ORIGINAL RESEARCH

Evaluation of the Efficacy of Different Systems in Determination of Root Canal Working Length: A Comparative Study

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Abstract

Aim and objective: This research aimed to assess the diagnostic efficiency of four different methods in the estimation of root canal working length (WL).

Materials and methods: Eighty human premolars, having a solitary root were chosen for this study. 5.25% sodium hypochlorite solution was used to disinfect the recently extracted teeth for a period of 24 hours. These teeth were then allocated at random into four groups consisting of 20 teeth each. Group I: Working length determination by tactile method, Group II: Digital radiographic method, Group III: Electronic apex locator (EAL), Group IV: Endodontic motor with integrated apex locator. The actual WL was estimated for every sample. The values procured by the four techniques were cross-tabulated with the levels of coincidence of authentic WL values.

Results: The WL measurements with an EAL (21.56 ± 0.862) had more or less satisfactory coincidence with the actual WL (21.84 ± 0.486), pursued by endodontic motor with an incorporated apex locator (20.96 ± 1.010), digital radiographic technique (20.74 ± 1.030), and tactile method (20.42 ± 1.002). However, the difference between these experimental groups was not significant statistically.

Conclusion: This study has some limitations, within which it may be concluded that the WL of root canals as estimated by the EAL implicated that these values were nearer to the actual WL than the values procured from endodontic motor with incorporated apex locator, digital radiograph, and tactile techniques.

Clinical significance: Establishing an accurate WL is among the elementary factors for the success of endodontic therapy. Instrumentation which is excessively short of or goes past the apex unfavorably influences the victory of endodontic treatment. Estimating the appropriate technique to precisely measure the WL would be advantageous for dental clinicians.

Keywords: Digital radiograph, Electronic apex locator, Tactile, Working length.

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Introduction

The success of endodontic therapy is determined by locating all the radicular canals appropriately followed by largely effective elimination of the non-pathogenic and pathogenic bacteria. To attain this objective, it is essential to determine the working length (WL) of the root canals, which also is an estimate; essential for the subsequent treatment stages. Infected root canals, as well as periapical infection, may also result from inadequate length of the finished obturation. Precisely determining the WL avoids shorter length instrumentation that is inadequate to eliminate periapical infected tissues and microflora. The risk of excess length instrumentation is also deterred as this would otherwise lead to patient distress, injury to periapical tissues or can lead to an infection/cystic transformation due to over-obturation with toxic substance outside the apical region.[1]

The essential prerequisites for perfect determination of the endodontic WL include precisely locating the apical limitations in various pulpal circumstances as well as the contents of the canal, ease of performing the measurements even in the presence of an abnormal relation amid apical constriction and apex as determined radiographically, agile cyclic observations and affirmations; the comfort of both the dental clinician and the patient, less radiation exposure of the patient, simplicity of use in a special group of patients and being economical.[2]

Combining various techniques helps attain the greatest level of preciseness in WL estimation. Due to ease and practical efficiency, a minority of clinicians still employ the tactile perception method in endodontic practice. Unfortunately, this methodology is

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generally not accurate in radicular canals with an immature apex, extreme curvatures and in case the canal is slender and contracted throughout its course.[3]

As technology advanced in leaps and bounds, the utility of digital radiography became profound and permitted a noteworthy reduction in exposure time and dose of radiation, as well as decreased time for image processing offering faster endodontic therapy. Though radiography allows numerous advantages like direct inspection of compound radicular canal anatomy, curvatures of canals, and presence of periapical pathosis, there is a drawback of the associated radiation exposure. To defeat such drawbacks, electronic apex locators (EALs) are being used in clinical practice to establish file location in the canal by determining apical constriction.[4]

Electronic apex locators offer multiple benefits such as a decrease in radiation exposure and treatment time, either of which helps maintain the cooperation of the patient. They may also be utilized to determine small constrictions. Microscopic researches have determined that apical constriction is present about 0.5–1 mm from the main foramen.[5] Moreover, this indicates cases where the apical foramen is at some distance from the radiographic apex and might help detect root canal perforations. Hence, this research was undertaken to comparatively assess the diagnostic efficiency of four methodologies that is the tactile method, digital radiographic method, EAL method, and endodontic motor with incorporated apex locater in the estimation of root canal WL.

Materials and Methods

Sample Preparation

The current *in vitro* research was performed in the Department of Conservative Dentistry and Endodontics, Buddha Institute of Dental Sciences and Hospital, Patna. Eighty human premolars, having a solitary root were chosen for this study. 5.25% sodium hypochlorite solution was used to disinfect the recently extracted teeth for a period of 24 hours. Radiographic examination of the teeth was performed to verify the patency of the radicular canals, following which cavity preparation was performed on every tooth. These teeth were then allocated at random into four groups consisting of 20 teeth each.

Group I: WL Determination by the Tactile Method

The openings of the root canals were subjected to widening and pre-flaring at the coronal portion with Gates–Glidden drills size number 2 and 3 (Dentsply Maillefer, Ballaigues, Switzerland). A 15 K-file (Mani K-files, Mani, Tochigi, Japan), placed within the canal till an augmented tactile resistance was noted. The rubber stopper was amended on the file such that it contacted the reference point. Cautiously withdrawing the 15 number *K*-file, the distance amid the tip of the file and the rubber stopper was calculated employing an Endo gauge (Dentsply Maillefer, Ballaigues, Switzerland), and the measurements were noted as TWL.

Group II: Digital Radiographic Method

Each sample was placed parallel to a digital radiographic sensor (Vatech EZ Sensor, Humanray Co. Ltd., Korea) by positioning the sensor and block in a customized acrylic jig. A *K*-file, number 15 with pre-assumed length as assessed from the diagnostic radiography, was placed in the root canal, following which a radiograph was exposed. The disparity amid the endodontic file end and apex was calculated on the radiograph.

Group III: Electronic Apex Locator

A file holding clip was attached to the shaft of a 21-mm size 15K (ISO) file (Dentsply Maillefer, Ballaigues, Switzerland) in the EAL (Root ZX mini, J. Morita Co., Tokyo, Japan) apparatus. The file having the rubber stopper was placed in the canal and eventually moved toward the apex in the canal till the machine made a fixed beeping noise and the light-emitting diode (LED) twinkled at the estimated reference point (situated at the triangle) as provided in the manual. The measurement was then documented after removing the 15K (ISO) file from the canal.

Group IV: Endodontic Motor with Integrated Apex Locator

Here, the WL was documented employing a size 15 K-file with a multi-functional endodontic motor incorporated with an apex locator (VDW Gold, VDW, and Munich, Germany) that was turned to the apex locator mode. Canal preparation was done with a ProTaper NiTi file to size F3 using VDW Gold that comprises an endodontic motor that is torque-controlled and has an incorporated EAL. The WL was tactfully maintained while the preparation was being done by constant monitoring the ability of the device. The master cone (ProTaper F3) was introduced up to the WL and subjected to radiographic examination by paralleling technique.

Determination of Actual Working Length

The actual WL for every sample premolar was then measured. A number 15 K-file (Dentsply Maillefer, Ballaigues, Switzerland) consisting of a silicon stopper was introduced into the radicular canal of every sample in the absence of any lubrication, till the file tip could be noted at the anatomic periapical apex. The expanse from the file tip to the silicon stopper was modified such that it just contacted the crest of buccal cusps of the sample teeth and was calculated employing an endodontic ruler. Lastly, 0.5 mm was deducted from the calculated distance to accomplish the definite WL.

The values as documented using the above-mentioned different methods were cross-tabulated with the levels of coincidence of actual WL values. All measurements were performed by two observers and interobserver variability was assessed. Where any discrepancy existed between the two observers a consensus was reached.

Exact Coincidence

Nil (0) difference amid value procured by any of the above methodologies and the value determined by AWL technique.

Acceptable Coincidence

0.5 mm decrease in values in contrast to that procured with actual WL methodology.

Non-acceptable Coincidence

>0.5 mm short of the actual WL or a value greater than the actual WL.

Statistical Analysis

All data thus procured were entered in an Excel sheet and assessed using the SPSS software (IBM SPSS Statistics 21.0, IBM, Armonk, NY, USA). Interobserver variability was assessed using the κ test. ANOVA was performed to appraise the actual length and that with the different methodologies employed. $\alpha = 0.05$ was set as the level of significance.

Results

Table 1 depicts κ values for the two observers that are in harmony with one another to a very short degree for the WLs calculated employing the tactile technique (0.013 and *p* value 0.941), digital radiograph (0.218 and *p* value 0.360), EAL (0.572 and *p* value 0.410), as well as an endodontic motor with an incorporated apex locator (0.724 and *p* value 0.386). The values delineated a κ value with a cent percent coincidence interval amid the two observers without significant disparity.

Table 2 demonstrates the evaluation of mean radicular length dimensions with different WL estimation techniques. The WL calculated by the tactile method was 20.42 ± 1.002, the digital radiographic technique was 20.74 ± 1.030, EAL was 21.56 ± 0.862, and endodontic motor with incorporated apex locator was 20.96 ± 1.010.

Table 3 shows the contrast of mean radicular length among different WL estimation techniques. The WL measurements with an EAL (21.56 ± 0.862) had more or less satisfactory coincidence with the actual WL (21.84 ± 0.486), pursued by endodontic motor with an incorporated apex locator (20.96 ± 1.010), digital radiographic technique (20.74 ± 1.030), and tactile means (20.42 ± 1.002). However, the difference between these experimental groups was not significant statistically.

Discussion

Establishing the apical extent of root canal preparation is a vital stage of endodontic therapy. It is a general opinion that the root canal preparation and obturation must be within the confines of the canal. Hence, precise estimation of the WL is one of the highly significant steps in root canal treatment.[6]

Table 1: Interobserver variability assessment using κ test

Working length determination methods observer	*Symmetric measures κ value*	*Significance*
Tactile 1 vs Tactile 2	0.013	0.941
Digital radiographic 1 vs Digital radiographic 2	0.218	0.360
Electronic apex locator 1 vs Electronic apex locator 2	0.572	0.410
Endodontic motor with integrated apex locator 1 vs Endodontic motor with integrated apex locator 2	0.724	0.386

Table 2: Assessment of mean root length measurements among different working length determination methods

Working length determination methods	*Samples (n)*	*Mean ± SD*	*Std. error*
Group I: Tactile method	20	20.42 ± 1.002	0.0144
Group II: Digital radiographic method	20	20.74 ± 1.030	0.0124
Group III: Electronic apex locator	20	21.56 ± 0.862	0.0126
Group IV: Endodontic motor with integrated apex locator	20	20.96 ± 1.010	0.0140

Radiographs have been the sole, unanimously recognized, accessible, and important technique of adequately determining the WL in clinical practice. Nevertheless, this calls for repetitive exposure to undesired radiation before, during, and soon after root canal therapy. Radiation may have untoward effects on regions in way of the ionizing radiation which includes the oral and periodontal tissues, embryos, and fetuses in child-bearing women.[7] Thus, decreasing the number of radiographs is critical to avoid recurring exposure of patients to ionizing radiation.

Previous findings by Kuttler[8] demonstrate that a file tip 1 mm less than the actual apex, is well within the region where the apical constricted is usually situated. Nevertheless, it was felt suitable to deduct 0.5 mm from the tooth length of every tooth to estimate the definitive length, according to the research by Leddy et al.[9] This study observed that the value determined by the electronic technique was within 0.5 mm of the definitive WL that can be accepted clinically.

0.5 mm of, actual working according to one other study by Ehsan,[10] a correlation of measured values from radiographic and electronic techniques for WL estimation with directly noted visible lengths of radicular canals was evaluated. The root canal length was calculated via the Root ZX apex locator. This tool was able to estimate the length to within 0.5 mm of the apical constriction with 94.1% accurateness in contrast with the 50.4% precision of digital radiographs. Singh et al.[11] also procured comparable findings authenticating the electronic technique for WL measurement of root canals, which were more precise when compared with the radiographic method. The main advantages of EALs include reduction in radiation dosage and procedure time, both of which aid in maintaining patient cooperation. The EALs are used to locate the minor constriction.

In this research, it was noted that the WL measurements by the EAL were nearer to the definitive WL. This observation was in harmony with numerous studies documented by Kielbassa et al.[12] and Subramaniam et al.[13] which cite the accuracy of the electronic technique in determining the WL when compared with the radiographic method.

Venturi and Breschi[14] documented that the exactness of the EAL was better than radiographs. *In vivo* research documented by Vieyra and Acosta[15] previously, cited that calculating the position of the apical constriction employing Root ZX apex locator was further

Table 3: Comparison of mean root length measurements among different working length determination methods

Working length determination methods	*Mean ± SD*	*Std. error*	*F*	*p value*
Group I: Tactile method	20.42 ± 1.002	0.0144	18.510	0.648
Group II: Digital radiographic method	20.74 ± 1.030	0.0124		
Group III: Electronic apex locator	21.56 ± 0.862	0.0126		
Group IV: Endodontic motor with integrated apex locator	20.96 ± 1.010	0.0140		

precise than radiography, decreasing the peril of instrumentation and obturation ahead of the apex. As Root ZX mini incorporates the industry Root ZX technique working on a similar principle, Root ZX mini can gauge in either wet or dry canal environment. In addition, the small dimension of the Root ZX mini is advantageous in routine clinical practice.[16]

Root canal WL through EAL measurements indicated they were closer to the actual WL than those obtained from endodontic motor with integrated apex locator, digital radiograph, and tactile methods. The establishment of a correct WL is one of the fundamental parameters for endodontic success. Instrumentation that is too short of or goes beyond the apical foramen will adversely affect its success.

This research has few limitations. Bigger sample size could have enhanced the capacity to more precisely evaluate the importance of the consequences. As the EAL enhances the safety and ease of root canal treatment, its utilization must be assessed further in clinical studies. The difficulties encountered in the clinical setting, within the mouth to determine the WL may not be simulated in an *in vitro* model.

Conclusion

This study has some limitations, within which it may be concluded that the WL of root canals as estimated by the EAL implicated that these values were nearer to the actual WL than the values procured from endodontic motor with incorporated apex locator, digital radiograph, and tactile techniques.

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