Scientific Article

Clinical Evaluation of the Accuracy of Conventional Radiography and Apex Locators in Primary Teeth

Nuria Patiño-Marín, DDS, MSc, PhD[1] • Norma Verónica Zavala-Alonso, DDS, MSc[2] • Gabriel Alejandro Martínez-Castañón, BSc, MSc, PhD[3] • Nereyda Sánchez-Benavides, DDS, MSc[4] • Muriel Villanueva-Gordillo, DDS, MSc[5] • Juan Pablo Loyola-Rodríguez, DDS, PhD[6] • Carlo Eduardo Medina-Solís, DDS, MSc[7]

Abstract: ***Purpose:*** *The purpose of this study was to clinically evaluate the accuracy of conventional radiography and 2 apex locators (Root ZX and ProPex) in determining the working length of root canals in primary teeth and to compare the results with scanning electron microscopy (SEM).* ***Methods:*** *A general medical and oral history was obtained from 1,600 children and 50 children were selected. The working lengths of the primary teeth root canals were determined with conventional radiography and 2 apex locators (Root ZX and ProPex). These results were compared with the ideal standard using SEM. To determine the difference among means of the different methods, the Wilcoxon test was applied. To determine the accuracy of the methods with the ideal standard (SEM), the Lin interclass correlation coefficient (ICC) was used.* ***Results:*** *Sixty-one canals were evaluated and there were no significant difference in the 3 techniques in accuracy of determination of the working length of the canals. The most accurate method of determining the working length of the root canals in primary teeth was the Root ZX (ICC=0.72), followed by the ProPex (ICC=0.70), and the least accurate was conventional radiography (ICC=0.67).* ***Conclusion:*** *The apex locators were more accurate than conventional radiography in determining the working length. (Pediatr Dent 2011;33:)* *Received June 25, 2009 | Last Revision September 21, 2009 | Accepted September 22, 2009*

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Primary tooth root canal treatment provides a mechanism to maintain the teeth in the dentition until their normal exfoliation time.[1,2] Most of the root canals requiring pulpectomy are contaminated with bacteria, and the working length determination is a necessary step in the pulp treatment to decrease the bacterial charge and avoid periapical lesions and damage to the permanent tooth bud. This procedure may be complicated, particularly in molars because of the resorption process of primary teeth and the eruption of permanent teeth.[3,4] Common techniques to determine the working length are by digital tactile sense technique or by conventional radiography (**CR**), but both techniques present some limitations.[4] The digital tactile sense technique requires that the clinician be trained and have experience. CR is a technique that provides information about the canal anatomy and surrounding tissues, but superimposition and anatomy interferences can be problematic and affect correct interpretation of the images.[2,3]

Other techniques, such as electronic devices (apex locators), have been proposed to determine primary tooth root canal working lengths. Reported advantages of these devices include reduction in radiation dosage and procedure time, both of which aid in maintaining patient cooperation. There are some published reports on the accuracy of determination of the working length with apex locators in permanent teeth, but the information on primary teeth is limited.[3] Investigations focused on the use of apex locators in the primary dentition have been done in vitro and on clinical patients.[1-3,5] Nevertheless, investigators report and recommend the necessity for further clinical studies.[1-3]

The purpose of this study was to evaluate clinically the accuracy of CR and 2 apex locators (Root ZX and ProPex) in determining the working length of root canals in primary teeth and to compare the results with the use of scanning electron microscopy (**SEM**) as the ideal standard.

Methods

A Cross-sectional study was performed from September 2006 to January 2009 on a select group of children who were treated at the Clinic of the Master's Degree in Dental Science, Faculty of Dentistry, The Autonomous University of San Luis Potosí (**UASLP**), San Luis Potosi, Mexico. The research protocol was approved by the Research Committee of the Masters Degree in Dental Sciences, Faculty of Dentistry, UASLP, and written consent was obtained from the parents or guardians of children selected for the study. A total of 1,600 children were examined in different schools, and 50 children who fulfilled the following criteria were selected: 4- to

Drs. [1]Patiño-Marín, [2]Zavala-Alonso, and [3]Martínez-Castañón are associate professors, [4]Dr. Sánchez-Benavides and [5]Villanueva-Gordillo are second-year residents, and [6]Dr. Loyola-Rodríguez is chair, all in the Master's Degree in Dental Science with Specialization in Advanced General Dentistry Program, The Autonomous University of San Luis Potosi, San Luis Potosi, Mexico; and [7]Dr. Medina-Solís is associate professor, Academic Area of Dentistry, Institute of Health Sciences, The Autonomous University of The State of Hidalgo, Pachuca, Hidalgo, Mexico.

Correspond with Dr. Nuria at nuriapatyr@uaslp.mx

10-years-old; and primary teeth diagnosed for extraction (dental mobility, nonrestorable, orthodontic treatment, or retained teeth) with or without root resorption.

Children with the following were excluded: pulpectomy treatment and/or previous pulpotomy; systemic disease contraindicating the tooth extraction; and primary teeth with calcified root canals or with two thirds root resorption. Also eliminated were any children whose teeth, due to root fracture during the extraction, were unable to be evaluated. To confirm the selection criteria, an initial radiograph was taken with the Endoray device (Dentsply Rinn, Elgin, Ill) using the paralleling technique.

Clinical tooth preparation. Using a rubber dam and local anesthesia, the chamber was accessed, the pulp was removed, and the canal was irrigated with a saline solution. The working length in the canal of the primary teeth was determined by CR, Root ZX, and ProPex via the following procedures:

Conventional radiography. An initial length was obtained with a K-file of the caliber and diameter of the canal (in anterior teeth, file nos. 15-80; in posterior teeth, file nos. 20-55), established by the initial radiography. A second radiograph was taken with the Endoray device using the paralleling technique, and the working length was determined with Ingle's technique (file 1 mm shorter than the radiographic apex).[6]

Apex locators. The working length was determined with the locators Root ZX (J Morita Corp, Kyoto, Japan) and ProPex (Dentsply Maillefer, Ballaigues, Switzerland). The ground lead of the locator was placed on each patient´s labial commissure, and an endodontic file was clasped to the opposite electrode. The K-file used to determine the working length with CR was inserted into the canal and advanced apically until the apex locator signaled that the apex had been reached. The working length was determined according to the manufacturer's instructions.

Working length determination using CR and apex locators. A reference (ie, the distance between the incisal reference points and the apices of the respective teeth) was established on the tooth crown, and the working length was registered on the file with a rubber stopper. The file was removed and fixed with tape (3M, St. Paul, Minn) on a negatoscope (Electro Medical Equipment Requena, Mexico) in order to measure the length in mm with a digital electronic caliper (Truper, Jilotepec, Mexico). The same procedure was followed with the radiographs and the 2 locators. Three examiners, who were previously calibrated in a pilot study, obtained the measurements. The extraction of the selected tooth was performed, and later all the patients were treated according to the clinical assessment and final diagnosis.

Working length determination using SEM (ideal standard). The extracted teeth were placed in a 2.5% sodium hypochlorite solution to eliminate organic remains, rinsed in deionized water (Milli-Q, Millipore Co, Billerica, Mass) and stored in 10% formaldehyde. The teeth were prepared for SEM (XL30, Philips, Eindhoven, Netherlands) examination as follows. The K-file, the same used with the CR method and with the apex locators, was fixed into the canal with a resin composite Tetric Ceram (Ivoclar-Vivadent, Schaan, Liechtenstein) using a predetermined length to extend beyond the apex. Then, the teeth were dehydrated with alcohol solutions of different graduations, placed into an incubator at 37°C for 8 hours[7] and sputter-coated with gold.

A fourth calibrated and blinded examiner performed the assessment with the SEM. The procedure used to determine the working length with the SEM was based on the following measurements:

1. The file (the one fixed with the resin composite) was measured in mm, from the reference marked with the rubber stop to the end of the file that extended beyond the anatomic apex foramen (canal with or without resorption). This was measurement #1.
2. The length of the portion of the file that extended beyond the root canal (with or without resorption) was accurately measured with the SEM and the aid of image analysis software (EDAX, Microsoft Windows, United States). This was measurement #2.
3. Measurement #2 was subtracted from measurement #1 to obtain the canal length.
4. The working length was finally determined by subtracting 0.5 mm from the canal length.

Statistical analysis

To train and calibrate the examiners in all the methods, several pilot tests were done and the interclass correlation coefficient (**ICC**) was calculated. To determine the difference of the means among the methods in the qualitative variables, the Wilcoxon test was applied. A *P*-value of <.05 was considered statistically significant. The variation coefficient and the Spearman Rho correlation was calculated. To determine the accuracy of the different methods compared with the ideal standard (SEM), the data was analyzed with the Lin ICC.[8,9] The analysis was performed using JMP 4.0 and Stat View software (SAS Institute Inc., Cary, NC).

Results

The examiners were calibrated in the different variables of the study and a CCI>0.90 was obtained. Fifty 4- to 10-year-olds (7.0±0.1; 54% girls, 46% boys) who fulfilled the inclusion criteria were the subjects for this study. Table 1 describes the tooth type, canal, pulp clinical findings, and root resorption

Table 1. TOOTH TYPE, CANAL, PULP CLINICAL FINDINGS, AND ROOT RESORPTION

Variables	Frequency N (%)
Teeth (N=58)	Incisors: 52 (89) Molars: 5 (9) Canines: 1 (2)
Canals (N=61)	Single: 53 (87) Mesial: 4 (7) Distal: 2 (3) Palatal: 2 (3)
Pulp	Nonvital: 12 (20) Vital: 49 (80)
Resorption	Absence: 3 (5) Presence: 58 (95)

of teeth of the study group. The study included 58 primary teeth (52 incisors, 5 molars, 1 canine), with 61 total canals. The teeth most frequency examined were incisors (90%), and single-rooted (87%). Eighty percent of the canals presented vital pulp, and 95% had root resorption.

In multirooted teeth (molars), 7 canals were eliminated (3 distals and 4 mesials). The working length determination obtained by different methods is reported in Table 2. The means of the working lengths in primary teeth were found to be between 9.0±3.1 to 11.0±2.8. A comparison of the means of the different methods used to determine working length found that there were no statistically significant differences (P>.05) in the accuracy of determining the working length among the three methods evaluated, CR, Root ZX and ProPex. Table 3 shows the correlation of SEM with the different methods used for determining the working length. Correlation of SEM with apex locators produced an r-value of 0.70 to 0.72, with a P-value of <001. The SEM is significantly more accurate than the apex locators in determining working length. The ICC among the SEM with the radiography and the apex locators is shown in Figure 1. The most accurate method compared with SEM in determining the working length in primary teeth was the Root ZX (ICC=0.72), followed by the ProPex (ICC=0.70). CR was the least accurate (ICC=0.67).

Table 2. WORKING LENGTH DETERMINATION IN PRIMARY TEETH CANALS USING DIFFERENT METHODS*

Methods	Mean±(SD) (mm)	Range (mm)	Variation coefficient (%)
Conventional radiography	11.0±2.8	5-16	25
Root ZX	10.0±3.8	3-17	38
ProPex	9.0±3.1	4-15	38
Scanning electron microscopy	10.0±3.3	4-16	38

* No. of canals=61; statistical test: Wilcoxon (P>.05).

Table 3. CORRELATION OF THE WORKING LENGTH IN PRIMARY TEETH WITH THE DIFFERENT METHODS USED IN THIS STUDY

Methods comparison*	r†	P-value
Scanning electron microscopy vs radiography	0.69	<.001
Scanning electron microscopy vs Root ZX	0.72	<.001
Scanning electron microscopy vs ProPex	0.70	<.001
ProPex vs Root ZX	0.88	<.001
Radiography vs Root ZX	0.59	<.001
Radiography vs ProPex	0.55	<.001

* No. of canals =61. † Rho Spearman correlation.

Discussion

When performing primary teeth pulpectomies, the procedure and its duration are very important in maintaining patient cooperation.[1] Determining the working length is a necessary step to perform the procedure.[3] The use of radiography in pulp treatments has some inconveniences, such as: interferences, superimposition or variation of images; patient exposure to X-ray; and technical aspects like quality of the equipment available in the clinic, the time to obtain radiographs, and the child's level of cooperation.[3]

Other methods have been proposed to determine the working length of root canals, such as apex locators. Some authors have reported the accuracy of the apex locators in permanent teeth, but information on primary teeth is limited in both in vitro and clinical studies.[1,3] Leonardo et al reported the accuracy of the apex locators Root ZX II and SybronEndo in determining the canal length in primary

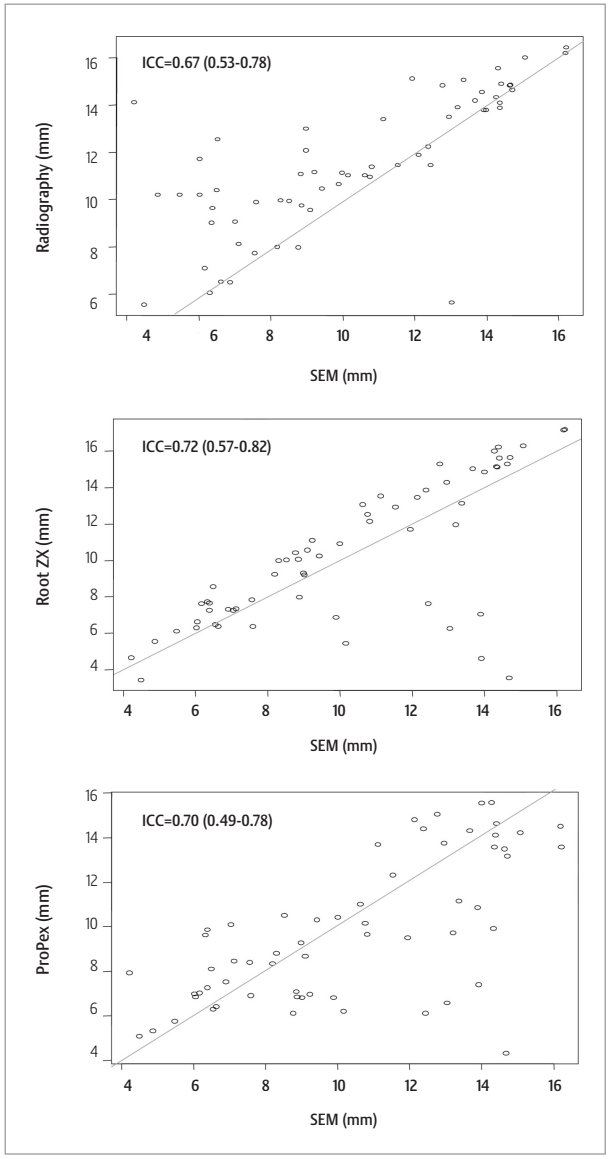

Figure 1. Comparison (interclass correlation coefficient [ICC]) of scanning electron microscopy (SEM) against conventional radiography and apex locators to determine the working length in primary teeth canals.

incisors and molars, with or without root resorption, comparing them directly with the canal length (actual) Ex vivo.[1] They observed an ICC of 0.99 in single-rooted and multirooted primary teeth with or without apical resorption.[2,3,5] However, some other authors have reported the opposite when comparing the apex locators in teeth with and without root resorption ($P<0.05$).[1]

Some studies have been published comparing the apex locators with CR. Katz et al reported the canal length of primary teeth obtained with the Root ZX and with CR in vitro. They did not find statistically significant differences comparing both methods with the actual length.[10,11] Subramaniam et al[12] reported an in vitro study comparing the digital tactile sense technique, apex locators, and conventional and digital radiography with the stereomicroscopy (real length) to determine the working length in primary single rooted teeth. They did not find statistically significant differences after comparing all the techniques.[12] Some authors have reported that the use of electronic apex locators is a tool to complement the radiographic methods of working length determination, since it reduces the number of radiographs required for determination of root canal length.[2,3,5,12]

Most research that has determined working length in primary teeth has been done in vitro. For this reason, we consider it important to perform further clinical studies. Our study showed that the most accurate method compared with the ideal standard in determining the working length in primary teeth was the Root ZX (ICC=0.72), followed by the ProPex (ICC=0.70). The least accurate was CR (ICC=0.67). However, these 3 techniques were not significantly different from each other in their accuracy in determining working length.

The results of this investigation agree with other clinical studies.[13,14] Kielbassa et al evaluated clinically the accuracy of determining the working length with the Root ZX. They included 71 primary incisors and molars with 105 total canals in teeth planned for extraction. The canal length was determined with the apex locator before extraction, and that measure was compared with the actual length obtained with optic microscopy. They reported that Root ZX was an accurate method and that tooth type, canal, and apex with or without resorption did not alter the locator's accuracy.[13] Some investigators had determined the canal length using optic microscopy; however, in the present study the SEM was used because of its high resolution.[3] Santos-Pinto et al, in a clinical study in which the objective was to compare, in vivo, the accuracy of the determination of the canal length in primary incisors using digital radiography with the actual length, found no statistically significant differences between methods.[15]

Conclusions

The apex locators were more accurate (Root ZX ICC=0.72 and ProPex ICC=0.70), than conventional radiography (ICC= 0.67) in determining the working length in Primary Teeth.

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