Electronic determination of root canal length in primary teeth with and without root resorption

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Abstract


Aim To test an electrical device for determining root canal length in primary teeth in vitro, and to compare it with the radiographic length measurement.

Methodology Two examiners determined the root canal length of 24 extracted maxillary primary incisors (12 with visible root resorption and 12 without) using an electrical root canal meter (Tri Auto ZX, Morita, Dietzenbach, Germany). The instrument was left in the root canal after the second examination and a radiograph was taken. The whole tooth was cleared by immersion in methylsalicylate and subsequently photographed. Both radiographs and photographs of cleared teeth were measured and compared with the electronic measurements.

Results The evaluation of the radiographs showed a mean distance between the instrument tips and apices of 0.60 (±0.41) mm; evaluation of the cleared teeth showed an equivalent distance of 0.62 (± 0.40) mm. The mean distance between instrument tip and acceptable working length (determined with the clearing method) was 0.26 (± 0.24) mm in teeth without resorption and 0.29 (± 0.30) mm in teeth with resorption.

Conclusion The presence of resorption in primary teeth did not affect the accuracy of electrical measurement of root canal length in vitro. The application of this method in primary teeth should be evaluated further.

Keywords: apex localization, electric endometry, endodontic treatment, primary teeth, resorption.

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Introduction

Pulpectomy is an important treatment option in primary teeth with infected pulps (Fuks & Eidelman 1991, Yacobi et al. 1991). Although pulpectomy is generally accepted as a safe procedure for primary teeth (Coll & Sadrian 1996), various factors must be borne in mind before starting treatment: long appointments may be tiring for young patients and the results of diagnostic procedures which require a child’s cooperation (e.g. vitality testing) are less reliable compared with adult patients (Nowak 1999).

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.

Radiographic determination of root canal length may give misleading results when lateral canals are present. Therefore, one of the critical aspects of pulpectomy in primary teeth is the presence of root resorption (Coll & Sadrian 1996). Minor degrees of resorption may not be obvious radiographically and more extensive resorption should be considered as a contraindication for root canal treatment (Nowak 1999). Electric root length determination may be helpful in overcoming the shortcomings of radiographic examination in teeth with resorption. The aim of this study was to evaluate whether initial resorption of primary teeth affects the accuracy of an electrical root canal measuring device.
Materials and methods

Twenty-four extracted maxillary primary incisors were selected and stored in 4% formaldehyde solution for up to 4 weeks before examination. An overview of the methodology is given in Figure 1. Half of the teeth (n = 12) showed obvious signs of external resorption. The teeth were placed in the aperture of the lid of a high-density polyethylene vessel containing 35 mL 0.9% saline in such a way that the root was completely submerged in saline (Weiger et al. 1999). At the bottom of the vessel a metal screw was connected to one electrode of a Tri Auto ZX device (Morita, Dietzenbach, Germany). The Tri Auto ZX device is an apex locator that simultaneously calculates the ratio of two impedances in the same canal using two different frequencies (Vajrabhaya & Tepmongkol 1997). The crowns of the teeth were shortened using a diamond bur to obtain a defined reference point. Two examiners (J. M. and M. J. K.) independently determined root canal length. A size 053 K-file or 073 Hedstroem file (VDW, Munich, Germany) was connected to the second electrode of the Tri Auto ZX device. The diameter of the endodontic instrument was chosen according to the canal size (between ISO 30 and 90); no preparation of the canal was performed. The endodontic instrument was inserted until the 0.5 mm distance diode became illuminated. The penetration depth of the instrument was marked using a silicone stop and measured using a millimetre scale. Care was taken not to remove pulpal tissue during instrumentation of the canal in order to ensure that the situation for the second examination was identical. The values were recorded to an accuracy of 0.5 mm.
Radiographic examination

After the second electronic measurement of root canal length, the instrument was inserted to the previously determined length. A radiograph of the tooth was exposed with an instrument in situ (K-file or Hedstroem-file) and a metal stopper (3.05 mm in diameter, Fig. 2) for reference using a 60-kV tube (Heliodent DS, Sirona, Bensheim, Germany; exposure time 0.16 s) and an Ultra Speed D film (Eastman Kodak, Rochester NY, USA). Films were developed using an XR 24 Nova (Dürr Dental, Bietigheim-Bissingen, Germany) device. A third examiner (J. S.), using a lens with 2-fold magnification, estimated the distance between the acceptable working length and the instrument tip on the radiographs. The acceptable working length was defined as the point at which the apical constriction was reached. In those cases where resorption had occurred (e.g. Fig. 2) and/or where there were lateral orifices, the acceptable working length was defined as that point where the instrument was just surrounded by dentine in the right-angled projection of the root axis. The radiographs were then digitized using a scanner (CanoScan 2700F, Canon, Tokyo, Japan) at a resolution of 970 × 648 dpi. The digitized radiographs were also analysed for the distance between the tip of the instrument and acceptable working length, and tip of instrument and tip of the root, using the same endometric software (SquareRoot! 2.0).

Clearing

After the radiograph was taken, the teeth with the endodontic instrument were dehydrated step-wise by immersion in varying concentrations of ethanol (80%, 90%, 95%, 100%) for 12-hour periods and subsequently immersed in methylsalicylate for 24 h. After clearing, the teeth were photographed at a magnification of 2× and the resulting slides were scanned at a resolution of 970 × 648 dpi. These digitized images were analysed for distance between tip of instrument and acceptable working length, and tip of instrument and tip of the root, using the same endometric software (SquareRoot! 2.0).

Statistical analysis

Statistical analysis was performed using SPSS for Windows 10.0 (SPSS Inc., Chicago, IL, USA). Inter-examiner reproducibility of the electric root length measurement was analysed with Cronbach’s α intra class correlation coefficient, confidence interval, and inter–item reliability coefficient.

Results

Reproducibility of electrical root canal length determination

Overall agreement between the two examiners was good. For primary teeth without visible resorption the single intraclass correlation (Cronbach’s alpha) was 0.95 (95% confidence interval 0.85–0.99). The correlation was...
α = 0.93 (95% confidence interval 0.78–0.98) for teeth with resorption. There was high agreement between the two examiners in both groups (Fig. 3).

**Radiographic examination**

Agreement between the radiographic evaluation of distance between instrument tip and the acceptable working length established by using magnification of the conventional radiograph compared to analysis of the digitized radiograph was good: The interitem reliability coefficient was α = 0.85 (Fig. 3).

**Evaluation of teeth following clearing**

Inter-examiner agreement of the acceptable working length was α = 0.92. The mean distance between the instrument tip and acceptable working length was 0.26 mm (95% confidence interval for mean 0.11–0.41) for teeth without resorption and 0.29 mm (95%...
confidence interval 0.11–0.47) for teeth with resorption (Fig. 4).

In general, the cleared teeth showed a close relationship between the instrument tip and the acceptable working length in teeth with and without resorption (Figs 5, 6). The overall mean distance between root tip and instrument tip was 0.62 (± 0.40) mm.

For the parameters evaluated, no statistically significant differences could be demonstrated between the groups with and without resorption.

Comparison of radiographs with cleared teeth

The agreement concerning the distance between the acceptable working length and instrument tip between clearing and radiographic computer supported measurement was 0.98.

Discussion

The use of radiographs during paediatric endodontic therapy should be considered carefully. The diagnostic value is often limited and exposure of children to X-rays should be limited. Alternatives such as tactile methods (Bagett et al. 1996), acoustic methods (Inoue & Skinner 1985) or electric methods (Czerw et al. 1995, Pratten & McDonald 1996, Vajrabhaya & Tepmongol 1997, Dunlap et al. 1998, De Moor et al. 1999, Ibarrola et al. 1999, Weiger et al. 1999) have been suggested in the past. This method has also been proposed for primary teeth: an *in-vitro* study reported superior results of the root length determination by the Root ZX device compared to radiographs (Katz et al. 1996).

There are a number of factors that might affect electrical measurement of root canal length. One might
be the presence of root resorption, which often occurs physiologically in primary teeth. It may, however, be pathologically present in both permanent and primary teeth. Radiographic assessment of small areas of resorption is difficult, particularly in cases where resorption occurs on buccal or lingual aspects of the root. This will often not be visible radiographically, resulting in an increased risk of overinstrumentation and/or overfilling. Overfilling of primary teeth beyond the apex is associated with a reduced of overinstrumentation and/or overfilling. Overfilling of teeth may be visible radiographically, resulting in an increased risk for root resorption, which often occurs in primary teeth. It may, however, be pathologically present in both permanent and primary teeth. Radiographic assessment of small areas of resorption is difficult, particularly in cases where resorption occurs on buccal or lingual aspects of the root. This will often not be visible radiographically, resulting in an increased risk of overinstrumentation and/or overfilling. Overfilling of primary teeth beyond the apex is associated with a reduced risk factor for clinical success (Holan & Fuks 1993). For this reason incomplete instrumentation has been indicated in those teeth which are seen in radiographs to be close to a tooth bud (Garcia-Godoy 1987). On the other hand, underfilling is also a risk factor for clinical success (Holan & Fuks 1993). Hülsmann & Pieper (1989) demonstrated that an apex locator gave incorrect results in teeth with open apices. However, these authors used a first-generation apex locator; whereas a third-generation Tri Auto ZX device, that is less susceptible when used in similar conditions, was used in the present study. The results of our study demonstrate that interexaminer reproducibility of electrical determination of root canal length in vitro is high for primary teeth, both with and without initial root resorption. The accuracy of determination of the acceptable working length was also high compared with the radiographic results. The Tri Auto ZX device is calibrated by the manufacturer to measure the tooth length minus 0.5 mm. It has already been stated that the reliability of electrical root canal length determination is slightly higher than of radiographic assessment (Pratten & McDonald 1996). It should be noted that the radiographs used in our study were not taken in vivo and are probably of higher quality than those taken intraorally, which will include surrounding bone and potential loss of clarity through angulation.

**Conclusion**

Electrical determination of root canal length may support other diagnostic measures and increase the safety of treatment in specific situations such as the presence of root resorption.

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**References**


