REVIEW ARTICLE

Apex Locators in Primary Teeth- Review

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Abstract

Maintaining the integrity of the primary dentition until physiologic exfoliation is a major goal when treating young patients. The removal of all pulp tissue, necrotic material and microorganisms from the root canal is essential for endodontic success. This can only be achieved if the length of the tooth and the root canal is determined with accuracy. Radiographic examination is most common method but in children it is usually achieved with difficulty because of the sensor size which cannot be used comfortably in a child's small mouth. Secondly, there is radiation exposure. To overcome these difficulties apex locators are introduced, but there is qualm about its use in primary teeth in various condition. Aim of this review article to map out in brief about need, evolution and accuracy of electronic apex locators in primary teeth.

Key word: Apex locators, Primary teeth

Introduction

Pulpectomy is defined as the removal of necrotic pulp tissue followed by filling the root canals with resorbable cement[1]. Maintaining the integrity of the primary dentition until physiologic exfoliation is a major goal when treating young patients.[2] The removal of all pulp tissue, necrotic material and microorganisms from the root canal is essential for endodontic success. This can only be achieved if the length of the tooth and the root canal is determined with accuracy.[3] The root canal anatomy of primary molars is difficult to predict because of the balance of resorption and hard tissue deposition.[2]The endodontic literature deals extensively with location of the apical foramen (Kuttler , 1955) and determination of the biological apex and working length, as well as with their relationship to the success of endodontic treatment (Sjogren et al, 1990).[4] In addition, pulp and periodontal inflammation may further complicate the anatomy [Kielbassa et al., 2003]. The working length determination is a critical step during root canal treatment in primary teeth due to possible damage to the permanent successor tooth germ [Katz et al., 1996].

The anatomic apex is the tip end or end of root determined morphologically, where as the radiographic apex is the tip or end of root determined radiographically[30]. The apical foramen is the main apical opening of the root canal[29]. In clinical practice, radiography has been the method of choice for determination of working length. However, radiographic assessment has limitations due to anatomic variations of the canal system, interference of adjacent anatomic structures or technical errors in projection. The radiographic method described by Ingle is one of the most common and reliable methods used in determining the working length of teeth undergoing root canal treatment. Radiographic examination in children is usually achieved with difficulty because of the sensor size which cannot be used comfortably in a child's small mouth. Secondly, there is radiation exposure. So a method that could minimize the need for exposing children to radiation during this part of root canal treatment is preferred. All factors together have stimulated the development of electronic root canal measuring devices, also known as electronic apex locators (EALs).[4]

Evolution of different electronic apex locators (EALs)

An electronic method for root length was first investigated by Custer (1918).[3] The idea was revisited by Suzuki in 1942 who studied the flow of direct

current through the teeth of dogs. He registered consistent values in electrical resistance between an instrument in a root canal and an electrode on the oral mucous membrane and speculated that this would measure the canal length (Suzuki 1942).[3] Sunada took these principles and constructed a simple device that used direct current to measure the canal length. It worked on the principle that the electrical resistance of the mucous membrane and the periodontium registered 6.0 kX in any part of the periodontium regardless of the person's age or the shape and type of teeth (Sunada 1962). Using direct current caused instability with measurement, and polarization of the file tip altered the measurement. In 1970 frequency measurement were taken a feedback of an oscillator loop by calibrating at periodontal pocket depth of each tooth. In mid 1980s, there is occurred the development of a relative value of frequency response method where apical constriction was picked by filtering the differences between the two direct potential after 1KHz wave was applied to canal space. A third generation apex locator was developed in late 1980s by Kobayashi. He used multiple channel impedance ratio based technolgy.

Discussion

Conventional radiography as a method of determining the working length has shortcomings in that it depends on the child's co-operation as well as the operator's proficiency. In addition to this, minor degrees of resorption may not be visible, and overlapping by adjacent anatomical structures can obscure the clarity of the image (Priya et al 2005).

For successful endodontic treatment of primary teeth, the root canal length should be determined exactly(Haluk et al 2006). Katz et al(1996) performed study to determine working length in dry and wet environment no significant difference was found in dry or wet canal condition. Also number of in vitro and in vivo comparative studies have performed to evaluate accuracy of apex locators with radiographic, tactile sense, visual method & digital radiographic method(Katz et a 1996, Priya et al 2005, Sara et al 2008, Neena et al 2011, S.Saritha et al 2012). No significant difference is found in between the methods compared.

Also numerous studies performed to determine working length using EALs in unresorbed roots and roots at different levels of resorption. Bodur et al. (2008) used primary teeth with resorption not more than one third and found that Root ZX (J. Morita, Tokyo, Japan) and Endex (Osada, Tokyo, Japan) exhibited only 63.4% and 48.4% accuracy within 1 mm of the visually determined root canal measurements in resorbed roots, respectively. Angwaravong & Panitvisai (2009) performed study onprimary teeth with one sixth to one third resorption and concluded that using a criterion of ± 0.5 mm, the accuracy of the Root ZX was high and not affected by root resorption. Most in vitro investigations reported the high accuracy of different types of EALs at different levels of resorption.

Various generations of EALs have tested in primary teeth out of these Root ZX & Root ZX II(J. Morita, Tokyo, Japan) have given more reliable results compared with others. Katz et al. (1996) suggested that Root ZX is a preferable auxiliary device to measure root canal length in the primary dentition. Sara Ghaemmaghami et al (2008) used Root ZX to measure the canal lengths of 150 primary incisors in vivo. After the teeth were extracted, a standard ruler was used to measure the canal lengths to the nearest 0.5 mm and found that Root ZX was able to locate the apex within this clinically acceptable range in 143 (95%). Leonardo et al (2008) using criteria 1mm short of apical foramen found accuracy(ICC-0.99) in apical foramen location using Root ZX II & Mini apex. Angwaravong & Panitvisai (2009) used criterion of ± 0.5 mm and found the accuracy of the Root ZX was high and not affected by root resorption and compared with direct canal measurement, the error in locating the apical foramen was smaller with measurement at meter reading 'Apex' than meter reading '0.5 bar. A. C. V. Mello-Moura et al (2010) used Root ZX in determining root canal of primary incisors with least two third resorption and found EAL method performed best for root canal length determination in primary. A. P. C. A. Beltrame et al (2011) found Root ZX apex locator was accurate in determining in vivo and ex vivo the working length ±1 mm in primary molar teeth in over 90%. S. Saritha et al (2012) used Root ZX II EAL to determine the electronic working length in forty primary maxillary central incisors and concluded Root ZX II EAL can be used as a reliable device for obtaining root canal length in primary maxillary incisor teeth

Generarations of EALs with working principle and examples

Generation of EAL	Working principle	Examples
Ist generation	Resistance	Endodontic Meter S II (Quinki Medical Co), Sono Explorer (Salatec, India), Neosono-D, MC and Ultima EZ (Amadent), Dentometer (Dahlin Electromedicine, Copenhagen, Denmark) and the Endo Radar (Electronica Liarre, Imola, Italy)
IInd genertion	Impedence	Sono-Explorer(Hayashi Dental Supply, Tokyo, Japan), Endocater (Yamaura Seisokushu, Tokyo, Japan), Formatron IV (Parkell Dental, Farmingdale, NY,USA)· Digipex II were some of the devices that came under this category.
IIIrd generation	Frequency ratio	Endex/Apit, The Neosono Ultima EZ (Satelag Inc., Mount Laurel), Justwo or Justy II(Yoshida Co., Tokyo Japan), Mark V Plus(Moyco/ Union Broach, Bethpage, USA), Endy 5000(Loser, Leverkusen, Germany)
IVth generation	Dual frequencies	Apex Finder , Elements Diagnostics Unit(Sybron), ROOT ZX II and PROPEX II
Vth generation	Multiple frequencies	EMF 100DELUX, JOYPEX 5
VIth generation	Adaptive type	-

Review of studies performed in primary teeth for working length determination using EALs

INVESTIGATOR	DEVICE	COMPARED WITH	RESULTS
Katz et al(1996)	Root-ZX	Radiographic method(in vitro)	No significant difference
Priya et al(2005)	Formatron D 10 EAL	Tactile sense , conventional & digital Radiographic method(in vitro)	Not statistically significant (P > 0.05)
Haluk Bodur et al (2007)	Root ZX & Endex	Lengths measured visually	no significant differences between the two apex locators
O. Angwaravong et al (2008)	Root –ZX	direct canal measurement (in vitro)	Root ZX was 96.7% accurate
Sara Ghaemmaghami et al (2008)	Root ZX	Radiographic method (in vitro, in vivo)	65% accuracy in Root ZX
M. R. Leonardo et al (2008)	Root ZX II & Mini apex locator	Actual length (ex vivo)	ICC- 0.99
Mario Roberto Leonardo et al (2009)	Digital Signal Processing (DSP)	both visually, with the placement of a K-file 1 mm short of the apical foramen(ex vivo)	high correlation (ICC=O.95)
A. C. V. Mello-Moura et al(2011)	Root ZX	Tactile, Radiographic method, Tactile+Radiographic method, Actual length(ex vivo)	most accurate and acceptable method was the EAL, followed by the Tactile + Radiographic method.
P.Nelson-Filho (2011)	i-Pex	both visually, with the placement of a K-file 1 mm short of the apical foramen(ex vivo)	(ICC = 0.99)
Neena IE et al (2011)	EAL	RVG & conventional Radiographic method (in vivo)	No significant difference
A. P. C. A. Beltrame (2011)	Root ZX	Actual length(ex vivo)	No significant difference between resorbed and non resorbed roots
Iyer Satishkumar Krishnan et al (2012)	Raypex-5	Radiographic method	Accuracy of EAL=92%
S. Saritha et al (2012)	Root ZX II	Digital radiography (in vivo)	Accuracy -70%
Wankhade AD et al (2013)		RVG, conventional Radiographic method, Tactile sense, Actual length(in vivo)	EAL was closest to that of the gold standard AL
A. Dandempally et al (2013)	Root ZX & I-pex	Radiographic method	Accuracy- Root ZX- 97.3% I-Pex- 90.3%
E. J. N. L. Silva et al (2014)	Joypex-5	Direct observation (DO)	No significant difference(P<0.05)

Conclusion

Acceptable accuracy in measuring working length in primary teeth can be achieved by using electronic apex locator. With continuous advancements in the technology of EALs, the correct use of apex locators has a definitive place in clinical Pedodontics and their day to day use in clinics can reduce chairside time, limit radiation and achieve more cooperation from the children.

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