A Clinical Evaluation of the Apex Locator - Endometer ES-02

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Summary

The aim of this study was to evaluate the accuracy of the electronic apex locator, Endometer ES-02 in measurement of root canal length in clinical practice. The Endometer ES-02 instrument uses impedance of high frequency electric current.

The sample consisted of 631 teeth (328 single rooted, 70 bi-rooted and 250 tri-rooted teeth). After extirpation of the pulp by pulp extirpators, the root canal was rinsed with the 2.6% NaOCl solution and dried by paper points. The root canal length was measured using an Endometer ES-02 instrument. After the standard endodontic procedure, the root canals were obturated with Diaket and gutta-percha points, based on the measurement result obtained by Endometer ES-02. The teeth were then X-rayed and accuracy of the procedure was evaluated by measuring the distance between radiographic apex and endodontic filling with a digital caliper. The accuracy of the procedure was 96.4%.

Key words: *Endometer ES-02, apical foramen, canal length measurement.*

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Introduction

Correct measurement of root canal length, i.e. the location of the physiological foramen (foramen physiologicum) is one of the key factors of the success of endodontic treatment. It is considered that the instrumentation of the canal should reach the physical foramen i.e. cement-dentine junction. (CDJ) (1) Different methods have been used to measure root canal length; which are typically divided into digital-tactile, radiographic and electronic methods (1, 2). The use of electronic devices for measurement of the root canal length was first mentioned by Custer, in 1916. Since 1942, when Suzuki (3) found the resistance between periodontal ligaments and oral mucosa to be 6.5 kΩ, and Sunada (4) clinically applied this discovery in 1962, numerous electronic apex locators have been constructed. Commercially available apex locators have been tested both *in vitro* (5-9) and *in vivo* (2, 10-13), and proved to be of various accuracy. The majority of devices has the accuracy in range 65%-93%, with

0.5-1.0 mm tolerance of distance from the physiological foramen (14-16). Different parametres were found to influence accuracy of appex locators, such as the presence of vital or necrotic tissues (17), moisture, especially electrolytes (18, 19), diameter of the apical foramen (20, 21). Clinical accuracy is assessed using X-rays of teeth, after endodontic treatment which includes measurement by the examined device (22) or by measuring root canal length of teeth scheduled for extraction (19).

The purpose of this study was to evaluate the accuracy of Endometer ES-02 device in determining physiological foramen. The evaluation was conducted using X-rays of treated teeth.

Materials and methods

A sample of 631 teeth (a total of 1167 canals), 328 were single rooted teeth (328 root canals: 125 vital extirpations (Vexp), 36 mortal extirpations (Mexp), 167 necrotic, gangrenes and periapical processes, 70 bi-rooted teeth (a total of 140 root canals: 26 Vexp, 50 Mexp, 64 NGPP) i 233 multi--rooted teeth (699 root canals: 78 Vexp, 256 Mexp, 365 NGPP). All teeth were X-rayed and preparation of the endodontic cavity was done according to standard requirements. After extirpation of the pulp by pulp extirpators, the root canal was rinsed with 2% NaOHCl solution, dried by paper points and the location of the physiological foramen measured by Endometer ES-02 (Figure 1). The Endometer ES-02 works by measuring the impedance at high frequencies. The device has two connected pieces, one of which used as an electrode and placed on the mouth-corner to ensure contact with oral mucosa. The other joined piece was connected to the endodontic reamer, which is than introduced into the root canal, until the indicator on the scale reaches AF mark. The mark itself represents the average AF obtained by the prototype-testing procedure (24). That length is marked on the endodontic reamer and used as the working length. After instrumentation, the canals were filled by Diaket (ESPE, Seefeld, Germany) and gutta-percha points (Kerr, Romulus, USA) using lateral condensation technique. The teeth were than X-rayed (Figures 2, 3 and 4). The distance between the endodontic filling and radiological apex was measured by a caliper. The procedure was considered accurate if the distance was up to 1-1.5 mm.

The results were analysed by significance testing of differences between proportions, and the results shown in tables and figures. The level of statistical significance was set to 0.05.

Results

The length of the root canal was assessed correctly in 92-98% in different sub-samples. Total accuracy was 96.4% (Figure 5).

Statistically significant difference was found between the accuracy of measurement in Mexp procedure, compared to Vexp (p=0.0465), while no differences were found between the accuracy of measurement in Mexp vs. NGPP and Vexp vs. NGPP (p=0.0977 and p=0.5252, respectively). Therefore, the accuracy in different procedures was highest for Mexp, and lowest for Vexp, while the measurement in NGPP procedures was between these two values and not significantly different from either.

The accuracy of measurement of single vs. bi- and tri-rooted teeth showed somewhat higher accuracy for tri-rooted teeth. Statistically significant differences were found between the accuracy of measurement in single vs. tri-rooted teeth, as well as in bi-rooted vs. tri-rooted teeth (respective significance levels being 0.0012 and 0.0125) and no significant difference between the accuracy in single vs. bi-rooted teeth. (p=0.9661)

The relative frequency of over-obturations (Figure 6) ranged from 0 to 8% in different subsamples. Total frequency of over-obturation was 2.7%.

Differences between over-obturation frequencies for different procedure types were not found. (p=0.6351 for Mexp vs. Vexp, 0.0847 for Mexp vs. NGPP and 0.7731 for Vexp vs. NGPP). Accuracy results for teeth with a different number of roots only showed statistically significant differences in single rooted vs. tri-rooted teeth (p=0.0185), while differences in accuracy were similar between single rooted vs. bi-rooted and bi-rooted vs. tri-rooted teeth. (p=0.9961 and p=0.1529).

The relative frequency of under-obturation (Figure 7) ranged from 0 to 4% in different subsamples, with average frequency of 0.9%.

The differences in under-obturation frequencies were statistically significant for Vexp vs. NGPP (p=0.0432) and not significant for Mexp vs. Vexp and Mexp vs. NGPP (with respective p levels of 0.2528 and 0.4679). Accuracy results for teeth with a different number of roots only showed statistically significant differences in single rooted vs. tri-rooted teeth (p=0.0401), while differences in accuracy were similar between single rooted vs. bi-rooted and bi-rooted vs. tri-rooted teeth (p=0.9344 and p=0.6742).

Discussion

The above mentioned results showed the accuracy of apex locator Endometer ES-02 to be 96.4%, when controlled by X-rays. This result is in accordance with other studies (25-27) reporting the accuracy of apex locators to range from 80 to 94%. An accurate apex locator enables endodontic procedure to be conducted with only two X-rays. Also, doubts exist about the reliability of radiographic control, as there is a possibility of interference of anatomical structures, radio-opacity of the film itself, and also subjectivity of clinicians (10). Chunn et al. (28) report that 43% percent of canals with radiographically-visible under-obturations were in fact over-obturated. Other reports of the unreliability of radiographic assessment of root canal length and obturation include studies by Becker et al. (29) and Griffith et al. (30). Garcia et al. (31), however, consider X-ray to remain the basis of all endometric procedures, so that even the latest procedures, such as radiovisography (RVG) i.e. direct digital radiography (DDR) are evaluated in comparison with the traditional X-ray (32-34).

However, when assessing the accuracy of endodontic treatment using X-ray, one must bear in mind the specific relationship between radiological apex and anatomical opening (foramen anatomicum; foramen externum; foramen apicis) to physiological foramen (foramen physiologicum; foramen internum; constrictio apicis). Kuttler (35) stated that the distance between the apical foramen and apical constriction is on average 0.5 mm in younger, and 0.7 mm in older age group. By comparing X-rays of extracted teeth with X-rays taken prior to extraction, Pineda and Kuttler (36) stated that the distance between apical foramen and radiological apex can range between 2-3 mm. Other authors (28, 37) report that the average distance between the apical foramen and radiological apex is 1 mm. Melius et al. (38) agree with the current conception that endodontic working length should terminate 1 mm from the radiographic apex. Authors report that the mean distance was 0.494 mm measured from conventional radiographs, and 0.594 mm from digital radiographs. According to these results, our study deduced 1 to 1.5 mm from the radiological apex in control X-rays. As the radiographic control was found to be rather unreliable, the same device was evaluated by measuring root canal length in teeth scheduled for extraction for orthodontic or parodontological reasons (39). The accuracy of Endometer ES-02 was 96.6%. These findings are in accordance with the results of this study, but also with an earlier study, using radiographic control (40).

Fouad et al. (21), Kaufman & Katz (37) and Stein et al. (41) report the effect of the apical foramen diameter on the accuracy of the apex locator. The locators evaluated proved to be more precise for apical constrictions with smaller diameter (found, for example in older patients). Fouad et al. (42) report that the diameter of the apical constriction, ranging from 0.17 to 0.42 mm, do not influence the accuracy of their apex locator, while the device under-estimates the length of the root canal if the diameter exceeds 0.62 mm. In our study evaluating Endometer ES-02 apex locator, no effect of the apical constriction diameter was noted, as this device requires the use of a needle of a diameter adequately chosen to obturate apical constriction. An earlier study of Fouad et al. (21) confirms the results of early studies (18, 19) about the influence of moisture (blood, sodium-hypochlorite (NaOCl), local anaesthetic, saliva, ethylenediaminetetraacetic acid (EDTA) on the accuracy of electronic apex locators. However, the same authors, Fouad et al. (42) found no such effects on the accuracy of new-generation apex locators. During our study, it was noted that Endometer ES-02 is sensitive to the presence of EDTA. It is, however, sufficient to rinse EDTA from the root canal with 2.6% solution of NaOCl and dry with paper points to avoid this effect. As the device is not sensitive to moisture, the canal need not be completely dry. Mayeda et al. (17) and Dun-

lap et al. (23) report no significant influence of vital or necrotic tissue to accuracy of the apex locator, although some authors (13) claim that canals with necrotic tissue can show different impedance from those with vital pulp tissue, due to the destruction of periodontal ligament. Our results also show that there are no clinically relevant differences in the accuracy of Endometer ES-02 apex locator regarding the vitality of tissues.

Conclusion

1. Endometer ES-02 showed 96.4% accuracy in determining root canal length.
2. Over-obturations were found to be three times more frequent than under-obturations (2.7% vs. 0.9%)
3. The type of procedure and type of tooth (number of roots) did not effect the accuracy of measurement by Endometer ES-02. The accuracy was slightly higher for Mexp procedure, when compared to Vexp. This difference is due to the more frequent under-obturation in Vexp procedures, while no differences were found in over-obturation frequency.

The results of this study, supported by the results of earlier studies (24, 39, 40) suggest the conclusion that Endometer ES-02 is a sufficiently accurate apex locator to be used in clinical practice.