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Clinical Evaluation of the Accuracy of an Electronic Tooth Apex Locator

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Clinical evaluation of the accuracy of an electronic apex locator, Ray-Pex 5, was carried out in 85 single-rooted teeth with vital pulp tissue. The normal procedure was followed, which included a standard endodontic access opening, pulp removal and irrigation of the root canal with 5.25% NaOCl. The working length of the selected teeth was estimated with Ray-Pex 5, using a size 15 K-file. The files were cemented at the measured working length and the teeth were extracted. It is thought that absolute comparisons could be made only with the actual working length directly measured after extraction of the teeth. For the teeth where the tip of the file was not visible at the apical foramen, the Berman-Fleischman technique was used. In locating the apical foramen Ray Pex 5 was 95% accurate, with clinically acceptable estimation within ± 0.5 mm. Ray Pex 5 was accurate 97.5% of the time to ± 1 mm. The significance of the difference between the electronically and microscopically assessed sample was found at the level of $p < 0.01$ when paired t-test performed (95% CI for the difference -0.496, -0.204). The electronic device used for this study was found reliable in estimating the real length of the tooth root minimizing the need for multiple periapical x-rays during endodontic treatment.

Key words: Root canal length, electronic apex locator, accuracy, Ray-Pex 5

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INTRODUCTION

The determination of the working length and its maintenance during cleaning and shaping procedures was a key factor for successful endodontic treatment. Root canal instrumentation should ideally terminate at the apical constriction. The widely used method for root canal length determination was the radiographic interpretation of an instrument placed in the canal. It is generally accepted that the apical limit of endodontic preparations should be between 0.5 and 1 mm short of the radiographic apex. This calculation constituted the weak point of this method because it is a known fact that the distance between the apex and the end of the root varied. Consequently, if the difference between the constriction and the apex is not 1 mm, due for example to a lateral exit of the root canal, subtracting 1 mm would lead to false measurement. Thus the most important advantage of the electronic method over radiography was the fact that it could measure the root canal length. However, it was impossible on the radiographic film to consistently detect the major and minor foramina or cemento-dentinal junction (Tselnik *et al.*, 2005; Venturi and Breschi, 2005; Stavrianos *et al.*, 2003). Kuttler (1955) showed that the apical constriction was 0.524-0.659 mm coronal to the anatomic apex of the tooth. Furthermore Lee *et al.* (2002) revealed that cemento-dentinal junctions were not always detectable even under microscopic examination. The development of electronic apex locators began when Suzuki (1942) reported that the electrical resistance between the periodontal ligament and the oral mucosa *in vivo* was a constant value of 6.5 K Ω . Later, Sunada (1962) proposed an electronic method for detecting the apical foramen who introduced the principle of biological characteristics theory into clinical practice, stating that the electronic apex locators could read the apex by measuring the differences of electrical resistance values between the periodontal ligament and the oral mucosa. Since then, different apex locators have been developed but the main problem has been the inaccuracy of measurement in a humid environment. The canals need to be reasonably free of electrically conductive material in order to achieve an accurate reading. These electronic devices were also based on alternating current, but they operated on the principle that the impedance difference between electrodes depended on the signal frequencies used (Gordon and Chandler, 2005; Hoer and Attin, 2004; Lucena-Martin *et al.*, 2004; Moshonov and Slutzky-Goldberg, 2004; Welk, 2003). The Ray-Pex 5 (VDW GmbH, Germany) was a unit similar to the fourth generation electronic devices. The aim of the present study was to evaluate the accuracy of Ray-Pex 5 under clinical conditions.

MATERIALS AND METHODS

Eighty five single-rooted teeth, scheduled for extractions due to periodontal disease or orthodontic reasons, were selected for this study at the Department of Dentoalveolar Surgery in 2005-2007. The teeth were free from periapical lesions, had a clear radiographic appearance and typical morphology. They also did not have metallic restorations nor roots with resorption, fractures, open apices, or radiographically invisible canals. It must be noted that 5 teeth from the original selected were discarded due to damage that occurred during extraction.

A single operator then applied Ray-Pex 5 (VDW GMBH, Germany) according to the manufacturer's instructions. Working lengths were measured with K-files (F.K.G. Dentaire, La Chaux-de-Fonds, Switzerland) using this electronic apex locator. The file was fixed at the measured working length with cement (Richter and Hoffmann cement, Harvard Dental-Gesellschaft, Germany) and the file handle was removed using wire cutters prior to extraction. Teeth were then extracted and were carefully examined. The apical foramen was viewed with a stereomicroscope (Zeiss Stemi 2000-C, Carl Zeiss) under x15 magnification. For the teeth where the tip of the file was not visible at the apical foramen, the Berman- Fleischman technique was used (Berman and Fleischman, 1984).

According to this technique a file Kerr No. 10 attached to an output of an electronic Digital Multimeter (Metex M-3800 for measurement of electrical resistance), was inserted into the root canal via the apical foramen. The other output of the Multimeter was attached to the cemented file. The file was advanced from the coronal part until the Digital Multimeter indicated value resistance 0 (the tip of the inserted file reached the tip of the cemented file). With a thin alcohol marker, a mark was made to the file at the point of apical foramen and then the file retracted. The measured distance between the tip of the file and the mark was given to the tooth as a negative value. The distances measured with the electronic apex locator were compared.

RESULTS AND DISCUSSION

The descriptive statistics regarding the percentage of accuracy found for Ray Pex 5 to be 95% in locating the apical foramen, with clinically acceptable estimation within ± 0.5 mm. The device was accurate 97.5% of the time to ± 1 mm.

The null hypothesis was that the means were equal in electronic and microscopic sample. The rejection of this hypothesis established because the significance of the

difference between these two groups was found at the level of $p < 0.01$ when paired t-test performed (95% CI for the difference -0.496, -0.204).

The accuracy of the working length determination in root canal therapy had a crucial role in the treatment and prevention of periapical disease. The electronic apex locator was a device used for the accurate determination of the location of the apical foramen. Kuttler (1955), has shown that the apex coincided with the anatomical foramen in less than 50% of cases. This limited the usefulness of radiographs even if they were of good quality. Electronic apex locators reduced the number of radiographs required in root canal therapy and were useful in cases where the radiographic method was insufficient or contraindicated (Gordon and Chandler, 2005; Moshonov and Slutzky-Goldberg, 2004). Moreover, electronic apex locators could be used for diagnosis and location of perforations and can also be useful in a variety of clinical conditions, such as extensive apical resorption, retreatment of previously apicoectomized teeth with no retrograde filling and treatment of horizontal root fractures (Stavrianos *et al.*, 2004). Third and four generation apex locators could operate in the presence of intact or necrotic tissue, blood, inflammatory exudates and various irrigation fluids and represent an excellent method of double-checking the position of the apex and length of the root canal. The electronic devices locate the maximum diameter of the apical foramen and not the apical constriction. It is of great importance that these instruments retained their accuracy even in the presence of irrigation fluids (Gordon and Chandler, 2005; Stavrianos *et al.*, 2003).

The use of electronic apex locators for the calculation of working length during endodontic therapy provided the clinician with accurate and reliable measurements for each individual root canal. Several studies have demonstrated that the latest generation of electronic apex locators could accurately determine the working length in between 75% to 96.5% of the root canals with mature apices (Stavrianos *et al.*, 2000, 2003, 2004).

These results indicated that electronic root canal measurement was an objective and acceptably reproducible technique. Under clinical conditions it was possible to determine the region between the minor and major apical foramen with electronic length measuring devices. However, the regular use of these devices did not result in precise determination of the apical constriction.

The results of this clinical study showed that Ray Pex 5 was accurate electronic apex locator even in the presence of NaOCl 5.25% in the root canals. However, it should be noted that in all experimental teeth there was no periapical disease, which could widen the apical opening and influence the accuracy of electronic root canal measurements.

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