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Original Article

A comparative evaluation of working length with digital radiography and third generation apex locator (ProPex) in the presence of various intracanal irrigants: An *in vivo*/*ex vivo* study

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ABSTRACT

Background: Accurate working length determination is a pre-requisite for a successful endodontic treatment. Even with improved systems of working length measurement, different readings may be recorded in different electrolytes present in the canal. The purpose of this *in vivo*/*ex vivo* comparative study was to determine the accuracy in measuring the working length of root canal using Direct Digital Radiographic Method (Radiovisiography or RVG) and ProPex electronic apex locator in the presence of three different irrigating solutions: 0.9% normal saline, 2% chlorhexidine, 3% NaOCl solutions.

Materials and Methods: Forty single-rooted human teeth scheduled for extraction with mature apices were selected for this study. Measurements were performed by using RVG and ProPex in the presence of irrigating solutions. After extraction of the teeth, light microscope was used to confirm visually the relationship of the tip of the endodontic file to the apical foramen, and actual lengths were determined by reducing 0.5 mm from this length. The statistical analysis was performed by one-way ANOVA test and Tukey-HSD *post hoc* procedure. $P < 0.05$ was considered as significant.

Results: No significant difference was found between overall mean electronic working length and digital radiographic length; however, prediction error ($P < 0.05$) was significant with respect to different irrigants. Among the irrigating solutions, chlorhexidine gluconate had the smallest distance to the actual lengths, whereas NaOCl had the greatest.

Conclusion: Electronic apex locator ProPex yielded best result in the presence of chlorhexidine, whereas the largest error was demonstrated with NaOCl indicating that higher electroconductive irrigating solutions affect the precision of multi-frequency apex locators.

Key Words: Apex locators, digital radiography, irrigation solutions, working length

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INTRODUCTION

Precise working length measurement is a pre-requisite for a successful endodontic treatment.[1,2] Traditional methods for estimating working length include radiography, anatomical averages and knowledge of anatomy, tactile sensation, and moisture on a paper point. All of these methods have limitations and do not allow precise localization of apical constriction.[3] In recent years to overcome the limitations offered by traditional methods, new techniques have been introduced, which include digital radiography and apex locators. Thus, in addition to radiographic measurements, electronic root canal working length determination and digital radiology has become increasingly important.[2] The

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electronic method eliminates many of the problems associated with radiographic methods. It is more accurate, easy and fast, with no requirements of X-ray exposures.[3,4] However, it requires special devices, and the accuracy is influenced by electrical condition of the canal. The presence of tissue and conductive irrigants in the canal can change the electrical characteristics and lead to measurement error. The most recent generation of dual frequency apex locators have attempted to minimize this problem.[5] Similarly, digital radiology that generates images by means of an X-ray sensor instead of conventional film had many advantages over conventional radiographs. They are: Speed of image acquisition, reduced patient irradiation, the possibility of editing the image, and a quality of detail similar to that afforded by conventional radiology.[6,7]

In view of the possible variation between the radiographic and anatomic apex with various techniques that have been employed to determine working length, along with the improvements in electronic apex locators an *in vivo* study has been conducted. Even with these improved systems, measurements may exhibit different readings according to the type of electrolytes present in the canal.

The purpose of this *in vivo/ex vivo* comparative study was to evaluate the diagnostic efficacy of an electronic system (ProPex) in the presence of three irrigants for the determination of working length of root canal, in comparison with direct digital radiographic method (RVG).

MATERIALS AND METHODS

Ethical clearance from institution was taken before the commencement of study. Forty human single rooted vital teeth scheduled for extraction for periodontal or prosthetic reasons with mature apices were selected for the study. Teeth with open apices, calcification in the pulp chamber or root canal, grossly resorbed apex, retreatment cases, and any abnormal canal configuration were excluded from the study. Detailed history and thorough clinical examination was done. Patients with heart pacemakers or with contributory medical history were excluded from the study. Informed written consent was obtained from each patient before treatment. Access opening of forty single rooted teeth was made under local anesthesia with rubber dam isolation. The incisal edges were flattened to establish a level surface to serve as a stable and reproducible reference for all measurements. The root canal orifices were widened and coronal preflaring was carried out with Gate-Glidden drills no 2-3 (Dentsply, Maillefer Chemin du Verger 3, Ballaigues [VD], Switzerland). Samples were divided into 3 equal groups according to the method of working length evaluation, containing 40 teeth each. For Group-I working length was determined by electronic apex locator (ProPex) (Dentsply, Maillefer, DENTSPLY New Zealand) in the presence of three irrigation solutions.

Three equal groups were made according to the method of working length evaluation, containing forty teeth each. The working length of all 40 teeth was determined using three different systems.

Group 1: Electronic Working Length method (ProPex)

Group 2: Digital Radiographic Method (RVG)

Group 3: Actual working length (AWL) under light microscope ×10

Group 1 was further divided into 3 equal subgroups containing 40 teeth each depending upon the irrigation solution used.

The first measurement was taken with ProPex apex locator in the presence of 0.9% normal saline. The canals of 40 single rooted teeth were irrigated with 0.9% normal saline, the lip-clip electrode was applied to the patient's lower lip. No. 15 stainless steel k-file was taken and the unit's cable was clipped to its metal shank. The ProPex apex locator was turned on and the file was advanced apically into the canal, and when the file reached 2-3 mm to the apex, 2 horizontal arrows appeared on the screen. The file progressed until "0.5" appeared on the screen, suggesting that the tip of the file was at the middle of apical zone (apical constriction). The rubber stop on the file was set to the reference point. If the measurement remained constant for 5 s, the file was withdrawn carefully and the distance between the rubber stop and the tip of the file was measured with a digital caliper (INSIZE, Mumbai, India) to the accuracy of 0.01 mm and recorded as EWL1 measurement. Then, two more measurements were taken after irrigating the canals with 3% NaOCl and 2% chlorhexidine gluconate solutions and recorded as EWL2 and EWL3 measurements. Between each measurement, the canal was irrigated with distilled water and dried with paper points.

For group II working length determination was carried out by digital radiography (RVG) (Progeny, Vision DX Progeny Dental, Lincolnshire, IL USA). A file with a length 1 mm less (safety factor) than the tooth length as noted from the pre-operative radiograph was kept in the root canal. After placing the instrument in the canal, working length was determined by radiovisiograph using extension cone paralleling technique. On the digital image the difference between the end of the instrument and the end of the root was measured. This amount was added to the original measured length. If the exploring instrument had gone beyond the apex then the amount gone beyond was subtracted from the original measured length. From this adjusted length of tooth 1 mm was subtracted to confirm with the cementodentinal junction. This value was registered as RVG working length (RWL).

After that teeth were extracted carefully and stored in 5.25% of NaOCl solution to remove remaining tissues from the external root surface. Then, a size 15 k-file was inserted into the canal to measure actual length for group III under ×10 magnification in a light microscope (Olympus, BX45 Melville, NY-Olympus America). From this length, 0.5 mm was deducted to obtain the proposed AWL [Figure 1].

The difference between RVG measurements, ProPex measurements and the actual canal length was calculated for each tooth and the mean values were calculated for each group. The statistical analysis was carried out by one-way ANOVA test and Tukey-HSD *post hoc* procedure. Proportion of exact coincidence with AWL method for various other methods was compared by Chi-square test. In the present study, $P \leq 0.05$ was considered as the level of significance.

RESULTS

Comparison of three methods Group I (EWL), Group II (RWL), Group III AWL with respect to length showed no statistically significant difference between groups ($P = 0.73$). Intergroup statistical analysis showed a statistically significant difference ($P < 0.003$) between three electronic working length measurements (Normal saline group, Chlorhexidine group and NaOCl group). Cross tabulation of coincidence of AWL method with electronic and digital radiography working length method was carried out. The electronic working length measurement in the presence of chlorhexidine irrigant (Subgroup-Ib) is giving the highest proportion of exact coincidence (42.50%) followed by digital radiographic working length method (Group II) (7.50%) and the lowest by electronic working length measurement in the presence of NaOCl (Subgroup-Ic) (0.00%). The proportion of exact coincidence in electronic working length method is significantly higher than digital radiographic working length method. The results were statistically significant ($P < 0.05$).

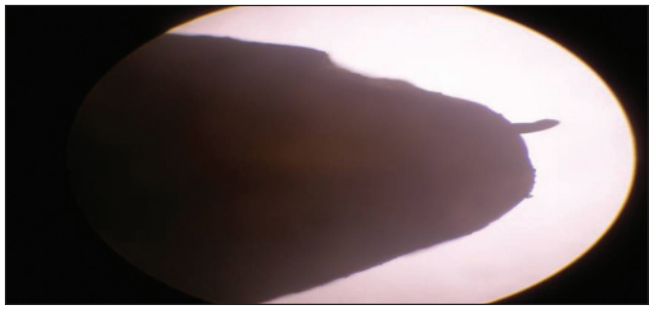

Figure 1: Determination of actual length under ×10 in a light microscope

DISCUSSION

Establishment of correct working length is an important stage in root canal treatment because sufficient evidence suggests that instrumentation either beyond or too short of apex can adversely affect the success.[8] Various schools of thought exist for the termination of root canal working length. Kuttler (1955) stated that the cementodentinal junction lies 0.507 mm short of the apical foramen in persons 18-25 years of age and 0.784 mm short in persons 55 years of age and older.[9] This natural constriction, where the dentin meets cementum, appears to be the ideal location for development of an apical seat for the root filling material.[10] Over the years radiography and electronic apex locators have been used for determining the working length. Although conventional radiography is the most commonly used diagnostic aid in endodontics, but radiation hazard concerns, time taking chemical processing and observer's bias in radiographic interpretation puts digital radiography in the front seat.[7] Current progress in the field of dental radiology is being channeled toward reducing exposure time and obtaining greater image definition.[11]

Different studies that have compared electronic working length and digital radiography[12-14] considered the reliability of the former technique in measuring working length to be equal or even superior to that of RVG. In the present study, results

of direct digital radiographic evaluation of working length showed overall accuracy of 62.50% under which 7.50% showed exact coincidence with AWL, 55% showed acceptable coincidence and 18% showed non-acceptable coincidence. Martínez-Lozano *et al*.,[6] showed accuracy of 61.4% by digital radiological method (RVG system) as compared to apex locator (Apit EM-S3), which showed accuracy of 67.8%. The results of evaluation of working length showed no statistical difference ($P > 0.5$) between the techniques investigated. Similarly, in the present study, no statistically significant difference was found between the techniques investigated ($P > 0.5$).

The effect of irrigation solutions on working length determination was also evaluated. Early generation electronic apex locators were often inaccurate in the presence of conductive fluids. However, manufacturer claims that ProPex locates the foramen under any canal condition (wet, dry, sodium hypochlorite etc.) as a result of its multi-frequency technology. Although frequency-dependent electronic apex locators enhance the measurement accuracy, there is still concern as to whether high electroconductive irrigants such as blood, saline, a local anesthetic solution, and irrigant fluids can affect the accuracy of the electronic apex locator performance. Several studies warned that a high electroconductive solution might affect the accuracy.[15] Kobayashi *et al*.[16] and Fan *et al*.[17] reported that the electroconductive solutions present inside the canal greatly reduce the impedance and there were tendencies toward short measurements in high electroconductive solution such as NaOCl, whereas longer measurements were in the lower electroconductive solution. When comparing the effect of individual irrigants on the working length evaluation by apex locator, the results of this study are in agreement with a similar study carried out by Ozsezer *et al*.[18] in which closer measurements to the actual length were obtained after extirpation and in the presence of chlorhexidine gluconate solution. When conducting fluids such as 0.9 NaCl and NaOCl were used, the accuracy of ProPex decreased, with the greatest distance to the actual length in the presence of saline. Whereas, in this study, the greatest distance to the actual length was obtained with NaOCl ($P < 0.50$). This is in agreement with other studies in which accuracy of different brands of apex locators were evaluated in the presence of different irrigants and the greater deviation from AWL was obtained with NaOCl.[5,8,18] The results of this study showed measurements of the ProPex were more precise in the presence of chlorhexidine. Presence of NaOCl solution in the canal almost inhibited its working capability, indicating that when the canals are filled with strong electrolytes, the results of ProPex were negatively affected; most of the measurements were short of AWL.

CONCLUSION

The performance of the direct digital radiography (RVG) was similar to that of electronic apex locator ProPex in the presence of irrigating solutions in terms of their capacity to diagnose working length. No statistically significant difference was noted in prediction error ($P > 0.05$). Among irrigating solutions, electronic apex locator ProPex yielded best result of 92.50% close to accepted AWL in the presence of chlorhexidine, whereas the largest error was demonstrated with NaOCl showing accuracy of 50%. A higher prediction error was apparent for more conductive solutions ($P < 0.5$); thus, indicating that higher electroconductive irrigating solutions affect the precision of multi-frequency apex locators.

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