Accuracy of Working Length Determination In Primary Molar Teeth Using Three Different Methods: An Invitro Study.

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Abstract

Background: An accurate working length plays a pivotal role for the success of treatment in endodontics. It involves a wide array of procedures. **Aim:** Use of digital radiovisiography (RVG), apex locator (EAL) and cone beam computed tomography technique (CBCT) to evaluate working length in primary teeth. **Materials and Methods**: This study included thirty extracted primary teeth having at least 2/3rd of root. Alginate was combined with 0.9% normal saline solution and teeth were inserted in it after access opening. Two qualified examiners recorded working length for all canals twice with RVG, EAL and CBCT. In control group, a Kerr- file from coronal reference to the apical foramen was used to visually determine the actual (AL) under stereomicroscope. **Statistical analysis:** Intraclass correlation coefficient (ICC) and Bland and Altman analysis were used to calculate the agreement on measurements of all methods using actual values of different methods. **Results:** Electronic working length measured with AL (0.0007) was statistically significant compared to RVG (1.9570) and CBCT (0.8440). Amongst all methods for determination of working length the ICC showed the highest reliability for EAL and least for RVG. **Conclusion:** In comparison to RVG and CBCT, the EAL performed the best for determining working length in primary teeth.

Keywords: apex locator, cone beam computed tomography, digital radiovisiography.

Introduction

Non vital pulp therapy which includes pulpectomy is a routine clinical procedure in pediatric dental practice. Straight line access, determination of working length, debridement technique and obturating materials are some of the critical factors which supports successful pulpectomy procedure in pediatric patients.

A technique to determine working length must give exact and reproducible results[(1)]. There are various techniques to evaluate working length in primary or permanent tooth, such as conventional radiography, digital radiography and many others. Conventional radiography provides adequate information about root canal anatomy and adjacent tissues, but superimposition and anatomic interferences can be problematic[(2)]. Digital radiovisiography (RVG) plays an important role to overcome limitations of conventional radiography. It contains computer software for capturing, enhancing and archiving direct radiography images[(3)]. It also features ease of repetition and eliminates use of chemicals. Electronic apex locators were developed to obtain more specific measurements for determining working length and to establish the apical limit of instrumentation and to give more precise results[(2)]. Advantages of measuring working length with EAL in children is that it does not cause any pain and avoids unnecessary radiation.

Newer techniques have also been used to give more precise results for determination of working length[(3)]. Endodontic working length may also be determined by cone beam computed tomographic which gives reliable linear measurements of dentomaxillo-facial structures[(4)].

This in vitro study aims to check use of digital radiovisiography (RVG), apex locator (EAL) and cone beam computed tomography technique (CBCT) to evaluate working length in primary teeth. The rationale behind this study is to find reliable and best working length determination method in ex-vivo environment. Hence the same can be correlated or applied clinically in pulpectomy procedure in pediatric patient.

Materials & Methods

The research was conducted in the Department of Pediatric and Preventive Dentistry. Ethical Committee of the Institutional Review Board provided ethical clearance. The

ethical approval number for the study was TDC/IRB-EC/107/2015. Thirty extracted maxillary and mandibular primary molars were selected based on the inclusion and exclusion criteria. With the help of pre-operative RVG teeth without anatomic modifications or previous endodontic therapy were included in the study. Inclusion criteria for the study were primary molars that have been extracted and have at least two-thirds of their root present, primary molars with adequate coronal structure and primary molars with intact furcation area. Exclusion criteria was resorption of roots not more than 2/3rd of the root length, internal resorption, fractured primary molars, primary molars with extensive decay and loss of coronal structure, calcification in root canals.

Preparation of teeth: In the present study, 78 canals were selected from 30 primary molars (maxillary- 15, mandibular-15). To remove adhering remaining soft tissue, selected teeth were rinsed under tap water for 30 minutes and immersed in 3% sodium hypochlorite (Parcan, Septodont, U.S.A.) for 30 minutes. Teeth were then stored in distilled water until the commencement of the access cavity preparation. Coronal access cavity was prepared using a round bur (No. 2 S. S. White, New Jersey) and Endo Z bur (Dentsply Maillefer, Ballaigues, Switzerland) at high speed, under cooling with distilled water. Canal orifices were located with a DG 16 probe (Hu-Friedy, Chicago, US). Care was taken to avoid damage to floor of pulp chambers, canal orifices and root canal anatomy. The standardization of the selected teeth was done by flattening the occlusal surface with a straight bur (FG #557, S. S. White, New Jersey) at high speed to keep the same coronal reference point. A single operator performed all procedures.

Working length was measured using the Propex® II EAL (Figure1)

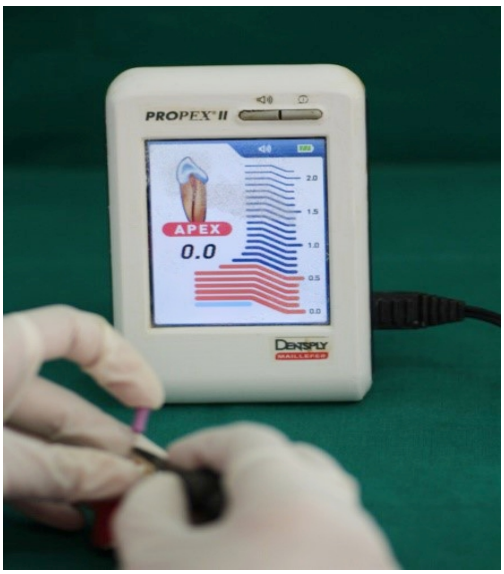

Figure 1: Progression of the file into the apical position.

(Dentsply Maillefer, Baillaigues, Switzerland). Alginate (Tropicalgin, Zhermack, Italy), was combined with 0.9% normal saline solution (Claris Otsaka Private Limited, India) and teeth were inserted in it after cavity preparation. and stabilized in a wax mold. The lip clip was placed in alginate before to its setting. 3% sodium hypochlorite was used to moisten the canal (Parcan, Septodont, USA). Apex locator (Propex®, fifth generation) was attached to #10 Kerr file (K File) 21mm (Dentsply Maillefer, Bailaigues, Switzerland) and introduced into the canal. Cursor on tooth icon on monitor of apex locator indicated progression of file inside the canal. When apex was reached, the cursor showed "APEX" and a solid tone emitted. Once the apex was reached, 0.5 mm was subtracted from this value.[5] To determine working length the silicone stop was set to coronal reference point. After adjustment of the silicone stopper, working length was determined with the help of endodontic ruler.

Working length was determined using RVG (Figure 2):

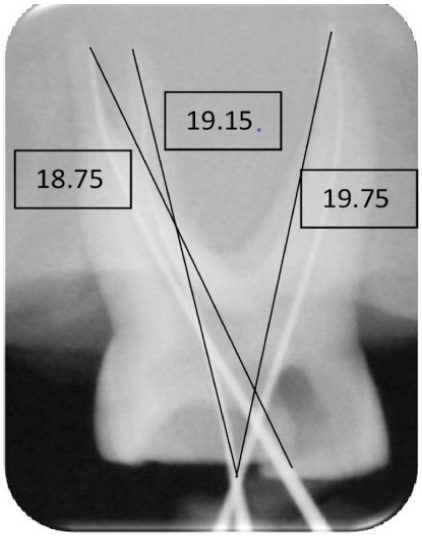

Figure 2: Straight line access was prepared from in a primary molar.

(Schick Sirona, Germany) with A 0.10 second exposure time. #10 K-file 21 mm (Dentsply, USA) was inserted into canal till apical foramen. At the coronal reference point, Silicone Stop was adjusted. Size 1 RVG with a Paralleling technique was used for every tooth at a distance of 15 cms. Intraoral periapical radiograph (IOPA) with RVG sensor were taken by paralleling technique and it was standardized for all sample teeth in these groups. Working length was measured with RVG software's 'measurement tool' and the value was recorded with 0.1 mm accuracy. Determination of Working length was calculated by subtracting 0.5 mm.

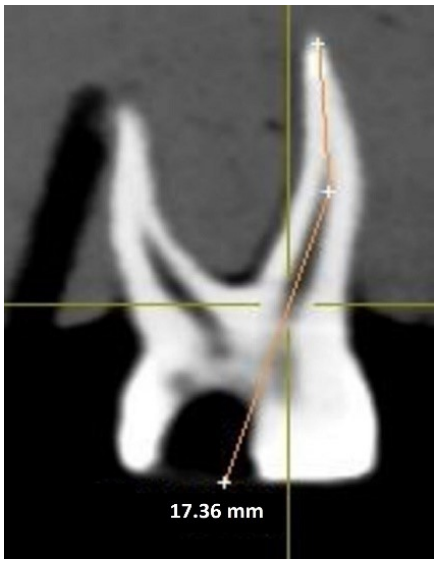

Figure 3: Working length determination using CBCT scans in a primary molar.

Determination of working length using CBCT (Figure 3): All mounted teeth were arranged in three batches and CBCT (Orthophos® SL 3D, Denstply Sirona, Charlotte, NC) scan was taken. Galileo Viewer software was used at 85kV, 5mA to measure working length. Images had a resolution of 0.2 mm voxel size. Teeth were evaluated in transverse, sagittal and coronal aspect. Sections were aligned along the long axis of root to be measured. The tooth to be measured was separately illustrated using the examination tool. The operator rotated the tooth to find a measurement plane that showed both the coronal reference point and the apical foramen. Measurements along the curvature of root canals were recorded as CBCT working length and 0.5 mm was subtracted to establish working length.

At 15X stereomicroscope (Figure 4): magnification actual working length (AL) of individual tooth was determined after

Figure 4: Stereomicroscopic images showing #10 K file visible at the apical foramen in a primary molar.

all assessments. #10 K-file 21 mm (Dentsply, USA) along with a silicone stop for coronal reference was placed within the root canal until the end of the file was seen at apical foramen or apical resorption bevel. The same file was then measured using endodontic scale (Dentsply Maillefer, Baillaigues, Switzerland). Working length was measured by subtracting 0.5mm from the coronal reference point to visible foramen or apical resorption bevel.

All working length measurements with EAL, RVG, CBCT and stereomicroscopy were carried out twice by two experienced blinded examiners.

Statistical analysis: Descriptive statistics were used to determine frequency, mean, standard deviation and range for all three methods. Intraclass correlation coefficient (ICC) and Bland and Altman analysis were used to calculate the agreement on measurements of all techniques using actual values of different methods. Systematic differences and 95% limits of agreement were identified using Bland and Altman analysis. Freidman test was applied to test differences amongst various procedures for working length measurements. Statistical significance was set to $p < 0.05$.

Results

The mean calculated values of EAL were 10.75 which was closer to reference standard method (10.74). Whereas mean values of RVG and CBCT were 12.69 and 11.58 respectively which gave overestimated measurements as compared to the reference standard method (10.74) (Table 1).

Table 1: Mean values of working length determination methods: EAL- Electronic apex locator, RVG- Digital Radiovisiography, CBCT- Cone beam computed tomography, Reference standard method- Stereomicroscope.

Variable	Mean value
EAL	10.75
RVG	12.69
CBCT	11.58
Stereomicroscope	10.74

Mean value of working length with EAL, in comparison with reference standard method was 0.007, and was statistically significant ($p<0.05$). However, mean of actual differences of working length with RVG and CBCT were 1.9570 and 0.8440 which were statistically insignificant ($p>0.05$) when compared with reference standard method. (Table 2)

Table 2: Mean and standard deviation values of absolutes differences of actual working length.

Variable	Mean value	SD*
EAL	0.007250	0.2612
RVG	1.9570	1.1553
CBCT	0.8440	0.8826

* Standard deviation

Within 95% limits of agreement, lower limit was -0.5047 whereas upper limit is 0.5192. As the difference between two values is less it is said that there is better agreement with apex locator method. While the difference between two limits for RVG (-0.3074 to 4.2214) and for CBCT (0.8859 to 2.5739) was much higher indicating less agreement with these two methods (Table 3)

Table 3: Limits of agreement among all different methods of working length measurement.

	Limits of agreement	
Variable	Lower limit	Upper limit
EAL	-0.5047	0.5192
RVG	-0.3074	4.2214
CBCT	-0.8859	2.5739

Intraclass correlation coefficient (ICC): Values for EAL, RVG, CBCT were 0.9937, 0.9897 and 0.9689 respectively. (Table 4)

Table 4: Intraclass correlation coefficient (ICC) among different methods of working length determination.

Variable	Intraclass correlation (ICC)	95% CI**
EAL	0.9937	0.9895 to 0.9962
RVG	0.9897	0.9828 to 0.9938
CBCT	0.9689	0.9486 to 0.9813

** Confidence interval

All the values showed excellent reliability. However, EAL showed greater reliability then CBCT between all working length determination methods. There was no inter-examiner variability seen in all the working length determination methods. Thus, inter-rater agreement seen was quite accurate with all the methods.

Frequency tables: The tables preset values determined by different methods of working length determination, which is recorded as shorter, closer or longer to the AL. In case of EAL, 95.8 % of values were closer to the AL, whereas 0.8% values were shorter and 3.3% were longer than the AL. For RVG 10 % of values were closer and 90% longer to the AL. In case of CBCT 34.2%% of values are closer to the AL, whereas 4.2% of values were shorter and 61.7% were longer. (Table 5)

Table 5: Distribution of assessments classified as acceptable measurements when the value obtained was near to actual working length (AWL) performed by different methods for working length measurement.

Working Lengths	EAL	RVG	CBCT
Shorter	0.8%	0.0%	4.2%
Closer	95.8%	10.0%	34.2%
Longer	3.3%	90.0%	61.7%

Discussion

Working length determination is a critical factor for successful pulpectomy procedure, therefore it must yield accurate and reproducible results.[6] American Association of Endodontics defines working length as 'the distance from a coronal reference point to the point at which canal preparation and filling should terminate'[7].

Conventional techniques for determing working length includes use of radiography [8], tactile sensation [9] and moisture on a paper point[10]. However, there are few limitations with these methods. Radiographs are subjected to distortion and magnification which are technique sensitive. It also has certain specific advantages over conventional films; as with any new method, it brings various hurdles for the dentist.[11]

In this study, mean value of 1.9570 was obtained for working length with RVG when compared with reference standard method, which was found to be not statistically significant.

These results also conformed with the studies conducted by Martinez et al, where no significant differences were observed in primary molar teeth when it was compared with conventional radiography and EAL[12].

In the present study, overestimation of working length was observed when it was compared with reference standard method. 10% of values were closer and 90% longer to the AL. Study conducted by Neena IE et al, also showed a similar result where over prediction of the working length was observed[13].

In 1942, Suzuki gave the scientific basis of apex locators. Sunada was the first to explain simple clinical device for

measuring working length determination in 1962, based on Suziuki's approach.[14]

Katz et al. in 1996 first proposed use of EAL in measuring working length in the primary dentition[15]. Since then, EAL has become a useful tool in paediatric dentistry for determining working length. The devices are based on electrical resistance. It functions by the use of the human body to complete an electrical circuit. A fifth generation Propex II apex locator is a multi-frequency based device that determines the working length using several frequencies. Rather than measuring the signal's amplitude, as all EALs do, it uses multi-signal frequencies to detect the signal's energy. As a result, it was incorporated into this research.

In this present study, statistically significant values were found when EAL when compared with reference standard method which was 0.007. In case of EAL,

95.8 % of values were closer to AL, whereas 0.8% values were shorter and 3.3% were longer than AL. A study by Kqiku et al also showed a similar result with the Propex II apex locator calculating working length of 93.4% accuracy.[16] In addition, an in vivo study done by Koruyucu M. et al compared measurement of length of root canal in primary teeth using EAL, RVG, CBCT along with conventional radiography. They concluded that accuracy of EAL was higher as compared to other methods.[17]

Main advantage of apex locators is that evaluation of working length determination is done till the apical foramen, and not up to radiographic apex. They are simple and quick to use and produce accurate results. EAL's have high accuracy even in presence of physiological root resorption, are quick, comfortable to both clinician and patient. The advantage of Propex II (fifth generation apex locator) is that it can also be used in moist canals as well. EALs also avoid certain limitations of radiographic technique like superimposition of structures and subjective interpretation.[18]

The working length may also be determined with CBCT images. A three-dimensional radiographic method like CBCT is routinely employed in the maxillofacial skeleton for, diagnostic imaging. In cases of multiple curvatures mapping and visualizing entire canal is difficult when a single slice of CBCT scan is used. This can be one of the possible explanations for primary molars showing a marked difference between CBCT and AL in working length determination.[19]

In our study, working length measurements of CBCT, RVG and EAL were 34.2 %, 10% and 95.8 % closer to the values observed with AL. When compared to the reference standard method, the mean value of working length was 0.8440, which was not statistically significant but there was strong correlation was found between CBCT working length and electronic working length.[20,21] Similar results were also observed in an in vitro study conducted by Ghule KD.et al where they measured root canal length using CBCT, EAL in primary teeth. The study concluded that CBCT method showed more accurate results, but no statistical significance was observed when compared with EAL. Moreover, when CBCT is compared with EAL the limiting factors which should be considered are increased costs, radiation exposure in children and its accessibility.[22]

However, further research and more in vivo studies would substantiate our results further.

Conclusion

Propex II apex locator reported highest values closer to AL and thus provided the best performance for determining working length when compared with RVG and CBCT. Therefore, the electronic apex locator was shown to give better results also can be a useful tool for determination of working length in primary molar teeth.

Source of Support : Nil

Conflict of Interest : Nil

Reference

1. Bodur H, Odabaþ M, Tulunoðlu O, Tinaz AC. Accuracy of 2 different apex locators in primary teeth with and without root resorption. Clin Oral Investig. 2008;12: 137-41.
2. Tosun G, Erdemir A, Eldeniz AU, Sermet U, Sener Y. Accuracy of 2 electronic apex locators in primary teeth with and without apical resorption: A laboratory study. IntEndod J. 2008;41:436-41.
3. Leonardo MR, Silva LA, Nelson-Filho P, Silva RA, Raffaini MS. Ex vivo evaluation of the accuracy of 2 electronic apex locators during working length determination in primary teeth. IntEndod J. 2008;41:317-21.
4. Goldberg F, De Silvio AC, Manfré S, Nastri N. In vitro measurement accuracy of an electronic apex locator in teeth with simulated apical root resorption. J Endod. 2002;28(6):461-3.
5. Mello-Moura AC, MouraNetto C, Araki AT, Guedes-Pinto AC, Mendes FM. Ex vivo performance of five methods for working length determination in primary anterior teeth. IntEndod J. 2010;43(2):142-7.
6. Goerig A, Camp JH. Root canal treatment in primary teeth: a review. Pediatr Dent.1983;5(1):33–7.

7. American Association of Endodontists (www.aae.org). Glossary of endodontic terms. American Association of Endodontists;2003. Available at:https: // www.aae.org / specialty/clinical-resources/glossary-endodontic terms/(Last assessed on 4th Dec 2021)
8. Stein TJ, Corcoran JF. Radiographic working length revisited. Oral Surg, Oral Med Oral Pathol. 1992;74:796–800.
9. Chandler NP, Bloxham GP. Effect of gloves on tactile discrimination using an endodontic model. IntEndod J. 1990;23:97–9.
10. Ruddle CJ. Cleaning and shaping root canal systems. In: Cohen S, Burns RC, editors. Pathways of the Pulp. 8th edn. St Louis, MO: Mosby. 2002.
11. Parks ET, Williamson GF. Digital Radiography: An Overview. J Contemp Dent Pract 2002;3:36-40.
12. Martínez-Lozano MA, Forner-Navarro L, Sánchez-Cortés JL, Llena-Puy C. Methodological considerations in the determination of working length. IntEndod J. 2001;34(5):371–6.
13. Neena IE, Ananthraj A, Praveen P, Karthik V, Rani P. Comparison of digital radiography and apex locator with the conventional method in root length determination of primary teeth. J Indian SocPedodPrev Dent. 2011;29(4):300-4.
14. Sunada I. New method for measuring the length of the root canal. J Dent Res 1962;41:375-87.
15. Katz A, Mass E, Kaufman AY. Electronic apex locator a useful tool for root canal treatment in the primary dentition. ASDC J Dent Child. 1996;63(6):414-7.
16. Kqiku L, Stadtler P. Radiographic versus electronic root canal working length determination. Indian J Dent Res. 2011;22(6):777-80.
17. Koruyucu M, Bayram M, Kasýmoðlu Y, Seymen F. Comparison of root canal length measurement methods in primary teeth. Dentistry 3000. 2018 Jul 13;6(1):8-16.
18. Pratten DH, McDonald NJ. Comparison of radiographic and electronic working lengths. J Endod. 1996 ; 22(4):173-6.
19. Arai Y, Tammisalo E, Iwai K, Hashimoto K, Shinoda K. Development of a compact computed tomographic apparatus for dental use. DentomaxRadiol. 1999 ; 28:245- 8.
20. Liang YH, Jiang L, Chen C, Gao XJ, Woo MK, et al. The validity of cone beam computed tomography in measuring working length using a gold standard. J Endod. 2013;39(12):1607-10.
21. Bahrololoomi Z, Soleymani AA, Modaresi J, Imanian M, Lotfian M. Accuracy of an electronic apex locator for working length determination in primary anterior teeth. J dent (Tehran) 2015;12(4):243.
22. Ghule KD, Naik S. Comparing the accuracy of cone beam computed tomography and electronic apex locator for root canal length determination in primary teeth. J Indian SocPedodPrev Dent 2019;37:157-61.