiographs were compared with the actual length of the tooth as well as with each other. The effects of age, status of the pulp and condition of the tooth were also determined.

The results of this study confirmed previous studies that demonstrate that electronic apex locators can

accurately determine the canal length to within 0.5mm of the apical foramen in 90% of the canals.¹¹⁻¹⁷ These results agree with the study of Schweiz¹⁸ who also compared radiographic and electronic working lengths. He found 77.2% of the measured radiographic lengths within 0.5mm of the apical constriction. The results of electronic apex locator were <0.5mm of the apical constriction 98.5% of the time. These results also confirm with the results of ElAyouti¹⁹ who found the radiographic working length measurements too long in 56% of the premolars he examined. He subsequently found that the use of Root ZX decreased the overestimation of working length of the premolars to 21%. This may be explained by the observation that the apical foramen is located laterally in 78% to 93% of the cases.²⁰ Fouad²¹, concluded that an electronic estimate of working length improved length quality of the final obturation, compared with radiographic estimate. The Root ZX simultaneously measures two impedances at two frequencies (8 and 0.4 kHz) inside the canal. The capacitance of root canal increases significantly at the apical constriction, and the quotient of impedances reduces rapidly as the apical constriction is reached. The change in electrical capacitance at the apical

constriction is the basis for the operation of the Root ZX and its reported accuracy.

In patients above 40 years of age the electronic apex locator showed better results when compared with radiographs. The reason could be a coronal transportation of the apical constriction secondary to cementum deposition.²² The difference in the electronic and radiographic measurements was significant in the nonvital group because the apical foramen showed signs of resorption without any visible periapical radiolucency. This was also the case in the study carried out by Dunlap.²³ Similar explanation can be given for symptomatic teeth.

The findings of this study show that if a file is set at the radiographic apex, its tip will be, in most cases, past the apical foramen. If the file is set 1mm short of the radiographic apex it will actually be short of the apical foramen. The Root ZX was able to identify the tooth length accurately and the real tooth length was not exceeded 65.5% of the time. Shabahang²⁴ suggested that an error of tolerance of 1mm should be clinically acceptable. When this standard is applied to the present study, electronic readings obtained with Root ZX showed an accuracy of 97.5%.

CONCLUSION

From clinical standpoint, the Root ZX showed 94.1% accuracy within ± 0.5 mm of the working length and 97.5% accuracy within 1.0mm of working length. Radiographs showed 50.4% accuracy within ± 0.5 mm of working length and 80.6% accuracy within 1.0mm of working length. Practically the combined use of electronic apex locator and radiographs can improve the accuracy of working length determination and enhance length control throughout the treatment.

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