ISSN: 1812–1217

An in Vitro Comparison of Root Canal Length Measurements in Primary Teeth

Aghareed Gh. Mohammed
BDS, MSc (Assist Lect)

Department of Pedod, Ortho, and Prev dentistry
College of Dentistry, University of Mosul

ABSTRACT

Aims: The current study aims at comparing the accuracy of root canal lengths in primary teeth determined by tactile sense, conventional radiography and electronic apex locator(EAL) **Materials and Methods:** The study consisted of 30 extracted, single-rooted primary teeth . A comparison was conducted between the root canal length measurements obtained by tactile sensation ,conventional radiography and electronic apex locator (EAL), using the actual root canal length as a standardization to compare the above methods. Root canal length measurements were completed with size15-K file in actual-standard and measuring methods. The accuracy of the three systems to determine the root-canal length were evaluated by measuring the distance from the tip of the file to the apex. **Results:** Statistical results revealed that the EAL was the most accurate method of measurement with the lowest value of standard deviation (0.88±1.41) when compared with the remaining two methods, followed by the conventional radiography while the tactile sense method can be considered the least accurate one since, a significant difference at $p<0.05$ was founded between this method (15.80±2.71) from the actual root canal length (16.13±2.32) as well as when compared with the other two methods. **Conclusions:** The use of radiographs during pediatric therapy should be considered carefully. The diagnostic value is often limited and the exposure of children to X- rays should also be limited. Results from this study indicated that the sole use of tactile method is generally depreciated because of it's non reliability. An electronic apex locator method have been proved to be the technique of choice in determining the root canal length in primary teeth.

Key words: electronic apex locator(EAL), primary teeth, root canal length.

Mohammed AGh. An in Vitro Comparison of Root Canal Length Measurements in Primary Teeth *Al–Rafidain Dent J*. 2009; 9(1):77-82

Received: 29/11/2007 ***Sent to Referees:*** 29/11/2007 ***Accepted for Publication***: 25/2/2008

INTRODUCTION

The development of diagnostic imaging techniques in dentistry has been of fundamental importance. The application of such techniques in endodontics allows the definition of root canal morphology as well the determination of endodontic working length.[1] One of the main concerns in root canal treatment is to determine how far working instruments should be advanced within the root canal, and at what point the preparation and obturation should be located.[2] In primary teeth, it is important to estimate the exact root canal length during endodontic therapy to avoid injury to the succedaneous tooth bud.[3] Although pulpectomy is an important treatment option in primary teeth with infected pulps, various factors must be borne in mind before starting treatment: long appointments may be tiring for young patients and the diagnostic procedures which require a child's cooperation (e.g. vitality testing) are less reliable compared with adult patients.[4] There are also specific problems which are characteristic of primary teeth: root canal walls are often thin and instrumentation of the canal may result in perforation or root fractures. In addition, the primary teeth are resorbed during eruption of their permanent successors.[5] A technique to be used in determining the root canal length most give précis and reproducible results.[6] Because the simple technique of the tactile perception and it's virtual effectiveness, they are fac-

tors that motivate a few clinicians in endodontic practice to still follow this technique, but it's generally inaccurate in root canals with constricted canal, excessive curvature and immature apex.[7] Conventional radiographic method described by Ingle has been one of the most popular diagnostic tool for determining working length in endodontics. However, it is only able to provide a two-dimensional image. The accuracy is difficult to be achieved in this technique, because a laterally situated foramina, presence of lateral canals or an apical constriction may not be identified. In addition, there is a radiation hazard both to the patients and the dental personnel.[8,9] One of the critical aspects of pulpectomy in the primary teeth is the presence of root resorption. Minor degrees of resorption may not be obvious radiographically and more extensive resorption should be considered as a contraindication for the root canal treatment.[4,10] The electronic apex locator (EAL) which is used for electronic root canal working length determination has become increasingly popular for eliminating many problems associated with the radiographic methods. It's advantage over radiographic methods is that it can measure the length of the root canal to the end of cementodentinal junction.[11] It is more accurate, easy and fast, with no requirements of X-ray exposures and it may be helpful in overcoming the shortcomings of radiographic examination in teeth with resorption. It is a pain less technique that's very useful to be used with uncooperative children.[12] In theory; apex locator work is based on the ratio method[13], in this method two electric currents with different signs wave frequencies will have measurable impedances that can be measured and compared as a ratio regardless of the type of electrolyte in the canal. The capacitance of the root canal increases at the apical constriction, and the quotient of the impedances reduces rapidly as the apical constriction is reached.[14] The purpose of this study is to compare the diagnostic efficacy of root canal length measurements in primary teeth, determined by tactile sense, conventional radiography and electronic apex locator (EAL).

Electronic apex locator device (ROOT ZX) with lip -clip and file holder

MATERIALS AND METHODS

Real (actual) root canal length determination (standardization):

Thirty extracted single rooted primary teeth were numbered and kept in isotonic sodium chloride solution. Access cavities were prepared using no.10 round–bur with slow speed hand piece. The root canal orifices were widened and coronal pre-flaring was done with Gates Glidden drills followed by extirpation of pulp, the canal was irrigated using 3% sodium hypochlorite solution and finally flushed copiously with distilled water. A real or actual root canal length was first determined for each numbered specimens by advancing number 15K-file apically with the rubber stopper touched the incisal edge and the tip of the file was showed by the naked eye to be with the level of the apical foramen, then the file was with drawled carefully and the distance from the rubber stopper to the file tip was measured by using a graduated metal scale and documented as the real root canal length (RRCL) to be compared with the mean root length of each measurement method.[9]

Root canal length determination by electronic apex locator (EAL) method:

The Root ZX, J. Morita Corporation was used on EMR Mode-Electronic measurement of a root canal (A full automatic apex locator, Tokyo, Japan). Blocks were made by embedding the teeth in alginate with 0.9% sodium chloride solution which act as a conducting gel simulating the periodontium.[15]Following the manufacturer's instructions measurements were taken after canal irrigation with 3% sodium hypochlorite and dried with a paper point. Since, the study was carried out in vitro the lip-clip (contrary electrode) was attached to the alginate block and the file holder was attached onto the shaft of the

hand file. The size 15 K-file with the rubber stopper adapted to the reference point (the incisal edge) was advanced apically into the canal, until the beeping sound and the light emitting diode (LED) marked APEX on the panel began to glow, indicating that the tip of the file had reached the predetermined length of the apical constriction. If the instrument penetrated the constriction, a caution light, a continuous alarm, as well as a flashing 'E' signal on the digital readout, provided the warning. The file was withdrawn with a slow counterclockwise turn until the pulsing audition and the flashing light went out. The distance from the tip of the instrument to the rubber stopper was measured using a graduated metal scale; the value was noted down and registered as electronic root canal length (ERCL).

***Root canal length determination by tactile sense method**:*

Tactile measurements were completed by using no. 15 k- file, the file was inserted into the root canal until an increase in tactile resistance was detected.[8]The stopper was adjusted to the reference point. The 15K-file was carefully withdrawn and the distance from the tip of the file to the rubber stopper was measured using a graduated metal scale; the values were noted down and registered as tactile root canal length (TRCL).

Root canal length determination by conventional radiographic method:

The radiographic measurement was taken by using the paralleling technique using an E- speed film, the exposure factors and the distances between the source and the tooth, and the tooth and the film were standardized.[16] The film packet was placed in a holder and positioned parallel to the long axis of the tooth under investigation. The X-ray tube head then aimed at right angles (vertically and horizontally) to both the tooth and film packet. In order to ensure centered and accurate positioning of the teeth, a series of marks were made at the centre of the labial and lingual aspects of the samples, in coincidence with other marks on the upper end of the supporting post. By using a film holder with a fixed film packet and X-ray tube head positions, the technique was reproducible. A file with a presumed length- as noted from the preoperative radiograph- was kept in the root canal and a diagnostic radiograph was taken. On the radiograph, the differences between the end of the file and the apex was measured. This amount was added / subtracted to the original measured length. This value was registered as radiographic root canal length (RRCL).

The statistical analysis included paired t-test and Duncan Multiple Analysis Range test were carried out to test the significance of difference of means between each technique and the actual canal length and to conclude the accuracy of the underlying methods. Results were considered significant when $P < 0.05$, 0.01 and highly significant when $P < 0.001$.

RESULTS

Using tactile measurement, the mean reading that obtained was (15.80±2.71), conventional radiography resulted in a mean of (16.21±2.79), apex locator measurement gave a mean reading of (16.16±2.42). Statistical results showed a significant difference at $p<0.05$ in mean reading of the tactile measurement method in relation to the mean reading of the actual root canal length method (16.13±2.32) as demonstrated in (Tab.1).

Table (1) Comparison of root canal length using different methods of measurements and the actual length.

Root canal length (mean ± SD), (mm), (n=30)			
Actual root canal	**Tactile method**	**Conventional X-ray**	**Electronic apex locator**
16.13 ± 2.32	15.80 ± 2.71*	16.21 ± 2.79	16.16 ± 2.42

* Significant difference from actual at $p<0.05$ using paired t-test

A significant difference of percent from actual root canal length at $p<0.05$ was found for the EAL method 0.88±1.41 when compared with both tactile sense (5.27±2.89) and conventional radiographic (4.27±3.04) methods as viewed in (Tab.2).

Table (2) Comparison of percent difference from actual root canal length among three measurement methods.

Percent difference from actual length, Mean ± SD (%),		
Tactile method	**Conventional X-ray**	**Electronic apex locator**
5.27 ± 2.89 b	4.27 ± 3.04 b	0.88 ± 1.41 a

Means with different letters horizontally have significant difference at $p<0.05$ using Duncan Multiple Analysis Range test

Statistical analysis recorded a significant difference at $p<0.05$ within the short root length group (<15mm) between the tactile method (13.01±0.83) and the actual root canal length (13.64±0.75), while no significant differences at $p>0.05$ between other methods and the actual root canal length within different root canal length groups as shown in (Tab.3).

Table (3) Comparison of root canal length using different methods of measurements and the actual length according to root length.

Actual length groups (mm)	**Root canal length (mm)**			
	Actual root canal	**Tactile method**	**Conventional X-ray**	**Electronic apex locator**
<15 (n=10)	13.64 ± 0.75	13.01 ± 0.83*	13.28 ± 1.30	13.58 ± 0.88
15-17 (n=10)	15.86 ± 0.69	15.41 ± 0.64	16.05 ± 0.91	15.89 ± 0.71
>17 (n=10)	18.88 ± 0.94	18.97 ± 1.62	19.30 ± 1.55	19.01 ± 1.00

* Significant difference from actual at $p<0.05$ using paired t-test

The accuracy of root canal length measurement was not affected by the length of the root of the primary tooth when measured by using the EAL $p>0.05$ where as statistical result recorded a significant difference at $p<0.05$ in the accuracy of measurement within the three root length groups for both the tactile and conventional radiographic methods as demonstrated in(Tab.4)

Table (4) Effect of root canal length on the accuracy of measurement according to method of measurement.

Method	**Difference from actual length, mean ± SD (mm)**		
	<15	**15-17**	**>17**
Tactile	6.97 ± 3.14 b	4.69 ± 2.50 ab	4.13 ± 2.41 a
Conventional	6.12 ± 3.38 b	2.75 ± 1.22 a	3.94 ± 3.23 ab
Electronic	1.09 ± 1.85 a	0.37 ± 0.31 a	1.17 ± 1.56 a

Means with different letters horizontally have significant difference at $p<0.05$ using Duncan Multiple Analysis Range test

DISCUSSION

Statistical results showed a significant difference of the tactile method compared with the actual root canal length, this was in agreement with the study carried by Shanmugaraj et al[7], a study that concluded an inaccuracy of the tactile method could be highly noticed in cases of incomplete pulp extirpation, periapical lesions, physiologic root resorption, narrow and curved root canals. As well as a significant difference at $p<0.05$ of the conventional radiographic method in relation to the actual root canal length. This shortcomings of the conventional radiography was in agreement with Zorem et al[17]; it may depend on the child's co-operation also the operator's proficiency. In addition, minor degrees of resorption may not be visible, and overlapping by adjacent anatomical structures can obscure the clarity of the image; while, no significant difference in the EAL method from the actual root canal length was observed this was in agreement with studies carried by Arora and Gulabivala and Shabahang et al.[18,19] In addition to that this study found the least magnitude of deviation from the mean in measurements by the apex locator when compared to the other two methods. It may remark that the EAL can overcomes the shortcomings of the former methods, since that the electronic devise based on electrical principles that can detect the narrowest of the canal even in the presence of moisture and conductive fluids. It is extremely useful in children who gag during radiography. As no previous studies considering variations in root length and their relation to the accuracy of the method used for measurement were found, a conclusion from this study that the EAL method was the most perfect method among different root canal length groups compared with the remaining two methods, this potentiated that the electronic method was the most precise diagnostic technique for determining root canal length amongst the systems examined in the present study.

CONCLUSIONS

It can be seen that the incorporation of a new measurement technique by the electronic apex locator can be of immense use in pediatric endodontic procedures. From the results of this in vitro study it can be concluded that the apex locator method can be considered reliable and precise since it is more superior than the tactile and conventional radiographic methods. Because this method increase both the safety and comfort of endodontic treatment in children, it's use should be further evaluated and certainly warrants more clinical studies.

REFERENCES

1. Lozano A, Forner L, Liena C. In vitro comparison of root-canal measurements with conventional and digital radiology. *J Int Endod*.2002;35:542-550
2. Martínez-Lozano M, Forner-Navarro L, Sánchez-Cortés J, Llena-Puy C. Methodological considerations in the determination of working length. *J Int Endod*.2001;34:371-376.
3. Subramaniam P, Konde S, Mandanna D. An in vitro comparison of root-canal measurements in primary teeth. *J Indian Soc Pedod Prev Dent*. 2005;37:124-125.
4. Nowak A. Pediatric Dentistry – the Handbook. 2nd ed. Chicago, IL, USA: American Academy of Pediatric Dentistry. 1999; pp: 207-223
5. Mente J, Seidel J, Buchalla W, Koch M. Electronic determination of root canal length in primary teeth with and without root resorption. *J Int Endod* . 2002;25: 447-452.
6. Gordon M, Chandler. Electronic apex locators. *J Int Endod* . 2004; 37:425-437.
7. Shanmugaraj M, Nivedha R, Mathan R, Balagopal S. Evaluation of working length determination methods: An in vivo/ ex vivo study. *J Ind of Dent Res*.2007;18(2):60-62.
8. Ingle J, Bakland L. Endodontics. 5th ed. Elsevier. Canada .2002; pp: 324 -327.
9. Katz A, Tamse A, Kaufman Y. Tooth length determination: A review. *J Oral Surg Oral Med Oral Pathol Oral Radiol Endod* .1991;72:238-242.
10. Plotino G, Grande N , Brigante L, Lesti B, Somma F. Ex vivo accuracy of three electronic apex locators: Root ZX, Elements Diagnostic Unit and Apex Locator and ProPex. *J Int Endod* 2006; 39(5): 408–414.

11. Nekoofar M, Ghandi M, Hayes S, Dummer P. The fundamental operating principles of electronic root canal length measurement devices. *J Int Endod*. 2006; 39(8): 595–609.
12. Fan W, Fan B, Gutmann J, Fan M. Evaluation of the accuracy of three electronic apex locators using glass tubules. *J Int Endod*. 2006; 39(2): 127–135.
13. Kobayashi C, Okiji T, Kaqwashima N, Suda H, Sunadi I. A basic study on the electronic root canal length measurement: Part 3. Newly designed electronic root canal length measuring device using division method. *Jap J Cons Dent.* 1991;34:1442–8.
14. Oishi A, Yoshioka T, Kobayashi C, Suda H. Electronic detection of root canal constrictions. *J Endod.* 2002;28:361–4.
15. Ounsi H, Hadded G. In vitro evaluation of the reliability of the Endex electronic apex locator .*J of Endod*. 1998; 4:120-122.
16. Leach H, Ireland A, Whaites E. Radiographic diagnosis of root resorption in relation to orthodontics. *J Bri Dent.* 2001;190(1):16-22.
17. Zorem C, Jhosef T, Varma B, Mungara J.A study of root canal morphology of human primary molars using computerised tomography: An in vitro study. *J Indian Soc pedo prev Dent.* 2005;3:7-12
18. Arora R, Gulabivala K. An *in vivo* evaluation of the Endex and RCM Mark II electronic apex locators in root canals with different contents. *J Oral Surgery, Oral Medicine and Oral Pathology* . 1995;79: 497–503.
19. Shabahang S, Goon W, Gluxkin A. An *in vivo* apex locator Root ZX. *J Endod*. 1997;15: 35–40.