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Effect of different irrigating solutions on electronic working length determination of root canals: An *in vitro* study

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Abstract

Aim: To evaluate the accuracy of three apex locators using four different irrigant solutions for determining the working length of root canals.

Material and methods: Thirty single rooted teeth were used. Teeth were randomly divided into three groups, in order to establish the working length, using different apex locators: Root ZX mini, Propex Pixi and Ipex Four different irrigant solutions were used combined with the apex locators: saline solution (0.9% sodium chloride), 40% citric acid, 17% EDTA and 5.25% NaOCL. Actual working length (AWL) was determined using a #15 K-file in each specimen until the end of the file was visualized in stereoscopic microscopy. Scores (%) were attributed to each difference found between the working length gave by the apex locators and the AWL.

Results: There was a significant difference between the RWL and that one found with the apex locators Propex Pixi and Ipex; however, Root ZX mini did not show statistical differences. The four different irrigant solutions did not show statistically differences between then.

Conclusions: The precision to estimate the working length with Ipex and Propex Pixi was affected by the different irrigant solutions in the root canal. Root ZX mini was the most accurate apex locator to estimate the AWL.

Keywords: Working length determination, root canal irrigants, apex locators

Introduction

The root canal working length is the distance between a coronal reference point and an apical level, in order to obtain the instrumentation and obturation limit ^[1]. This accurate measurement of working length is one of the main factors in endodontic treatment success ^[2]. Determination of accurate working length is critical to cleaning, shaping and obturation of radicular canals and has to be carefully measured ^[3]. The use of electronic devices to determine the working length was first proposed by Custer (1918) ^[4], and the scientific basis of apex locators originated with the investigation by Suzuki, in 1942, that studied the current flow across the teeth of dogs. Consistent values in the electrical resistance between an instrument in a root canal and an electrode in the membrane of the oral mucosa was recorded, and may speculated that this would serve as a measure of the canal length ^[5]. Sunada (1962) was the first to describe the details of a simple clinical device for measuring the working length in patients. Since then, electronic apical locators have become an invaluable tool in the practice of modern endodontics ^[6]. The use of irrigant solutions is an important step in endodontic treatment, once these products are fundamentally used to clean and disinfected the root canal ^[7]. However, these solutions may affect the performance accuracy of apex locators. ^[8]. evaluated three apex locators (Root ZX, Propex and Neoson EZ) and three irrigant solutions (0.9% NaCl, 3% H₂O₂, 2.5% NaOCl and 17% EDTA), and found decreased accuracy of Root ZX and Propex, due to the higher amount of electrolytes; being Neoson EZ the most accurate apex locator. ^[9]. Ozsezer analyzed PROPEX after pulpal excision with three irrigants: 2.5% NaOCl, 0.9% NaCl and 0.2% chlorhexidine gel, demonstrating that the highest discrepancies occurred with 0.9% NaCl, and the lowest with 0.2% chlorhexidine gel. Therefore, the objective of this study is to evaluate the performance of three apex locators using four irrigant solutions to determine the working length of root canals.

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Materials and method

Thirty human premolars were obtained extracted due to orthodontic or periodontal reasons, with the inclusion criteria: only one root canal, absence of restoration, caries, root cracks, posts or crowns, absence of severe root curvatures, and exclusion criteria: fractured roots, internal or external absorptions, opened apex, calcified roots or previous endodontic treatments.

Specimen teeth preparation: Radiographs were performed in mesiodistal and buccolingual views from all teeth using a custom made jig. The specimens were planned with a cylindrical diamond bur (Mani) in order to obtain a reference point for all the evaluations. The endodontic access was conducted with a high speed spherical diamond bur (Mani). The cervical portion was enlarged with Gates-Glidden burs # 1, 2 and 3 (Dentsply Maillefer, Ballaigues, Switzerland). The roots were irrigated with 10 ml of saline solution and dried with absorbent papers. After these previous procedures, teeth were randomly divided in three groups, in order to stabilize the working length, using different apex locators: Root ZX mini(J Morita Japan), Proper Pixi (Dentsply Maillefer, Ballaigues, Switzerland), Ipex (NSK, Tochigi, Japan).To evaluate the working length, an electronic circuit was made with alginate (Jeltrate, Dentsply Maillefer, Ballaigues, Switzerland). The alginate was dispensed in a polymeric matrix, where the specimen was positioned before the alginate

gelification. Four different irrigant solutions were used combined with the apex locators: saline solution (0.9% sodium chloride Schwitz Biotech Ahmadabad India), 40.0% citric acid, EDTA (17% Ethylenediamine tetra-acetic acid, Ultradent, South Jourdan, UT, USA) and 4% sodium hypochlorite (Pravest India). Between measurements, the canals were irrigated with 2 mL of saline solution and dried with paper points before application of the next irrigant, to remove the previous irrigant completely [10, 11]. After the working length mensuration with the apex locators, the real working length (AWL) was determined using a # 15 K-file (Dentsply Maillefer, Ballaigues, Switzerland) in each specimen until the end of the file was visualized in stereoscopic microscopy (Global, USA). This length was adjusted with a silicon endo stop; the distance between the silicon stop until the end of the file was calculated with a digital calibrator (Stainless Hardened, China). This procedure was repeated three times, and an arithmetic mean was made, determining the AWL.

Statistical Analysis

Scores (in%) were attributed to each difference found between the working length gave by the apex locators and the AWL. D'Agostino normality test was applied for the data, and t-paired test was used to analyze statistical differences between the AWL and the WL determined by the apex locators, for each experimental group.

Table 1: Differences distribution (in %) between the working length determined by the apex locators and AWL, according to the irrigant solutions used.

Ipex				Root Zx Mini								Propex Pixi								P Value				
Saline		Edta		Citric Acid		Naocl		Saline		Edta		Citric Acid		Naocl		Saline		Edta			Citric Acid		Naocl	
n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	
-	-	-	-	1	3.3	-	-	1	3.3	-	-	-	-	1	3.3	-	-	-	-	-	-	-	-	<.1
-	-	1	3.3	-	-	1	3.3	2	6.6	1	3.3	3	10	3	10	1	3.3	-	-	1	3.3	2	6.6	1.0a-.51
4.0	13.3	2	6.6	2	6.6	2	6.6	7	23.3	9	30	6	20	6	20	6	20	7	23	3	10	7	23	0.5a-0.0
12	40	14	46.6	11	36	11	36	11	36	12	40	11	36	8	26.6	8	26	10	33	13	40	8	26	0.01a0.5
9	30	6	20	9	30	8	26	6	20	4	13.3	7	23	11	36	11	36	6	20	8	26.6	9	28	0.51a1.0
5	16.6	7	23	7	23	8	26	3	10	4	13.3	3	10	3	10	3	10	7	23	5	16.6	4	13	>1.1

Results

The score distribution showed high differences (between 0.01 and 05) in all groups (Table 1). For the apex locators Ipex and Propex Pixi, the percentages were higher than 1.1, being statistically different from Root ZX mini (between 0.51 and 1). The apex locators Ipex and Propex Pixi demonstrated significant differences between the working length and the AWL. Ipex showed significant differences (p<0.001) between the irrigant solutions (saline solution: 0.5080 ± 0.4608, EDTA: 0.5243 ± 0.5124, Citric acid: 0.5483 ± 0.5400,

Sodium hypochlorite: 0.5750 ± 0.5319). For Propex Pixi, differences were also demonstrated (p<0.001) (saline solution: 0.4300 ± 0.5326, EDTA: 0.4257 ± 0.5788, Citric acid: 0.5063 ± 0.5771, Sodium hypochlorite: 0.3570 ± 1.168). Root ZX mini was the only apex locator which did not showed significant differences (p=0.282) between the irrigant solutions (saline solution: 0.1973 ± 0.5774, EDTA: 0.2820 ± 0.5055, Citric acid: 0.2927 ± 0.5957, sodium Hypochlorite: 0.1960 ± 0.7573). These differences are demonstrated in Table 2.

Table 2: Mean and standard deviations of difference in measured and AWL among various irrigants.

	Saline	Naocl	Edta	Citric Acid
IPEX	0.508+-0.4608	0.575+-0.531	0.524+-0.512	0.548+-0.540
ROOT ZX MINI	0.1973+-0.577	0.196+-0.757	0.282+-0.505	0.292+-0.596
PROPEX PIXI	0.4300+-0.532	0.357+-1.16	0.426+-0.5788	0.506+-0.577

Discussion

The initial generation of apex locators was based on resistance, differently from the current impedance technology [12]. Main disadvantage of these devices was poor accuracy in the presence of fluids or blood [13]. The third generation was developed by frequency-base, which showed better precision to estimate the working length, compared to second generation impedance-based apex locators [14]. Recent meta-

analysis evaluated the precision of apex locators in determining the AWL. The authors concluded that the device used and the type of irrigation influenced the results [15]. In order to verify the precision of three apex locators, this study showed that the performance of Root ZX mini apex locator was not influenced by the irrigant solutions to determine the working length. Similar results were found in the literature [10, 11]. The accuracy of Propex Pixi and Ipex was influenced by

the use of the four irrigant solutions. [8]. Fan found that accuracy of Root ZX and Propex was decreased, as glass tubules were full of electrolytes. The main reason for the different results may be the parallel glass tubules used, without tapered or constriction, as teeth [8]. In natural anatomy of a permanent tooth, the tubule walls are thicker along its length, and electric properties of glasses are different from human dentine. Also, Ozsezer *et al.* [9] concluded that Propex was more accurate when the root canal was full of Chlorhexidine, compared to NaOCl solution. This discrepancy may be attributed to the product concentration (0.2% rather than 2%); the 2% concentration used in this study is commonly cited in the literature as an effective irrigant solution [7]. The results of this work found there is a significant difference between the AWL and that one found with the apex locators Ipex and Propex Pixi. Even when compared with conventional radiographs [16, 17]. Demonstrated that Propex Pixi showed an accuracy of 86.7%. In this study, the authors measured the distance from the file tip until the major foramen under stereomicroscopy. Other study showed that Propex Pixi was affected by 2.5% sodium hypochlorite (NaOCl), 0.9% saline solution (NaCl), and 17% EDTA. The authors concluded that better results could be found in dry canals. Root ZX mini was the only apex locator that did not show differences with the 4 irrigant solutions. This fact may be due to Root ZX mini locator reached the apical foramen and the operator should move back 0.5 mm, according to the manufacturer's instructions, which ensures more security to determine the working length. As other authors reported, the operator should retrograde 0.5 to 1 mm from the indicated position by the apex locators, in order to establish the correct working length [18-20]. The measurements made with Root ZX mini showed that this device gives 100% of accuracy (± 0.5 mm until the apex foramen), which may be considered an acceptable range [14]. Also, when the canals were irrigated with 4% sodium hypochlorite, there was a slight difference compared to the other irrigant solutions, maybe because sodium hypochlorite has higher conductivity. These differences were not statistically significant, as the 0.5 mm range was clinically acceptable.

Conclusions

The precision to estimate the working length with Ipex and Propex Pixi was affected by the different irrigant solutions in the root canal; Root ZX mini was the most accurate apex locator to estimate the AWL.

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