

EVALUATING THE ACCURACY OF AN ELECTRONIC ROOT CANAL MEASURING DEVICE USING THE CLEARING TECHNIQUE ‡

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يعتبر جهاز قياس طول قنوات جذور الأسنان الإلكتروني أحد الأجهزة الحديثة المستخدمة في علاج عصب وجذور الأسنان.

لقد تم تقييم دقة هذا الجهاز من خلال استخدامه على أربعين مريضاً يراد قلع أسنانهم. ثبت المبرد المتصل بالجهاز بحشوة كومبوزيت بعد أن أدخل في قنوات الأسنان المراد قلعها وتم التأكد من ذلك من خلال الإشارة الضوئية الموجودة في الجهاز وحسب إرشادات الشركة المنتجة، بعد ذلك تم قلع الأسنان وفحص نهاية الجذور بجهاز الميكروسكوب وذلك بعد أن تم تحضيرها في المعمل بحيث أصبحت شفافة. بينت النتائج بأن الجهاز يستطيع قياس قنوات الأسنان الأمامية بنجاح وذلك بنسبة (95%) وتقل هذه النسبة عند قياس الأضراس الخلفية (63%).

The accuracy of an electronic root canal measuring device is evaluated using forty human subjects seeking tooth extraction: Both single and multi-rooted teeth were used. The position of the file tip to the apical constriction of the root apex was examined microscopically after tooth extraction using the clearing technique. Results showed 95% accuracy for anterior teeth, 80% for premolars and 63% for molar teeth.

Introduction

One of the most important steps in doing a good root canal therapy is to measure the length of the root canal before starting the biomechanical instrumentation. The common procedure is to take a working length radiograph using the radiographic root apex as a reference point.¹

One of the problems of using such a procedure is to locate the apical constriction of the root canal which usually opens eccentric of the anatomic apex.²⁻⁵ This eccentricity will limit the usefulness of radiographs where errors of instrumentation and obturation procedures might occur. In addition,

this method is time consuming and exposure to radiation is hazardous. Furthermore, anatomical structures such as the maxillary sinus and the zygomatic arch can obstruct the root apex and, therefore, interfere with the accuracy of radiographs.

To overcome these problems, new devices called "electronic apex locator", have been introduced in the market as a substitute for measuring the root canal length. Several investigators have evaluated the accuracy of these devices *in vivo* and *in vitro*.⁶⁻¹⁵ It was reported that these are just as accurate as the radiographic measurements.¹¹ According to Sunada,⁶ the measurement of the electrical resistance between the apical foramen and the oral mucosa was the principle behind all electronic apex locators. The accuracy of measuring the root canal using new devices were evaluated mostly by taking radiographs and/or extraction of tooth with the file inside the root canal [Table 1].

The purpose of this investigation was to study the position of the file tip relative to the apical constriction of the root apex using a clearing technique.

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Table 1. Summary of the procedures used in prior clinical studies for determining accuracy of electronic root canal measuring devices.

Study	Procedure
Sunada, 1962	Accuracy checked by radiograph, extraction and grinding the tooth root.
O'Neill, 1974	Extraction and new measurement done with newfile.
Blank <i>et al</i> , 1975	Extraction.
Chunn <i>et al</i> , 1981	Radiographs, extraction and grinding the root apex.
Berman & Fleischman, 1984	Radiograph, extraction and direct microscopic observation.
Trope <i>et al</i> , 1985	Radiograph.
McDonald & Hovland, 1990	Extraction, sectioning the tooth in a buccolingual direction and direct microscopic examination.

Materials and Methods

Forty human subjects seeking tooth extraction were randomly selected from the primary care clinic of King Saud University, College of Dentistry. Seventy single and multi-rooted teeth were used for this study. The Neosono D-SE* electronic apex measuring device was used. Teeth were obtained from patients going for orthodontic treatment or with periodontal disease with normal vital pulp.

Every patient contributed for this study filled a written consent, as governed by the regulation of the King Saud University Research Centers, before treatment is initiated.

Using local anesthesia and rubber dam isolation, access openings were made. When present, all metallic restorations were removed before access opening. Pulp tissue extirpated and the root canal was irrigated with water then dried with paper points. A file was attached to the file holder and the lip clip was attached to the patient's lower lip. The machine was operated according to the manufacturer's direction. The file was advanced into the root canal until the device indicated that the apical constriction had been reached. The file was held in place by filling the access opening with composite resin. The file handle was sectioned with a bur at high speed and the tooth was

*The Neosono D-SE, American Medical and Dental Corporation, Cherry Hill, NJ, USA

extracted. The extracted tooth was radiographed then stored in sodium hypochlorite solution to remove the periodontal tissue. All teeth were washed in running tap water for two hours.

The teeth were decalcified for three days in 5% nitric acid at room temperature. The nitric acid solution was changed daily and agitated by hand. After decalcification, the teeth were rinsed in running tap water for four hours, dehydrated in a series of ethyl alcohol rinses then placed in methyl salicylate for two hours.¹⁶ The root apex of the transparent teeth were examined with a dissecting microscope. Photographs of the root apex were taken using color slide film. The following criteria were used for evaluating the position of the file tip at the apical area:

Acceptable: the file tip is 0.5 - 1 mm shy of the radiographic apex.

Short: the file tip is > 1 mm shy of the radiographic apex.

Long: the file tip is > 1 mm beyond the radiographic apex.

These criteria were based on radiographic measurements of the extracted teeth. The results of the radiographic examination were compared with photographs.

Results

Table 2 gives the results of the microscopic evaluation of the transparent teeth and Figure 1 illustrates an example of one of the evaluated cases.

Of the 70 teeth examined, four teeth were fractured during extraction. Measurements showed 95% accuracy when the anterior teeth were evaluated. This accuracy decreased (premolars 80% and molars 63%) when posterior teeth were evaluated. The percentage of the accuracy of the apex locator was found to be 80.3% for all teeth.

Table 2. Microscopic evaluation of the position of the file tip relative to the radiographic apex.

Sample	Results						
	Acceptable	%	Long	%	Short	%	Total
Anterior	19	95	1	5	0	0	20
Premolars	24	80	4	13	2	7	30
Molars	10	63	4	25	2	12	16
Total	53	80.3	9	13.6	4	6.1	66

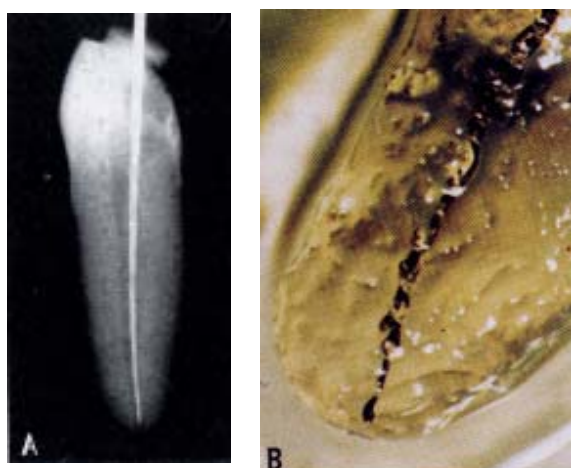


Figure 1. An illustration of the position of the file tip at the apical area.

- A) Radiographic picture of the extracted tooth showing a file shorter than the acceptable length. The root canal looks straight.
- B) Photograph of the same tooth after clearing. Note the position of the file and the deviation of the root canal at the apical area away from the anatomic apex.

Discussion

Most of the studies conducted to evaluate the accuracy of the electronic apex locator devices were based on pre-operative radiographic measurement of the evaluated teeth. This study is different in that the patient was not exposed to radiation. The measurement of the root canal system was based only on the machine reading. Our results showed an accuracy of 80.3%. The results were closely similar to previous studies.^{7-8,17-18} The high percentage accuracy when the anterior teeth were measured means that it is easy to measure a canal with large diameter. This may be due to the total removal of the pulp tissue and the complete dryness of the canal. This agrees with Sunada⁶ and Huang's¹³ observations that the dried canal will allow the file tip to touch the periodontal ligament at the apical foramen of the root canal.

Radiographic evaluation of the accuracy of the electronic device without extracting the tooth may be difficult due to absence of a three-dimensional picture. This inaccuracy was reported by Chunn *et al.*⁹ Comparing an electronic device with a radiograph, Kaufman *et al.*¹⁷ found a significant difference between the length read by the device

and that read by X-rays. Only 48% of the readings of the electronic device were identical with those obtained radiographically. The observer's bias and its influence on reading the radiograph,¹⁹ and the morphology of the root apex is another problem. The deviation of the opening of the apical foramen from the root apex,²⁵ makes the determination of the radiographic length precarious.

McDonald and Hovland¹⁵ reported that the determination of accurate working length using electronic devices may not be possible in teeth without apical constriction. In addition, the relationship between the diameter of the root canal and the diameter of the diagnostic file may cause some difficulties in establishing accurate working length. This was considered to be a major problem of using electronic measuring device. The majority of the previous studies used radiographs and extractions as a medium to determine the accuracy of these devices. None of these studies tried to precisely determine which point in the canal the electronic device was registering in relation to the apical constriction. Therefore, in this study the clearing method was of great use in determining the exact location of the file. This technique has been used in the study of root canal morphology.^{16,20-22} Unlike the radiographic technique, this method gives a three dimensional view of the root canal which makes it easy to determine the position of the file tip at the root apex and at what level it stops.

Finally, most of the studies concluded that the electronic measuring devices have a place in Endodontics specially when exposure to X-rays is contraindicated, as in pregnancy. Nonetheless, an electronic measuring device is a machine and is subject to mechanical errors. Required accuracy will not be obtained if the manufacturer's instructions were not carefully followed. Furthermore, the selection of an accurate diagnostic file in relation to the diameter of the canal and the knowledge of the average length of the tooth will lead to accurate measurement.

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