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Endodontics

EVALUATION OF THE ACCURACY OF TWO DIFFERENT APEX LOCATORS FOR LOCATING STANDARDIZED ARTIFICIAL ROOT PERFORATIONS

B. Arıcan Öztürk İstanbul Okan University, Faculty of Dentistry, Department of Endodontics, Turkey

E İriboz* Marmara University, Faculty of Dentistry, Department of Endodontics, Turkey
*Corresponding Author

ABSTRACT

Aim: The purpose of this study was to evaluate the accuracy of Propex Pixi and Root ZX Mini on locating artificial middle and apical root perforations.

Methodology: Forty extracted single rooted mandibular premolars with single canals were selected for the study and randomly divided into two groups (n:20). Standardized artificial perforations were prepared in the both middle and apical thirds of the proximal root surface with 90° angle into the pulp space. Actual lengths of middle and apical perforations were measured under operation microscope. Then, electronic measurements were obtained by two different apex locators (EALs); Root ZX Mini and Propex Pixi for both apical and middle perforation sides. Two-way ANOVA test was used for statistical analysis ($P \leq 0.05$).

Results: There were no statistically significant difference between Propex Pixi and Root ZX Mini on locating artificial standardized root perforations.

Conclusion: It was concluded that both EALs could locate apical root perforations. However this could not be possible for middle root perforations.

KEYWORDS : Artificial root perforation, Electronic apex locator, Propex Pixi, Root ZX Mini

INTRODUCTION

Root perforation involves communication between the periodontal tissues and root canal system [1], and may be caused by caries, resorptive processes, or iatrogenic accidents. The location and size of the perforation, etiology, and time to detection can affect the prognosis after treatment [2,3]. Radiographic examination, electronic apex locators (EALs), operating microscopes, and computed tomography have been suggested to detect perforations [4]. Although intraoral radiographs are widely used in endodontic procedures, their two-dimensional nature prevents location of the perforated area [5]. Especially, root perforations on the buccolingual aspect are very difficult to diagnose on radiographs [6,7]. Therefore, EALs are widely used due to their high reliability, accuracy, and reproducibility in locating the major foramen[8].

Root ZX Mini (J. Morita Corp., Kyoto, Japan), a compact version of Root ZX, is a fourth-generation EAL that operates according to a proven ratio technique. It can measure the impedances of two frequencies (400 Hz and 8 kHz) and can operate under both dry and wet conditions. It requires no adjustment or calibration and can be used both when the canal is filled with strong electrolyte and when it is "empty" and moist, and has become the benchmark for EALs [9-11].

Propex Pixi (Dentsply Maillefer, Ballaigues, Switzerland) is a pocket-sized fifth-generation EAL [12], which uses a new multifrequency technology in addition to calculating the root mean square (RMS) values of the electrical signals. EALs of this generation are less affected by electrical noise [13].

To our knowledge, there have been no previous studies evaluating the accuracy of several apex locators for different level root perforations. This study was performed to evaluate the accuracy of Propex Pixi and Root ZX Mini for locating artificial middle and apical root perforations.

MATERIALAND METHODS

This study was approved by the Ethics Board of Marmara University, Istanbul, Turkey (29.11.2018/2018-225).

Forty extracted single-rooted mandibular premolars with single canals were selected for the study and randomly divided into two groups (both n = 20). Soft tissues and calculus were removed from the root surface, and the teeth were stored in 0.1% thymol solution until use in the experiments. The teeth were evaluated under an operating microscope to exclude roots with open apices, cracks, root caries, resorptive defects, and apical curvature > 10°. To evaluate the root canal anatomy, intraoral radiographs were taken from buccolingual and mesiodistal angles. The teeth were decoronated at the cementoenamel junction to obtain a plain surface and root length was standardized. Apical patency was checked with a 10 K file. Barbed broaches were used to extirpate the pulp. The root canals were then irrigated with 2.5 mL of 2.5% sodium hypochlorite and 2.5 mL of distilled water.

Standardized artificial perforations were prepared in the middle or apical thirds of the proximal root surface with an angle of 90° into the pulp space using a size 014 round diamond bur. The perforations were approximately 1.5 mm in size. Actual lengths up to both the apical and middle third of the perforations were measured by visualization of the tips of size 20 and 25 K files, respectively, under a microscope at 20× magnification (AL). The distance between the file tip and rubber stop was measured using a digital caliper and recorded as the actual working length to the apical perforation side (AL_{AP}) and the actual working length to the middle perforation side (AL_{MP}). The teeth were than embedded in freshly mixed alginate medium.

Electronic measurements

Electronic measurements (EL) were obtained by the same operator using two different apex locators, Root ZX Mini and Propex Pixi, according to the respective manufacturer's instructions. Root canals were irrigated with 2.5 mL of 2.5% sodium hypochloride and dried with two paper points before the measurements.

Propex Pixi group: The lip clip of the Propex Pixi was placed into the alginate model. For ELs, 20 and 25 K files were used in the apical and middle perforations, respectively. The endodontic file was advanced up to the "0.5" mark visible on the display screen. The readings were designated as ($\mathbf{EAL_{P\text{-}AP}}$) for the apical perforation and ($\mathbf{EAL_{P\text{-}MP}}$) for the middle perforation.

Root ZX Mini group: The lip clip of the Root ZX Mini was placed into the alginate model. For ELs, 20 and 25 K files were used in the apical and middle perforations, respectively. The endodontic file was advanced up to the "APEX" mark visible on the display screen. The measurements were determined after a 5-s period for stabilizing the device. The readings were designated as ($\mathbf{EAL_{R\text{-}AP}}$) for the apical perforation and ($\mathbf{EAL_{R\text{-}MP}}$) for the middle perforation.

Statistical evaluation was performed using NCSS Statistical Software (NCSS LLC, East Kaysville, UT, USA). Two-way analysis of variance (ANOVA) was used to analyze the data. In all analyses, $P<0.05$ was taken to indicate statistical significance.

Results

The mean differences (standard deviation, SD) between the EL and AL of perforations for each EAL at different perforation sides are shown in Tables 1 and 2. There were no significant differences between Propex

Pixi and Root ZX Mini in ability to locate the apical and middle root perforations. Taking into consideration the perforation diameters, both EALs could locate apical perforation sides, whereas neither could determine the middle perforation areas.

Table 1: Electronic length measurements to the perforation side and mean difference between EL and AL with standard deviations for electronic apex locators in apical and middle perforation areas

		Propex Pixi	Root ZX Mini
EL to perforation side (mm)	**Apical root perforation**	**(EAL_{P-AP})** 16.88±1.81	**(EAL_{R-AP})** 16.78±1.94
	Middle root perforation	**(EAL_{P-MP})** 13.69±2.12	**(EAL_{R-MP})** 14.00±2.26
Mean difference	**Apical root perforation**	1.38±1.51	1.28±1.59
	Middle root perforation	2.28±3.36	2.59±3.48

Table 2: Mean difference between EL and AL according to two-way ANOVA

Mean difference	Type III Sum of Squares	df	Mean Square	F	P
Intercept	20.54	1	6.85	0.97	0.412
Apical/middle	19.69	1	19.69	2.79	0.100
Material	0.19	1	0.19	0.03	0.870
Apical/middle * Material	0.66	1	0.66	0.09	0.761

Discussion

Root canal treatment should be limited to the root canal system [14]. For this purpose, radiography has been the most commonly used method to determine the root canal anatomy. However, radiography has several limitations, such as provision of only two-dimensional images [5], radiation exposure [15], and inconsistent outcomes due to variations in readings by the practitioner [16]. Root perforations on the buccolingual aspect are difficult to diagnose with radiographic methods [6,7]. EALs represent a valuable alternative to radiographs. These devices have been used not only to locate the apical constriction, but also to identify anomalies, perforations, and immature apices [17,18]. The efficacy of EALs for locating root perforations has been examined in several studies, and different results have been reported [19-24]. In the present study, the accuracy of Propex Pixi and Root ZX Mini for different level root perforations was evaluated.

Perforation of the middle third of the root canal can occur during root canal preparation, and specifically during root canal entrance preparation. Perforation areas of various diameters (0.3, 0.4, 0.7, 1 mm) have been used in previous studies [19-21]. D'Assunção et al. evaluated the ability of Mini Apex Locator, Root SW, Root ZX II to locate 1-mm root canal perforations and concluded that all EALs provide excellent ex vivo accuracy [22]. On the other hand, other investigators reported that EAL accuracy decreased with foramen sizes of 0.8 mm [23] and 0.9 mm [24]. Taneja et al. reported that for sizes beyond 1.3 mm, Root ZX Mini was less accurate in detecting the perforation side [18]. This finding was consistent with an in vitro study by Ebrahim et al. [25]. Akisue et al. evaluated the accuracy of different EALs on enlarged apical foramina up to 0.72 mm in size, and reported that the accuracy of Propex II decreased with increasing foramen size [21]. In our study, low accuracy was observed in both the Propex Pixi and Root ZX mini groups for middle perforations 1.5 mm in size. However, both EALs showed higher accuracy for locating apical perforations. One reasonable explanation for this result is the selection of the file best adapted to the anatomy of the root canals.

Larger defects on the root surface may occur as a result of resorption, use of larger files, operator error, or use of metal posts. Such errors could create larger perforation diameters. Therefore, perforations with a diameter of 1.5 mm were created in this study to emulate these situations, consistent with Altunbaş et al. [26]. In the present study, neither EAL could locate the 1.5-mm diameter middle perforation side. One reason for the lower accuracy of these EALs in the present study may have been the difficulty in determining the narrowest part of the artificial perforation, especially for the middle perforations. Therefore, further studies of different perforation diameters and multirooted teeth should be performed in future.

Agar-agar, alginate, and saline have been used as electroconductive materials in previous *in vitro* apex locator studies [17,22,26]. However, as an embedding medium, alginate was shown to have greater accuracy than the other media [27,28]. In the present study, alginate was used because of its good electroconductive properties, stability, and ease of preparation [29].

According to the Propex Pixi instructions, root canals should be neither very dry nor wet to ensure accurate results (http://dentsplymea.com/sites/default/files/DFU%20(English).pdf). According to the Root ZX mini instructions, the presence or absence of blood, electrolytes, saline, hydrogen peroxide, or other types of discharge has little effect of the measurements obtained using this EAL [30]. To maintain standardization, the access cavity was dried with cotton pellets to prevent current leakage in both experimental groups. The root canals were then irrigated with 2.5% NaOCl and dried with only two paper points. Thus, the root canals were kept moist.

In the present study, mandibular premolar teeth were used. The canal anatomies were verified with buccolingual and mesiodistal radiography before inclusion in the study. Mancini et al. showed that EALs provide more accurate data on bicuspids than molar or anterior teeth [31].

CONCLUSION

Under the conditions used in this study, it was concluded that both EALscould locate apical root perforations. However, this would not be possible for middle root perforations 1.5 mm in diameter. Further studies with different perforation diameters should be performed in future.

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