In Vitro Evaluation of the Ability of Three Apex Locators to Determine the Working Length During Retreatment

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Abstract

The purpose of this in vitro study was to evaluate the accuracy of three apex locators in determining the working length during the retreatment process. Twenty extracted single-rooted human teeth with mature apices were used in this study. The root canal length of each tooth was measured placing a #15 file until the tip was visible at the apical foramen. The direct visual measurement was reduced by 0.5 mm and recorded. The root canals were instrumented and filled to the direct visual measurement using lateral compaction technique. After 7 days the teeth were retreated using three apex locators: ProPex, NovApex, and Root ZX, for determining the retreatment working length. Afterward, comparison between the visual working length and the retreatment working length were made. ProPex, NovApex, and Root ZX were accurate within 0.5 mm 80, 85, and 95% of the time, and within 1 mm 95, 95, and 100%, respectively. No significant differences were detected between the three apex locators ($p > 0.05$).

Key Words

Apex locators, retreatment, working length

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The retreatment of endodontic failures has become a routine procedure in a clinical endodontic practice. Procedural errors that lend themselves to intracanal leakage and latent infection appear to be one of the major factors associated with endodontic failures (1, 2).

Sjögren et al. (3) observed 62% success in roots with periapical lesions that were previously filled and were retreated.

Bergenholtz et al. (4) reported a 94% success when the cause for retreatment was attributed to technical inadequacy. Retreatment is considered to be least complicated when the failure of the primary endodontic treatment is because of the underfilling of the root canal.

Sundqvist et al. (5) provided evidence that microorganisms harbor themselves in anatomic branches of the root canal system and may even reside in areas that were thought to be obliterated by the primary root canal filling material. As such, the complete removal of the previous root canal filling material is necessary to enhance the effect of irrigating solutions and intracanal medicaments.

An accurate working length determination during the retreatment process will make it easier for an operator to completely remove the primary root canal filling material and by so doing offer one the opportunity to precisely prepare and reobturate the canal.

The importance of establishing an adequate determination of the working length during retreatment is supported by the findings of Bergenholtz et al. (6). In a clinical radiographic follow-up investigation, they showed the overinstrumentation and overfilling of retreated root canals significantly decreased the frequency of complete regeneration of apical lesion repair.

The conventional technique for the determination of canal length is the radiographic method. However, in many cases it is difficult to establish the actual length of the canal with a two-dimensional image (7, 8).

Custer (9) was the first to introduce an electrical method to estimate the root canal length. In 1962, Sunada (10) constructed the first electronic apex locator. Since then, different generations of electronic apex locators have been developed to measure root canal length (11).

Several studies have demonstrated the accuracy of apex locators in determining the working length (8, 12–15). However, only a few studies have considered the canal obstacles that influence retreatment (16).

With concerns over radiation exposure, the adjunctive use of electronic apex locators during endodontic treatment decrease the radiation exposure to patients by reducing the number of radiographs required for endodontic therapy (17).

The purpose of this in vitro study was to evaluate the accuracy of three apex locators in determining working length during the retreatment process.

Materials and Methods

Twenty extracted single-rooted human teeth with mature apices were selected for this study. Digital radiographs were taken in buccolingual and mesiodistal directions and used to evaluate the existing root canal anatomy.

Conventional endodontic access cavities were prepared using diamond round burs. The coronal and middle thirds of the canals were shaped using #1, #2, and #3 Gates-Glidden burs (Dentsply-Maillefer, Ballaigues, Switzerland). Intermittent irrigation was performed with 2.5% sodium hypochlorite solution.

TABLE 1. Accuracy of the different apex locators within 0.5 mm of the direct visual measurement

Device/Measurement	ProPex	NovApex	RootZX	Total
Acceptable	16 (80%)	17 (85%)	19 (95%)	52 (86.6%)
No acceptable	4 (20%)	3 (15%)	1 (5%)	8 (13.3%)
Total	20	20	20	60

$\chi^2 = 2.02$; $p = 0.36$.

TABLE 2. Accuracy of the different apex locators within 1 mm of the direct visual measurement

Device/Measurement	ProPex	NovApex	RootZX	Total
Acceptable	19 (95%)	19 (95%)	20 (100%)	58 (96.6%)
No acceptable	1 (5%)	1 (5%)	0 (0%)	2 (3.3%)
Total	20	20	20	60

$\chi^2 = 1.03$; $p = 0.60$.

The root canal length of each tooth was measured by placing a #15 file into the root canal until the tip became visible at the apical foramen. The silicone stop on the inserted file was set to a flat anatomical reference point on the crown. The file was carefully removed and measured from the file tip to the stop with an endodontic ruler. This direct visual measurement (DVM) was reduced by 0.5 mm and recorded.

The root canals were then instrumented to the DVM to a #45 K file (Dentsply-Maillefer). Two milliliters of 2.5% sodium hypochlorite solution was used for irrigation between each instrument and again upon the completion of instrumentation. The canals were then dried with paper points. A standardized #45 gutta-percha master cone (Dentsply-Maillefer) coated with AH26 sealer (Dentsply DeTrey, Konstanz, Germany) mixed according to the manufacturer's instructions, was fitted to the working length. Lateral compaction was performed using a #30 finger spreader (Dentsply-Maillefer). Fine accessory gutta-percha cones (Dentsply, Petropolis, Brasil) were inserted and compacted as needed. Digital radiographs were taken to confirm obturation. The teeth were then stored for 7 days at 37°C and 100% humidity to ensure the setting of the sealer.

After incubation the root canal filling material within the coronal and middle thirds of the canals was removed 4 to 5 mm shy of the DVM with a #2 Peeso reamer (Dentsply-Maillefer). The roots of the teeth were then seated to the CEJ in a plastic tube filled with normal saline solution. The lip clip was also inserted in the plastic tube. A gutta-percha solvent (Xylene, Farmadental, Buenos Aires, Argentina) was injected into the root canal and the softened apical gutta-percha was penetrated with a #20 K file attached to the apex locator file holder. The file was advance apically, removing gutta-percha as it progressed, until the apex locator signal indicated the apex. The file was retracted slowly until the digital display read 0.5. This is a position that most agree represents the location of the apical constriction. The silicone stop was then set to the same anatomical reference point as used during the DVM trials. The file was removed and measured with the same endodontic ruler. This measurement was designated as retreatment working length (RWL). The measurement of each tooth was recorded.

For consistency, the individual tests of the three different electronic devices: ProPex (Dentsply-Maillefer). NovApex (Forum Technologies, Rishon Le-Zion, Israel) and Root ZX (J. Morita Corp., Kyoto, Japan) were conducted, measured and recorded by one operator.

Comparisons between the DVM and the RWL were made, and the accuracy of the electronic apex locators was evaluated within $\pm$ 0.5 and $\pm$ 1 mm, respectively.

The data were analyzed using analysis of variance and the χ^2 test (Software:SPSS10.0).

Results

According to the results, as shown in Tables 1 and 2, measurements determined by the three different apex locators (ProPex, NovApex, and Root ZX), were accurate within 0.5 mm 80, 85, and 95% of the time, and within 1 mm 95, 95, and 100%, respectively.

Statistical analysis showed no significant differences between the three apex locators tested ($p > 0.05$).

Discussion

Several studies have demonstrated the accuracy of apex locators in determining the working length of root canals during routine endodontic treatment (8, 12–15). The exact determination and the critical maintenance of working length during retreatment, should be considered as just as vital an aspect of therapy (18).

Sjögren et al. (3) reported 50% success in retreated root canals with overfilling compared to 67% success in teeth adequately sealed.

Bergenholtz et al. (6) found complete apical bone regeneration in 36% of retreated root canals with overfillings compared with 62% in cases without overfillings. They reported the frequency of apical regeneration in retreated cases significantly decreased when overfilling existed.

In the present study the primary root canal treatment was performed up to the DVM level to mimic clinical failures when radiographically acceptable fillings were observed. Allen et al. (19) investigated factors that contributed to the failure of 1300 treated teeth. They found 22.6% of the teeth, with radiographically acceptable fillings but no apparent cause for failure was detected. On the other hand, in some clinical cases with radiographically acceptable fillings retreatment is indicated because of coronal leakage (20–22).

In this study, electronic readings obtained with ProPex, NovApex, and Root ZX showed an accuracy of 95, 95, and 100% within 1 mm of the DVM. Based on the study of Shabahang et al. (14) where they considered an error tolerance of 1 mm to be clinically acceptable, the results of this study were quite meaningful.

The findings obtained in this in vitro study were similar to that observed in vital and necrotic pulps by other authors (13, 15).

During root canal retreatment a number of radiographs are required to completely remove the primary filling material and to obtain a controlled working length during reinstrumentation and reobturation. According to Brunton et al. (17) the use of an electronic apex locator reduces the number of radiographs required for working length determination, desirably decreasing the radiation exposure to patients.

The authors found the electronic devices employed in this study generated no acoustic or visual signal when the file passed the gutta-

percha filling and went through the apical foramen. Once the file was retracted back into the root canal, the visual and acoustic signals of the different units could confirm instrument position at the appropriate 0.5 mm working length.

The results of this study indicate electronic apex locators are useful in determining the working length of root canals when retreating endodontic failures.

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