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Evaluation of Methods for Determining Working Length in Root Canal Treatment for Primary Molars: An In-Vivo Study

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BACKGROUND/AIMS
The aim of this study was to evaluate the effectiveness of tactile sensation, digital periapical radiography, and two varieties of electronic apex locators (EALs) as methods of determining working length in root canal treatment for primary molars.

MATERIAL and METHODS
In this study, 30 infected mandibular primary second molar teeth in 12 children aged 5-8 years were analyzed. The working length was determined for each tooth using the tactile sensation, digital radiography, the ProPex Pixi®, and Ipex® apex locators separately.

RESULTS
The mean root canal measurements taken using tactile sensation, Ipex, radiography, and Propex Pixi were 11.02 ± 2.05 mm, 9.47 ± 1.71 mm, 9.73 ± 1.57 mm, and 8.85 ± 1.58 mm, respectively. The radiographic method yielded results that were similar to those derived with the apex locators but differed from the measurements obtained via tactile sensation.

CONCLUSION
EALs can be used to safely determine the working length in root canal treatment for primary molars.

Keywords: Apeks locators, primary molar, root canal treatment

INTRODUCTION

Although dental caries in children has decreased with increasing parental awareness and fluoride applications, numerous children still need pulp treatment.[1] This endodontic treatment maintains the health of primary teeth until their expected exfoliation when their pulp is necrotic or infected. Successful endodontic treatment crucially depends on accurately determining the working length in primary teeth as this prevents harm to periapical tissues and tooth germs.[2] The techniques for working length determination should, therefore, generate precise and reproducible results.[3] The problem is that the accurate determination of the working length in primary teeth is difficult because of the altered anatomy of the teeth and physiological or pathological root resorption.[4,5]

The anatomic apex is the end of a root to be determined morphologically, whereas the radiographic apex is the end of a root to be determined radiographically.[6] In clinical practice, tactile sensation and conventional radiography have long served as methods of choice for determining the working length, but these approaches suffer from certain limitations. For example, the accuracy of tactile sensation changes with experience, and radiographic examination involving children is typically difficult because of poor cooperation of patients or an unsuitable sensor size for a child's small mouth.[7] These techniques may also yield inaccurate information, especially in cases with root resorption.[8] For these reasons, electronic apex locators (EALs), which are based on electrical principles instead of visual determinants, have been used more frequently to determine working length in primary teeth in recent years.

The first generation of EALs, developed in 1969, were resistance based. The second, third, fourth, and fifth generations developed in succeeding years were created on the grounds of impedance, frequency ratio, dual frequencies, and

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multiple frequencies, respectively. Fifth-generation EALs, such as Propex Pixi, measure the capacitance and resistance of a circuit separately to determine the position of the file tip in the root canal.[9]

Limited studies have been devoted to the techniques used to determine working length in root canal treatment for primary teeth.[10–12] To address this gap, the present in vivo study was conducted to compare the accuracy of tactile sensation, the digital radiographic method, and EALs in ascertaining working length. Thus, it was aimed to obtain a guiding result for physicians in determining the canal length in primary tooth canal treatments in pediatric dentistry clinical practice.

MATERIALS and METHODS

This study was conducted in the Department of Pediatric Dentistry at the Faculty of Dentistry in Eskişehir Osmangazi University, Turkey. The study protocol was approved by the university's ethics committee (E25403353-050.99-107474). Before performing any clinical procedures, informed consent was obtained from each child and parent or guardian.

Study Sample

To evaluate the accuracy of the working length measurement techniques, the sample size required for this study was calculated using G*Power (version 3.1.9.2), with consideration for a significance level of 5%, an effect size of 0.215, and a power of 90%. A sample size of 90 root canals per group was determined as enabling sufficient sensitivity to detect a difference of 0.4 mm.

Inclusion and Exclusion Criteria

Accordingly, 30 infected mandibular primary second molar teeth (90 root canals) of 12 children aged between 5 and 8 years were treated at the Department of Pediatric Dentistry.

Children with any systemic diseases as contraindications to endodontic treatment were excluded from the study. The teeth that were subjected to previous root canal manipulation and exhibiting radiographic evidence of calcification have perforated pulpal floor, excessive internal root resorption, external resorption to more than two-thirds of a root, excessive bone loss in furcation, uncontrollable bleeding, and insufficient structure for restoration were also excluded.

Pilot Study

Before initiating the clinical intervention, a pilot study involving six children was conducted. Pulpectomies of six primary molars were performed in a single appointment to standardize the procedure and to train the researcher on implementing the intervention and the researcher's measurements. For training and calibration, a standard reference researcher and an evaluator measured working length for the six primary molars using tactile sensation, the radiographic method, and two EALs (the ProPex Pixi and Ipex). The inter- and intraexaminer kappa coefficients were >0.91 and 1.00, respectively. All the root canal treatments were completed, but these measurements were not included in the main research.

Main Points

- This study showed that EALs and radiographic methods exhibit similar performance in measuring the working length of root canals in primary molar teeth.
- The use of EALs in root canal treatments for primary molars reduce the need for radiography.
- EALs can be used to safely determine the working length in root canal treatment for primary molars.

Access Cavity Preparation

The teeth were first anesthetized with Ultracaine D-S Forte and then isolated using a rubber dam. Caries was removed, and the access cavity was prepared using a round diamond bur as copious water was sprayed onto each tooth. Barbed broaches were used to extirpate pulpal tissue, and 2.5% sodium hypochlorite served as the irrigation solution. Sterile cotton pellets were used to dry the cavity.

Study Groups

To determine working length for 90 root canals, the teeth were categorized into the following measurement groups:

Group 1: Tactile sensation method

Group 2: Radiographic method (digital periapical radiography)

Group 3: Ipex EAL

Group 4: Propex Pixi EAL

Root Canal Length Determination via Tactile Sensation. In determining working length using tactile sensation (group 1), a K-file with a tip that is best adjusted to the apical area was selected and gently inserted into the canal until the operator detected the narrowest region. A silicone stop was then placed at the coronal reference, and the tooth length was measured with an endodontic ruler (0.5 mm accuracy), with consideration for the end of the root.

Root Canal Length Determination by Radiography. In group 2, working length determination was performed using digital periapical radiography. Files, which were 1 mm shorter than the tooth length (as determined using a preoperative radiograph), were inserted into the canals. Before the radiographic evaluation, children were fitted with a protective thyroid lead and a protective lead apron. Digital periapical radiographs were taken using the paralleling technique while the files were in the canals. An X-ray positioning device was used to standardize the distances between the source and the tooth, and the tooth and the radiographic film. The cusp adjacent to the canal was regarded as the occlusal reference. The difference between the tip of the file and the end of the root was calculated on the basis of image. In cases wherein the file did not pass the apex, this amount and the original length were calculated. In cases where the file passed the apex, the amount of length protruding from the apex was subtracted from the original length. In cases where the file did not pass the apex, the amount of length retruding from the apex was added from the original length. Finally, 1 mm was subtracted from the adjusted length to confirm the cemento-dentinal junction and was recorded as the radiographic working length.

Root Canal Length Determination Using EALs. Electronic working length determination was performed either with Ipex (group 3) or ProPex Pixi (group 4). A lip clip was attached to the

patient's lower lip to complete the circuit. Then, the root canals were moistened with 0.9% saline solution, and a No. 15 K-file mounted onto a holder was gently inserted into the canals until a distance of 0.5 appeared on the screen (meaning that the tip of the file was at the apical constriction). Under a reading that was stable for at least 5 seconds, the file was pulled back, and the length between the silicone stopper and the tip of the file was measured with an endodontic ruler. The endodontic treatments were completed in a single appointment.

Statistical Analysis

All the data were analyzed using the Statistical Package for the Social Sciences (SPSS) version 22.0 (IBM SPSS Corp.; Armonk, NY, USA). Descriptive analyses were initially performed. The accuracy of the electronic and radiographic methods was ascertained on the grounds of the total values of the measurements. The data were also examined via one-way repeated-measures analysis of variance and Sidak post hoc tests. A *P*-value of .05 was considered indicative of statistical significance.

RESULTS

The working length measured via tactile sensation ranged from 9.50 to 13.50 mm with a mean value of 11.02 ± 2.05 mm. The measurements taken using Ipex ranged from 8.00 to 11.30 mm with the mean value of 9.47 ± 1.71 mm, whereas the measurements derived through Propex Pixi ranged from 7.00 to 10.30 mm, with the mean value of 8.85 ± 1.58 mm. The working length measured using digital periapical radiography ranged from 8.00 to 11.50 mm, with a mean value of 9.73 ± 1.57 mm.

The results of the radiographic method were similar to those obtained using Ipex ($P = .938$) and Propex Pixi ($P = .212$), but these results differed from those acquired via tactile sensation ($P = .023$). The measurements taken using tactile sensation statistically and significantly differed from those taken using Ipex ($P = .004$) and Propex Pixi ($P = .000$). Tactile sensation also yielded longer measurements than those derived using the other techniques.

DISCUSSION

Maintaining the unity and functioning of primary teeth until physiological exfoliation is the main purpose of pediatric dentistry. Teeth with traumatic injury or excessive carious lesions may require endodontic treatment in the primary dentition.[13,14] In the endodontic treatment of primary teeth, establishing working length accurately is vital for thorough cleaning and disinfecting root canals.[5,15,16] However, working length determination in primary teeth is challenging because of issues such as oblique physiological root resorption, underlying succedaneous tooth germs, and poor cooperation of children.[2] Different techniques are used to determine the working length of primary teeth, but no definite judgment has been provided as to an ideal approach. The most important motivation for the current research was to clarify this issue.

Various ex vivo studies have evaluated the accuracy of root canal length determination in primary teeth using different methods, such as tactile sensation, radiography, and EAL usage. However, the precise simulation of the oral environment is impossible under ex vivo conditions and, therefore, cannot be a true representative of clinical situations in which the treatment is carried out entirely in the mouth. Only a few studies have been exclusively performed in in vivo conditions for primary teeth.[17–19] To the best of our knowledge, no in vivo report has evaluated and compared the use of Propex Pixi and Ipex with different methods of determining working length (tactile sensation, radiographic method).

Physiological root resorption is not continuous. It has resting periods, which sometimes have cementum deposition on the resorbed root surface. These resorption–deposition processes cause changes in the shape, dimension, and position of the root apex.[17–19] When apical construction is destroyed by root resorption, it could be difficult to determine the working length with radiography and tactile sensation. Physiological root resorption usually starts after the age of 8 in primary molar teeth.[19] Therefore, primary molars (without root resorption) of patients aged 5-8 years were included in the present study to compare the reliability of root canal working length measurements.

Previous studies indicated that determining the working length using only tactile sensation produces incorrect results.[4,5,8] This poor quality is attributed to the physiological resorption that causes variations in canal constriction. The results of these studies agree with those derived in the present study.

Generally, radiographs have been the main tool for establishing root canal length, but this approach has some drawbacks in the establishment of canal length.[20] Radiographs are two-dimensional depictions of a three-dimensional complex, and correct canal length determination may be complicated given root resorption and the superimposition of succedaneous tooth germs over the roots of primary teeth.[15] Radiographic distortion is another drawback, along with issues in patient cooperation, especially in children, which also affects the quality of a radiograph.[21–23] Radiography also extends treatment time and, more importantly, subjects a patient to ionizing radiation. Despite these disadvantages, however, radiography remains the most frequently used method for determining the working length.

Some of the problems listed above have been eliminated with the introduction of intraoral digital radiography. The most important of these advancements is the reduction in radiation dose due to decreased exposure time.[8] Such reduction in digital radiography is approximately 60%. Other advantages include the prompt display, improvement, magnification, storage, retrieval, and transmittal of images.[24] The main drawback to intraoral digital radiography is the high cost. Furthermore, as with conventional radiography, the adjustment of a sensor inside a child's mouth continues to be a problem. Both conventional and digital radiographic methods have been reported to produce misleading results for primary teeth because of variations in apical constriction and apical outcomes being located more coronal after oblique physiological resection.[2] Nevertheless, studies have concluded that digital radiographic methods and the use of apex locators reliably and accurately determine root canal length in primary teeth.[2,8] In the present research, the radiographic method yielded results that were similar to those obtained with the apex locators.

EALs eliminated some of the inherent limitations of radiographic methods. They have gained popularity because they rely on electrical principles instead of visual determinants. They are more reliable and possess high reproducibility in locating

apical foramen despite the presence of electrolytes inside canals.[25] They also solve the radiation problems associated with radiography.[26] The first versions of EALs measure the electrical resistance between the oral mucosa and the periodontal ligament. But unfortunately, they were generally insufficient in locating true apical constriction in the presence of conductive fluids.[9] These devices cannot provide accurate measurements in the presence of vital tissue or fluid in the canal. In the recent past, multifrequency-ratio type EALs have been developed. The working mechanism of these devices is based on detecting the ratio between different electrical proportions for each impedance using different frequencies. With multifrequency-ratio type EALs, the shortcomings of the previous types were tried to be eliminated. These types of EALs, which have the ability to locate apical narrowing according to the rate of change in the impedance of signals of different wavelengths, have been the most frequently used and preferred devices.[9–18]

In this study, two different multifrequency-ratio type EALs (Propex Pixi and Ipex) were used and give similar results. The manufacturer of Propex Pixi and Ipex claim that these EALs perform highly accurate measurements given their use of multifrequency technology under any canal conditions. Although frequency dependent EALs improve the accuracy of determining apical constriction, the performance of apex locators affected by the presence of liquids such as blood, saline, local anesthetics, and endodontic irrigants remains unclear.[27]

An ex vivo study showed that compared with tactile sensation, conventional radiography, tactile sensation+conventional radiography, and digital radiography, EALs perform best in determining root canal length in primary teeth. Nonetheless, tactile sensation+conventional radiography can be an alternative when electronic resources are unavailable.[28] Another study reported that radiovisiography and Propex Pixi generate similar results in determining working length in the presence of irrigation solutions, with these methods showing no statistically significant difference in prediction rates.[29] Consistent with the literature, no statistically significant difference was found between the working lengths determined by radiographic methods and apex locators in the current study.[17–19,28]

To conclude, the results indicated no significant difference between the use of Ipex and Propex Pixi and periapical digital radiography in determining the working length in root canal treatment for primary molars. The use of EALs may be useful as a means of protecting children from exposure to recurrent ionizing radiation, over-instrumentation, overfilling, damage to permanent tooth germs, and radiation exposure. These locators may also be useful in cases wherein the radiographic determination of root lengths is encumbered by limitations.

Clinical Significance

Apex locators, which are routinely used in determining the canal length in permanent dental endodontic treatments, have a definite place in determining the length of the primary tooth for pediatric dentists in clinical use.

Ethics Committee Approval: Ethical committee approval was received from Eskişehir Osmangazi University's ethics committee (E25403353-050.99-107474).

Informed Consent: Verbal informed consent was obtained from each child and parent or guardian who participated in this study.

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