Electronic Length Measurement in Teeth with Open Apex

SUMMARY

2 electronic apex locators were used to determine the working length in teeth with incomplete root formation. Electronic length measurements were performed in 20 maxillary incisors and 2 maxillary second premolars with open apex at the beginning of the apexification therapy. Calcium hydroxide was used to induce apexification. In the beginning of the apexification treatment, both electronic devices gave incorrect results. When the apical closure with the formation of calcified bridge was radiographically detected, and confirmed clinically, the results obtained with 2 electronic apex locators were correct.

The electronic apex locators evaluated in this study (Root ZX and Ray-Pex 5) may be useful in the treatment of teeth with incomplete root formation.

Keywords: Electronic Apex Locators; Ray-Pex 5; Root ZX; Incomplete Root Formation; Apexification

Introduction

The usual cause of endodontic involvement in a tooth with an incompletely developed root is trauma. Unfortunately, traumatic injuries to young permanent teeth are not uncommon; it is said that they affect 30% of children. The majority of these incidents occurs before root formation is complete, and may result in pulpal inflammation or necrosis. The completion of root development and closure of the apex occurs up to 3 years after eruption of the tooth (Fig. 1).

Hertwig’s epithelial root sheath is responsible for determining the shape of the root or roots. The epithelial diaphragm surrounds the apical opening to the pulp and eventually becomes the apical foramen. The root sheath of Hertwig is usually sensitive to trauma, but because of the degree of vascularity and cellularity in the apical region, root formation can continue even in the presence of pulpal inflammation and necrosis. Because of the important role of Hertwig’s epithelial root sheath in continued root development after pulpal injury, every effort should be made to maintain its viability.

Endodontic management of the pulpless permanent tooth, with a wide-open blunderbuss apex, has long presented a challenge in dentistry. Depending upon the vitality
of the affected pulp, 2 approaches are now possible - apexitogenesis and apexification. Apexitogenesis (calcium hydroxide pulpectomy) is a vital pulp therapy procedure performed to encourage continued physiological development and formation of the root end. Apexification is the process of stimulating the formation of a calcified barrier in a root with an open apex or the continued apical development of an incomplete root in teeth with necrotic pulp.

The apexification method involves opening the tooth, cleaning and rinsing properly the canal and then filling it with a temporary paste to stimulate the formation of calcified tissue at the apex. The temporary paste is later removed, and a permanent filling of gutta-percha is placed in the canal. In such cases with incomplete root formation, in order to allow the condensation of the root filling material and to promote an apical seal, it is imperative to create an artificial apical barrier or induce the closure of the apical foramen with calcified tissue (apexitogenesis). Calcium hydroxide pastes have become the material of choice to induce apexification. Studies have indicated mineral trioxide aggregate (MTA) as an alternative to calcium hydroxide. In many instances, after variable periods of time, further growth of the root and complete closure of the root end will appear.

One of the major difficulties in performing endodontic treatment in a tooth with incomplete root formation is evaluating the working length. The missing apical constriction causes a high risk of initial over instrumentation. The purpose of this study was to evaluate the usefulness of electronic apex locators in endodontic treatment of teeth with incomplete root formation (apexitogenesis).

**Material and Methods**

In this study, electronic length measurements were performed in 20 maxillary incisors and 2 maxillary second premolars. The age of the patients (8 male and 14 female) ranged from 7 to 13 years. All of the teeth showed radiographically incomplete root formation. Electronic measurements of root canal length for each tooth were undertaken at the beginning of the therapy, when the apical foramen was open. The results obtained with both the electronic apex locators were compared with the results from radiographs, taken to determine length. In 8 cases the pulp was necrotic and in 14 cases pulpectomy was carried out before the electronic measurement.

Each tooth was anaesthetized, isolated with rubber dam and a standard endodontic access opening was made. Vital or necrotic pulp tissue was carefully removed and the root canals were irrigated with sodium chlorite and dried with sterile paper points. This procedure was continued until bleeding had stopped. A single operator then applied both devices (Root ZX, J. Morita GmbH, Germany), and Ray-Pex 5 (VDW GmbH, Germany) according to the manufacturer’s instructions. Working lengths were measured with K-files (F. KG. Dentaire, La Chaux-de-Fonds, Switzerland) using both electronic apex locators. All the teeth were measured with both apex locators.

The Root ZX (3rd generation) was introduced by the J. Morita Corporation, Japan, and uses the ratio or division method for measuring the root canal length. The ratio method simultaneously measures the impedances of the canal contents using 2 signals of different frequency (400 Hz and 8 kHz) and calculates the quotient of the impedance, which is used to determine the position of the file inside the canal. This is a constant value that is reliable in the presence of electrolytes or pulp tissue. The Root ZX needs no calibration before measuring working length. A lip clip is attached to the patient’s lip and the electrode connects to the file. The file is advanced into the canal until the display indicates that the minor diameter is reached.

Ray-Pex 5 (VDW GmbH, Germany) is a 4th generation device and records impedance measurement based on advanced multi-frequency system and uses the latest digital technology. According to the manufacturers, the combination of using only 1 frequency at a time and basing measurements on the root mean square values of the signals increases the measurement accuracy and the reliability of the device. There is no need for individual calibration, as the device has a pre-calibrated display of the apical constriction.

Measurements were considered as valid if the instrument remained stable for at least 5 sec. The clip was applied in the corner of the patient’s mouth and the file holder was attached to a size 15 stainless steel K-file and advanced into the canal until the screen of the device showed the “apex” indication and the audible continuous signal indicated that the anatomical foramen had been reached. The results of the electronic measurements were recorded and compared to the results obtained from radiographs.

Only the root canals of the incisors were prepared using K-files and sodium chloride as an irrigation solution. After proper cleaning and rinsing, they were temporarily filled with calcium hydroxide paste (Merck & Co Inc, NJ, USA). The paste was prepared by mixing powder of chemical pure calcium hydroxide and powder of barium sulphate (4:1), with sodium chlorite solution. A temporary cavity filling (Alganol, Howmedica International Ltd, London UK & Harvard Cement, Dental-GmbH, Berlin, Germany) was placed and the calcium hydroxide paste was controlled radiographically.

The two premolars with incomplete root formation were scheduled for extractions due to orthodontic reasons and examined in scanning electron microscope (Fig. 2).

The incisors used in this study were considered to be ready for definite obturation when either the radiographic control revealed complete closure of the root end with
the formation of calcified bridge, or when the apical constriction could not be passed with size 15 K-file. The root canals were cleaned of calcium hydroxide remnants, irrigated with sodium chlorite and dried with cotton pellets. An endodontic instrument was inserted into the root canal until it reached the apical barrier. The working length of each root canal was measured with both electronic apex locators. The results of the electronic measurements were recorded and compared to the results obtained from radiographs. The root canals were permanently obturated with gutta-percha (Fig. 3).

Results

The results can be seen in tables 1-3, and diagram 1.

| Table 1. Results of electronic measurements at the beginning of the apexification therapy |
|-----------------------------------------|---------|---------|---------|--------|
| Necrotic teeth n=8 | Vital teeth n=14 |
| Electronic measurement | correct | too short | too long | correct | too short | too long |
| Root ZX | 0 | 8 | 0 | 0 | 14 | 0 |
| Ray-Pex 5 | 0 | 8 | 0 | 0 | 14 | 0 |

| Table 2. Results of electronic measurements at the end of the apexification therapy |
|----------------------------------------|---------|
| Necrotic teeth n=8 | Vital teeth n=12 |
| Electronic measurement | correct | too short | too long | correct | too short | too long |
| Root ZX | 8 | 0 | 0 | 12 | 0 | 0 |
| Ray-Pex 5 | 8 | 0 | 0 | 12 | 0 | 0 |
Discussion

The use of electronic apex locators for calculation of working length during endodontic therapy provides the clinician with accurate and reliable measurements for each individual root canal. Several studies have demonstrated that the latest generation of electronic apex locators can accurately determine the working length in between 75% to 96.5% of the root canals with mature apices\(^8\)\(^{-10}\). Moreover, it has been reported that electronic devices are ineffective in determining length in treatment of teeth with incomplete root formation\(^11\)\(^{-13}\).

Hülsmann & Pieper\(^11\) demonstrated that an apex locator gave incorrect results in teeth with open apices. However, these authors used a first-generation apex locator, whereas a 3\(^{rd}\) generation Root ZX device and a 4\(^{th}\) generation Ray-Pex 5 device, that are less susceptible when used in similar conditions, were used in the present study.

Suchde and Talim\(^13\) have achieved correct results in only 7 of 11 teeth with incomplete root formation. Berman and Fleischman\(^14\) describe 5 cases in which measurements performed in teeth with open apices were too short. Huang\(^15\) has demonstrated in vivo that the width of the apical foramen has great influence on the accuracy of endodontic measurements. When the diameter of the apical foramen is larger than 0.5 mm, the results from the electronic measurement differ from the correct working length. These results were again confirmed in our study.

Further clinical studies should be performed to evaluate electronic apex locators under different clinical conditions, such as the presence of severe apical root resorption or blunderbuss canals.

Conclusion

The findings of this study demonstrated that the electronic apex locators did not give correct results in teeth with incomplete root formation. No difference in the results was noted between vital teeth and teeth with necrotic pulps. However the electronic apex locators in all teeth at the end of the apexification therapy gave correct results and complete agreement was obtained between the radiographs and the electronic measurements. Even in teeth in which complete apical closure could not be obtained, the results of electronic measurements were correct.

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References


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