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ORIGINAL RESEARCH

Ex vivo Accuracy of Root ZX II, Root ZX Mini and RomiApex A-15 Apex Locators in Extracted Vital Pulp Teeth

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ABSTRACT

The objective of this study was to compare, *ex vivo*, the accuracy of three electronic apex locators (EALs), Root ZX II, Root ZX Mini and RomiApex A-15, in detecting the apical foramen (AF). Forty extracted single-rooted human teeth with vital pulp were used in this study. After access preparation, the root canal length of each tooth was measured by placing a #10 file until the tip was visible at the AF under a stereomicroscope. The teeth were subsequently embedded in an alginate model. In each root canal, all three EALs were used to determine the working length, which was defined as the zero reading or equivalent. The distance between the file tip and AF was measured to an accuracy of 0.01 mm. Results were analyzed using analysis of variance and the Chi-squared test. Root ZX II, Root ZX Mini and RomiApex A-15 were accurate within 0.5 mm, 62.5, 56.2, 50% of the time. No significant differences were found between the three EALs ($p > 0.05$). Considering all EALs, the mean distance from the file tip to AF was 4.49 mm. The accuracy of the three EALs evaluated in this study was not statistically significantly different. The 'Apex' or '0.0' marks of the EALs do not indicate the AF itself, but just a position coronal 0.49 mm to the AF. Using a tolerance of $\pm$0.5 mm from the actual lengths, the ZX II yielded the most acceptable measurements.

Keywords: Root ZX II, Root ZX mini and RomiApex A-15.

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INTRODUCTION

During endodontic treatment, a precise working length (WL) prevents inadequate debridement, apical transportation and overfilling of root canal.[1] The cementodentinal junction (CDJ) is the most widely accepted limit for biomechanical preparation. However, it is a variable point and additionally cannot be determined radiographically.

Historically, the conventional technique to determine the WL has been the radiographic method. However, radiographs are subject to distortion and interpretation variability. Furthermore, the fact that anatomical structures are superimposed and the apical foramen (AF) does not coincide with the root apex renders radiography inaccurate for this purpose.[2] Due to these limitations, electronic apex locators (EALs) are indicated as adjunctive tools to enhance the accuracy of the radiographic method in obtaining the WL.[3]

Electronic apex locator evaluation resulted in the development of a fourth-generation product in 2003, with the introduction in the market of the elements diagnostic unit (SybronEndo, USA). Basically, this device measures the impedance value by calculating both resistance and capacitance. The value obtained is compared with a database in the device.

The aim of this *ex vivo* study was to compare the accuracy of three fourth generate EALs, Root ZX II, Root ZX Mini and RomiApex A-15 to detect the AF.

MATERIALS AND METHODS

Thirty-two extracted permanent teeth with a single root and vital pulp were selected for this study. The reasons for extracting were orthodontic, prosthetic or periodontal indications. The teeth were soaked in 10% formalin solution until use. Radiographs were taken in buccolingual and mesiodistal directions and used to verify the presence of only one root canal.

Assessment of the root surface and apical portion of each tooth confirmed the absence of fractures, presence of a mature apex and only one AF. A Leica DFC 295 (Hessen, Wetzlar, Germany) stereomicroscope at 6× magnification was used for this procedure.

The crowns of selected teeth were sectioned with a diamond disk to provide access to the root canal, and establish a fixed and stable coronal reference point for further measurements. Thereafter, #10 C + files (Dentsply Maillefer,

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Ballaigues, Switzerland) were used to ensure AF patency in all teeth.

The middle third of the canals were prepared using Gates Glidden drills, starting with a #2 and progressing in coronal direction with a #3 and #4 (Dentsply Maillefer, Ballaigues, Switzerland). Irrigation was performed with 2.5% NaOCl after each instrumentation.

The actual root canal length of all teeth was obtained using a #15 C+ file (Dentsply Maillefer, Ballaigues, Switzerland) with double silicone stoppers, which was inserted in the root canal until the tip could be visualized at the AF with the aid of a Leica DFC 295 (Hessen, Wetzlar, Germany) stereomicroscope under 6× magnification. When the stoppers were stabilized at the coronal reference point, the file was carefully removed from the canal and the distance from the stoppers to the tip was measured with a digital caliper with 0.01 mm precision (Digimess, São Paulo, Brazil). Each set of files and silicone stoppers was used for only one measurement and discarded.

For the electronic WL measurements, the teeth were immersed in a glass box containing freshly manipulated alginate (Avagel, Dentsply, Petrópolis, Brazil) to simulate the periodontal tissues. The teeth were kept in position until the alginate had set completely. All measurements were made in an interval of 2 hours, with the alginate kept sufficiently humid throughout this period. A labial clip was attached to the alginate. Measurements were taken after 2 ml irrigation with 2.5% NaOCl.

Each EAL was used according to manufacturer's recommendations to detect the AF. For the Root ZX Mini, this was the 'Apex' reading, which was indicated by a solid audible tone. For the RomiApex A-15, this was the '0.0' mark and a constant audible tone. Measurements were recorded and repeated twice for each tooth with each EAL. For all electronic measurements, the file was gradually inserted until the visor and corresponding acoustic signal indicated that the instruments had reached the specific WL. A measurement was defined as valid when the EAL reading remained stable for at least 5 seconds. For consistency, the individual tests of the three different EALs were conducted, measured and recorded by one single operator.

The difference between the mean electronic measurements, and the actual canal length was calculated for all teeth (Table 1). Positive values indicated measurements beyond the apical foramen and negative values indicated measurements close to the apical foramen. The accuracy of the EALs was evaluated within the acceptable range of 0.5 mm. The data thus obtained were analyzed using analysis of variance (ANOVA) and the Chi-squared test with a significance of 0.05.

Table 1: Mean of difference between the mean electronic measurements and the actual canal length

EAL	*Mean (mm)*	*n*	*Standard deviation*
ZX II	–0.51	32	0.34
ZX Mini	–0.45	32	0.34
RA	–0.51	32	0.41
Total	–0.49	96	0.36

EAL: Electronic apex locator

RESULTS

Analysis of variance (ANOVA) showed no significant difference between Root ZX II, Root ZX Mini and RomiApex A-15 in their ability to identify the AF ($p = 0.07$). The mean distance from the file tip to AF was –0.51 mm, –0.45 mm and –0.51 mm for Root ZX II, Root ZX Mini and RomiApex A-15 respectively. Considering all EALs, the mean distance was 0.49 mm. Chi-squared analysis found no significant difference among the EAL in the proportion of measurements within a ± 0.5 mm range of clinical acceptability. Given this tolerance, Root ZX II, Root ZX Mini and RomiApex A-15 were accurate in 62.5, 56.2 and 50% of cases respectively.

DISCUSSION

Accurate determination of working length is a critical step for the success of endodontic treatment. Historically, radiographs have been the main method for detecting the working length in endodontic therapy.[4] Given the limitations of conventional radiography, EALs play a key role in estimating the correct working length, but these devices differ in precision.

In the present study, all samples had vital pulps, which preserved the apical anatomy, and all had patent apical foramens since the main reason for EAL dysfunction is the presence of obliteration or filling remnants in the root canal.[5]

Similarly to other studies,[6-9] this research used an *ex vivo* model with alginate to assess EAL accuracy. According to a study,[10] the favorable results achieved with alginate show that this medium not only features good electroconductive properties but also it remains around the root, simulating the periodontal ligament with its colloidal consistency. Convenient handling and preparation combined with an affordable price make it the material of choice for use in *in vitro* tests with apex locators. The canals were carefully preflared with Gates Glidden drills before using the EALs to increase accuracy.[11-13]

The underlying principle of the EALs assumes that the electrical conductivity of tissue surrounding the root apex is greater than that of tissue inside the root canals.[14,15] The accuracy of EALs has been reported in numerous studies,[6,9,16,17] which differ in the method used to determine the reference point. Some authors measured from the apical foramen

while others measured from the apical constriction (AC). Many authors[17,18] used the '0.5' mark to determine the WL because it has been reported that the WL should be established at the AC.[4] However, less than 50% of the teeth have a 'traditional' single AC,[19] and often no AC is present, particularly with apical pathosis and root resorption.[20] The literature provides scant information as to what position the '0.5' mark indicates in those cases. Many studies showed that the '0.5' mark of the EALs does not indicate the AC *per se* but just a position coronal to the AF.[16,17]

The results of some studies have demonstrated the accuracy of Root ZX II. A study[21] found a 50% accuracy while other authors[22] found 97.5%, both within ±0.5 mm of tolerance. In the present study, the accuracy of Root ZX II was 62% within the same tolerance range. The accuracy found for Root ZX Mini and RomiApex A-15 was 56.2 and 50% respectively. This is the first report comparing Root ZX Mini with RomiApex A-15.

The mean distances from the file tip to the AF for the Root ZX II, Root ZX Mini and RomiApex A-15 were –0.51, –0.45 and –0.51 mm respectively. Considering all measurements, the mean distance between the file tip and the AF was –0.49 mm. Microscopic studies have shown the distance from the AF to the apical constriction to be in the range of 0.5 to 1.0 mm.[23]

The frequency of measurements that passed the AF was 3.12% for Root ZX II and there were no such cases for Root ZX Mini and RomiApex A-15. These findings raise the question of whether the WL should be established at the point where the EALs indicates the AF since this point is close to the apical constriction, the ideal terminal end for instrumentation and obturation.[1,24] In conclusion, the accuracy of the three EALs evaluated in this study was not statistically significantly different. The 'Apex' or '0.0' marks of the EALs do not indicate the AF itself, but just a position coronal 0.49 mm to the AF. Using a tolerance of ±0.5 mm from the actual lengths, the ZX II yielded the most acceptable measurements.

REFERENCES

1. Ricucci D, Langeland K. Apical limit of root canal instrumentation and obturation, Part 2: a histological study. Int Endod J 1998; 31(6):394-409.
2. Tamse A, Kaffe I, Fishel D. Zygomatic arch interference with correct radiographic diagnosis in maxillary molar endodontics. Oral Surg Oral Med Oral Pathol 1980;50(6):563-566.
3. ElAyouti A, Weiger R, Lost C. The ability of root ZX apex locator to reduce the frequency of overestimated radiographic working length. J Endod 2002;28(2):116-119.
4. Ricucci D. Apical limit of root canal instrumentation and obturation. Part 1: literature review. Int Endod J 1998;31(6):384-393.
5. ElAyouti A, Kimionis I, Chu AL, et al. Determining the apical terminus of root-end resected teeth using three modern apex locators: a comparative ex vivo study. Int Endodont J 2005; 38(11):827-833.
6. Plotino G, Grande NM, Brigante L, et al. Ex vivo accuracy of three electronic apex locators: Root ZX, elements diagnostic unit and apex locator and propex. Int Endod J 2006;39(5):408-414.
7. Bernardes RA, Duarte MA, Vasconcelos BC, et al. Evaluation of precision of length determination with 3 electronic apex locators: Root ZX, elements diagnostic unit and apex locator, and Romiapex D-30. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2007;104(4):e91-94.
8. D'Assuncao FL, De Albuquerque DS, Salazar-Silva JR, et al. The accuracy of root canal measurements using the mini apex locator and root ZX-II: an evaluation in vitro. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2007;104(3):e50-53.
9. Goldberg F, De Silvio AC, Manfre S, et al. In vitro measurement accuracy of an electronic apex locator in teeth with simulated apical root resorption. J Endod 2002;28(6):461-463.
10. Baldi JV, Victorino FR, Bernardes RA, et al. Influence of embedding media on the assessment of electronic apex locators. J Endod 2007;33(4):476-479.
11. Ibarrola JL, Chapman BL, Howard JH, et al. Effect of preflaring on root ZX apex locators. J Endod 1999;25(9):625-626.
12. Jenkins JA, Walker WA 3rd, et al. An in vitro evaluation of the accuracy of the root zx in the presence of various irrigants. J Endod 2001;27(3):209-211.
13. Tinaz AC, Alacam T, Topuz O. A simple model to demonstrate the electronic apex locator. Int Endod J 2002;35(11):940-945.
14. Kim E, Lee SJ. Electronic apex locator. Dent Clin North Am 2004;48(1):35-54.
15. Nekoofar MH, Ghandi MM, Hayes SJ, et al. The fundamental operating principles of electronic root canal length measurement devices. Int Endod J 2006;39(8):595-609.
16. Tselnik M, Baumgartner JC, Marshall JG. An evaluation of root ZX and elements diagnostic apex locators. J Endod 2005; 31(7):507-509.
17. Shabahang S, Goon WW, Gluskin AH. An in vivo evaluation of root ZX electronic apex locator. J Endod 1996;22(11):616-618.
18. Pascon EA, Marrelli M, Congi O, et al. An ex vivo comparison of working length determination by 3 electronic apex locators. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2009; 108(3):e147-151.
19. Dummer PM, McGinn JH, Rees DG. The position and topography of the apical canal constriction and apical foramen. Int Endodont J 1984;17(4):192-198.
20. Mayeda DL, Simon JH, Aimar DF, et al. In vivo measurement accuracy in vital and necrotic canals with the endex apex locator. J Endod 1993;19(11):545-548.
21. Siu C, Marshall JG, Baumgartner JC. An in vivo comparison of the root ZX II, the apex NRG xfr, and mini apex locator by using rotary nickel-titanium files. J Endod 2009;35(7):962-965.
22. Guise GM, Goodell GG, Imamura GM. In vitro comparison of three electronic apex locators. J Endod 2010;36(2):279-281.
23. Kuttler Y. Microscopic investigation of root apexes. J Am Dent Assoc 1955;50(5):544-552.
24. Simon JH. The apex: how critical is it? Gen Dent 1994;42(4):330-334.