RESEARCH ARTICLE

Evaluation of the Working Length Determination Accuracy by Cone-beam Computed Tomography in Primary Teeth

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ABSTRACT

Background: In primary teeth, working length determination is complicated due to its continuous alteration in dimension, shape, and root apex position. Accurate working length determination is essential to achieve the optimal cleaning and disinfection of the canal. Despite the use of conventional radiographic method, newer methods are available to increase the accuracy of WL determination. This study aims to compare electronic apex locator (EAL) with radiographic method of WL determination and to evaluate its accuracy using cone-beam computed tomography (CBCT).

Materials and methods: Sixty root canals from 34 extracted primary teeth were included. Occlusal surfaces were flattened and access opening done for all the samples. Teeth were subjected to working length determination by conventional radiograph and EAL. Samples were then mounted on a U-shaped wax and subjected to CBCT. Results were recorded and statistically analyzed using ANOVA and ICC for quantitative data.

Result: The mean measurement of radiographic, EAL and CBCT methods are 11.708, 11.200, and 10.895, respectively. Mean measurements demonstrated significant difference (p < 0.05) between three methods. ICC demonstrated high correlation between EAL and CBCT with Cronbach’s a value of 0.962 and moderate correlation were observed between radiographic method and CBCT (0.706) and EAL and radiographic method (0.763). EAL demonstrated 87% accuracy whereas radiographic method demonstrated 63% accuracy to the actual length as evaluated by CBCT.

Conclusion: EAL is more accurate than conventional radiographic method as evaluated by CBCT.

Keywords: Electronic apex locator, Primary teeth, Pulpectomy, Working length.

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INTRODUCTION

A major goal of treating young patients is to maintain the integrity of primary dentition till its physiologic exfoliation.1 Pediatric endodontics deals with the management of pulpally involved primary and young permanent teeth in children.2 Patient’s cooperation, limited access, anatomical variations, and complex anatomy of the primary roots makes the treatment difficult.3 The most important factor for the success of pediatric endodontics is to decide the extent of instrumentation and to what point the obturation should end.4

The traditional methods of working length determination in primary teeth are looking for the presence of moisture/blood at the tip of the paper point, relying on tactile sensation to feel the apical constriction and knowledge of the average length of tooth.5 Ingle’s radiographic method is one of the most common and reliable methods used in determining the working length.6 But the technique has some disadvantages and limitations, such as limited access to the mouths of young children, poor patient cooperation, increased appointment time, and exposing the children to ionizing radiation. As the radiographic image is bidimensional and the tooth and periradicular area are three-dimensional, there might be distortions and errors in the evaluation of WL measurements, and at times the major foramen or apical constriction position can go undetected.7

Limitations of radiographic technique was overcome by the invention of electronic apex locator (EAL) which has a higher accuracy than that of the conventional radiograph. They work on the electrical resistance that is demonstrated by the apical foramina instead of visual inspection.8 Over a period of time, generations of EAL devices were evolved with each generation overcoming the shortcomings of the former generation. The fifth generation apex locator overcomes the limitation of the fourth generation, such that it can function efficiently even in the presence of the blood and exudate.

The methods to determine the accuracy of radiographic technique and EAL are by Stereomicroscope and cone-beam computed tomography (CBCT). The CBCT is the advanced imaging technique with high potential in clinical application and improved accuracy in treatment planning. The most important advantages of CBCT are relatively low radiation dose and less exposure time than the conventional computed tomography. Overlapping problems inherent with the conventional periapical radiographs can be overcome with the CBCT. Therefore, this research aims to compare the radiographic and EAL method of WL determination in primary teeth and to evaluate accuracy using CBCT.

MATERIALS AND METHODS

The research was performed in the Department of Pediatric and Preventive Dentistry. The study was approved by Institutional Ethical Committee (XXXXXX).

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The study included 43 extracted primary teeth that are retained, nonrestorable and the teeth with not more than 1/3rd apical root resorption. To rule out any calcified canals or perforation or any remnants of obturated material, radiograph of the extracted tooth were taken. Finally, 60 root canals were included from 34 extracted primary teeth.

The occlusal surface of the teeth was flattened to create a defined reference point, that is, 3 mm from CEJ occlusally. Access cavity preparation was done using a round diamond bur under abundant water spray. Pulpal tissue of each tooth was extirpated using a 21 mm long H file. The pulp chamber was dried using absorbent points. As per Ingle’s method of working length determination, WL was determined for the selected canals, files were inserted and a conventional radiograph was made (Fig. 1).

Working length determination by using EAL was carried out following the conventional radiographic method. In order to simulate clinical environment of PDL the teeth were mounted in container filled with alginate. The fifth generation apex locator (Woodpex III) was used in this study. The file (K-files #15, 21 mm in length) was attached to the file holder and the lip hook was attached to alginate material. Alginate was chosen, as the electrical conductance of alginate and PDL is same. The file was advanced till the device indicated 0.0 mark. The rubber stop was moved to the occlusal reference edge and the file was removed. The distance between the rubber stopper and the file tip was measured using the Endo gauge.

The teeth were then mounted in a U shape wax pattern for CBCT analysis. CBCT images was acquired with Vatech 3D imaging system. The tube voltage was 85 Kvp and the tube current was 4.5 mA with the exposure time of 9 seconds. The voxel size was 0.0 mm (thickness of the slice of the image) and the Field of View was 80 × 80 mm. The buccolingual and the mesiodistal section of every teeth was recorded and the root length was measured in the software (Ez3Di) (Fig. 2). Data obtained were entered in excel sheet and subjected to statistical analysis.

**RESULTS**

The mean working length measurements by radiographic method, EAL and CBCT are 11.708, 11.200, and 10.895 (Table 1). It demonstrated a significant difference between the three techniques (p < 0.05).

Post hoc analysis was carried out to assess the difference between each technique. Analysis revealed that there was no statistically significant difference between EAL and Radiographic determination (p = 0.343) and also between EAL and CBCT (p = 1.0). This implies that the measuring accuracy of CBCT and EAL were similar. But, a statistically significant difference was observed between Radiographic method of determination and CBCT method p = 0.036.

When 18 anterior canals and 42 posterior canals was evaluated, anterior teeth canals demonstrated insignificant difference (p = 0.06) between the techniques whereas posterior teeth demonstrated significant difference (p = 0.029) in the mean working length measurements.

The correlation between each technique have been assessed using Intraclass Correlation Coefficient (ICC), the high correlation and agreement were observed between EAL and CBCT with Cronbach’s α value = 0.962. When Radiographic method and CBCT technique were assessed by ICC, it demonstrated moderate correlation and substantial agreement with Cronbach’s α value = 0.706. The ICC correlation between EAL and Radiographic technique demonstrated moderate correlation and substantial agreement with Cronbach’s α value = 0.763.

Regression analysis was done to evaluate the accuracy of EAL and radiographic method. EAL demonstrated about 87% accuracy of CBCT values (Table 2) whereas radiographic method demonstrated 63% of accuracy in predicting the CBCT technique (Table 3).

**DISCUSSION**

One of the key factors for the success of endodontic treatment in primary teeth is determining the accurate working length of the tooth which is essential for preventing over instrumentation, thereby preserving the underlying permanent tooth bud and for achieving the optimal cleaning and disinfection of the root canal.

The established postulated norm regarding pulpectomy procedure is the root resorption which shouldn’t exceed 1/3rd of its length. In the present study, 60 canals from 34 extracted primary teeth that did not show root resorption more than 1/3rd of the root length were subjected for the evaluation of working length of radiographic method and EAL method and its accuracy was evaluated using CBCT. The study result revealed that there was a significant difference between the mean measurements of all three methods (p = 0.04) when compared with each other.
Radiography is the most widely recognized, easily available and a good means of measuring the working length in a typical clinical setting. In pediatric patients, the number of radiographs and unnecessary radiation before and after the endodontic clinical setting. In pediatric patients, the number of radiographs type, file size, irrigating solution, and pulp electro-conductivity.15 In our study the paralleling technique of intra oral radiography demonstrated insignificant difference between EAL and other actual length (AL) determination methods like direct visual method, direct visual method with magnification and stereomicroscope method.4,6,15,18,26-29

Table 1: Mean working length measurements by electronic apex locator (EAL) method, radiographic method, and cone-beam computed tomography (CBCT) method

| Group               | N  | Mean (mm) | S.D  | F value | p value |
|---------------------|----|-----------|------|---------|---------|
| EAL                 | 60 | 11.200    | 1.902| 3.291   | 0.04a   |
| Radiographic        | 60 | 11.708    | 1.552|         |         |
| CBCT                | 60 | 10.895    | 1.790|         |         |

| Coefficientsa        |                     | Unstandardized coefficients | Standardized coefficients | 95.0% confidence interval for B | Lower bound | Upper bound |
|----------------------|----------------------|------------------------------|---------------------------|--------------------------------|-------------|-------------|
| Model                |                      | B Standard error  Beta       | t Sig.                    |                                |             |             |
| 1 (Constant)         | 1.108                | 0.520                        | 2.130 0.037               | 0.067 2.149                    |             |             |
| EAL                  | 0.874                | 0.046                        | 0.929 19.086              | 0.782 0.966                    |             |             |

| Coefficientsa        |                     | Unstandardized coefficients | Standardized coefficients | 95.0% confidence interval for B | Lower bound | Upper bound |
|----------------------|----------------------|------------------------------|---------------------------|--------------------------------|-------------|-------------|
| Model                |                      | B Standard error  Beta       | t Sig.                    |                                |             |             |
| 1 (Constant)         | 3.517                | 1.481                        | 2.375 0.021               | 0.553 6.482                    |             |             |
| Radiographic         | 0.633                | 0.126                        | 0.551 5.026              | 0.381 0.885                    |             |             |

Radiography is the most widely recognized, easily available and a good means of measuring the working length in a typical clinical setting. In pediatric patients, the number of radiographs and unnecessary radiation before and after the endodontic procedure is of prime concern. The child’s cooperation is as essential and unnecessary radiation before and after the endodontic clinical setting. In pediatric patients, the number of radiographs type, file size, irrigating solution, and pulp electro-conductivity.15 In our study the paralleling technique of intra oral radiography demonstrated insignificant difference between EAL and other actual length (AL) determination methods like direct visual method, direct visual method with magnification and stereomicroscope method.4,6,15,18,26-29

The reason for using CBCT values as actual root length is because, CBCT exhibited high accuracy in the working length determination and it produces undistorted images, which enhances the root length determination.10 It also overcomes the drawbacks of conventional radiographs such as overlapping of images, 2D image presentation, and positioning errors. Even though it has many advantages, the effective dose of CBCT (5–300 µSv) is high when compared to IOPA (5 µSv) and is equal to a full mouth series of intraoral radiograph (35 µSv), but when compared to CT (1320–1400 µSv) the effective dose required is less. In addition to

The limitations of radiographic methods were overcome by introduction of an electrical method, that is, EAL which can precisely locate the apical constriction of primary teeth. The accuracy level of an EAL can be influenced by a few factors: the apical foramen size, file type, file size, irrigating solution, and pulp electro-conductivity.15 In our study we have used multiple frequency apex locator, which is a fifth generation type EAL (Woodpex III) that can efficiently function even in the presence of exudate and blood. In addition to that EAL also has the advantage of measuring the root canal length in the resorbed roots.16 Samples were immersed in alginate material to simulate the electrical resistance property of PDL which has been experimented in few studies16-20 and found to be appropriate. Nguyen et al., in 1996, reported that the file size did not affect the accuracy of EAL measurements.21 The measurement was feasible and reproducible with inserted instruments in our study. In every root canal, the same file #15k file was used to provide comparable conditions for in vivo measurements. The file was advanced till the display of 0.0 mark in apex locator with the lip hook inserted to the alginate material.8,19

Earlier, Berman LH et al. and Hulsman M et al. stated that when the apical foramen is large or immature the working length determination by EAL demonstrated less accurate results.22,23 Later on, the efficacy of EAL was proven accurate in large apical foramen. The results of our study demonstrated insignificant difference (p = 1.0) when EAL is compared with CBCT (actual length); this indicates the measuring accuracy of EAL was similar and comparable to the actual length using CBCT.19,24,25 Various in vivo and ex vivo studies in the literature demonstrated insignificant difference between EAL and other actual length (AL) determination methods like direct visual method, direct visual method with magnification and stereomicroscope method.4,6,8,15,18,26-29

Table 2: Regression analysis between electronic apex locator (EAL) and cone-beam computed tomography (CBCT)

| Model | Unstandardized coefficients | Standardized coefficients | 95.0% confidence interval for B | Lower bound | Upper bound |
|-------|-----------------------------|---------------------------|--------------------------------|-------------|-------------|
| 1 (Constant) | 1.108 | 0.520 | 2.130 0.037 | 0.067 2.149 |             |             |
| EAL   | 0.874 | 0.046 | 0.929 19.086 | 0.782 0.966 |             |             |

| Model | Unstandardized coefficients | Standardized coefficients | 95.0% confidence interval for B | Lower bound | Upper bound |
|-------|-----------------------------|---------------------------|--------------------------------|-------------|-------------|
| 1 (Constant) | 3.517 | 1.481 | 2.375 0.021 | 0.553 6.482 |             |             |
| Radiographic | 0.633 | 0.126 | 0.551 5.026 | 0.381 0.885 |             |             |
tooth/root measurements and assessing the tooth morphology, Cone Beam Computed Tomography have also been used to assess the working length of primary and permanent roots. In our study CBCT and Radiograph demonstrated significant differences (p = 0.03) which was contradictory to Morais AL et al. study.

The regression analysis demonstrated 63% accuracy by radiographic technique and 87% accuracy by EAL method to the CBCT measurements which is similar to the Krishna IS et al., whose results demonstrated 92% accuracy for EAL and 72% for radiographic technique.

Using Pearson correlation evaluation in our study, the tested EAL (Woodpex III) proved to be beneficial and precise in the working length determination with high correlation between EAL and actual length CBCT measurements. This result suggests that EAL is an effective tool in determination of working length in primary teeth which has advantages of unnecessary ionizing exposure of radiation to children (Gordon and Chandler - 2004) and added advantage of reduced discomfort to the children. Hence, EAL can be used as an alternative tool in determining the working length of primary teeth.

Furthermore, it is important to remember that this research was done in vitro, which may not include the errors that could exist in clinical settings when calculating the length of the root canal. There is scarcity of studies that have evaluated the working length accuracy of EAL and Conventional radiographic methods using CBCT measurements. Woodpex III (fifth generation) EAL has not yet been evaluated in the root canal length determination.

CONCLUSION

From this study it is concluded that EAL is more accurate than the conventional radiographic technique in measuring WL in primary teeth. Also it reduces the unnecessary exposure to radiation, thereby facilitating child cooperation during treatment.

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