A comparison between the Raypex5 apex locator and conventional radiography for determining working length of straight and curved canals

Shiva Sadeghi [1]* DDS, MS and Masoomeh Abolghasemi [2] DDS
1. Assistant Professor of Endodontics, Dental School, Guilan University of Medical Sciences, Rasht, Iran.
2. Private practice

Abstract

Introduction: The purpose of this *in vitro* study was to compare the accuracy of the new electronic apex locator Raypex5 with radiography for working length determination of straight and curved root canals.

Materials and Methods: Twenty straight and single canals of maxillary central teeth and twenty curved mesiobuccal canals of mandibular molar teeth were used. Access cavities were prepared and working lengths were determined by means of Raypex5 and conventional radiography then compared with actual working lengths (AWL). Data were analyzed by ANOVA with repeated measurements and Least Significant Difference (LSD) test.

Results: There was no significant difference between electronic and actual working length determination for straight canals ($p=0.74$). For curved canals the difference between electronic and actual working length was significant ($p<0.0001$). There was a significant difference between radiographic and actual working length determination either for straight and curved canals ($p=0.024$, $p<0.0001$). The difference between radiographic and electronic working length determination was also significant for straight canals ($p=0.006$). The percentage of electronic measurements within ±0.5 of AWL was 70% for straight canals and 35% for curved root canals. The percentage of radiographic measurements within ± 0.5 of AWL was 50% for straight canals and 25% for curved root canals.

Conclusion: Raypex 5 is an apex locator that measured the tooth length within a clinically acceptable range especially in anterior straight canals.

Keywords: Apex locator, Conventional radiography, Raypex5, Working length.

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*Correspondence: Dr. Shiva Sadeghi, Department of Endodontics, Dental School, Guilan University of Medical Science, Opp. Pardis Hotel, Rasht, Iran. E-mail: sadeghi_dds@yahoo.com

Introduction

The significance of precise working length (WL) estimation for a successful endodontic treatment is well recognized (1-4).

Traditionally, the generally accepted method for root canal length determination is the radiographic interpretation of an instrument placed in the canal. However, radiographs are subjected to distortion and magnification and are technique sensitive in both their exposure and interpretation (5). Furthermore, a radiograph provides a two-dimensional image of a three-dimensional structure which lacks of a real representation (6). Taking radiographs is sometimes problematic in non-cooperative patients, patients with severe gagging reflex as well as pregnant females. Valuable chair side time is lost while waiting for the radiograph to be developed.

Electronic methods for working length determination have gained increasing popularity in recent years. Many studies on electronic apex locators (EALs) using the third generation report accuracy rates of 85-95% (7-11). Moreover, it has been reported that radiographic methods for working length determination might be less accurate than the electronic methods (5). A literature search failed to reveal any studies that directly compared the accuracy of electronic apex

locators in determining working length of straight and curved root canals.
Recently, a new apex locator, Raypex5 (VDW, Munich, Germany) has been introduced. The manufacturer claims that this apex locator may be regarded as the fourth generation of EALs. Similar to the third generation of EALs, these devices use two separate frequencies, 400 Hz and 8 KHz, produced by a variable frequency generator. Unlike the later devices, the fourth generation devices use only one frequency at a time. According to apex locator Raypex5 user manual, based on the proven technology of the fourth generation device Raypex4, this new apex locator presents additional features for optimal performance during root canal treatment. Raypex5 has a unique ergonomic design featuring a hinged front panel with large color graphic display, black light illumination and increased measurement precision (12).
The purpose of this *in vitro* study was to compare the accuracy of the new electronic apex locator Raypex5 with radiography for working length determination of straight and curved root canals.

Materials and Methods

Twenty straight and single canals of maxillary central teeth and twenty curved mesiobuccal canals of mandibular molar teeth were used. Roots with resorption, fractures, open apices or radiographically invisible canals were excluded from the study. Canal patency was evaluated using a #10 K-file (Mani, Japan). The size of root canal at the apical foramen was determined using the largest instrument fitting at this level. Maxillary central teeth with apical terminus size 30- 35 file and mesiobuccal canals of mandibular teeth with apical terminus size 15-20 file and Schneider angle 25-35 degree were chosen (13). The cusps were flattened to establish a level surface to serve as a stable and reproducible reference for all measurements. Standard access cavities were prepared. Pulp chambers and canals were cleansed by irrigating with 5 mL of normal saline.
The actual working length (AWL) was measured by inserting a # 10 K-file until the file tip was just visible at the level of the apical foramen. After adjusting silicone stopper to the coronal reference, the file was removed from the canal and its length was measured under 3x magnifications using a digital caliper to the nearest 0.01 mm. According to Kuttler`s study, 0.5 mm was subtracted from this length and the new length was considered as the actual working length (14).
The freshly extracted human teeth were prepared for electronic working length (EWL) measurements by socking in normal saline for 15 min. Teeth were embedded in an alginate model specially developed to demonstrate electronic working length measurement (15). Next to the tooth a metal rod was also inserted to be attached with the lip clip of the Raypex5. All measurements were made within 2 h of the model being prepared in order to ensure the alginate was kept sufficiently humid (6). A size 15 K-file (Mani, Japan) connected to the EAL was used in all cases. At first, canals were irrigated using normal saline and a blunt needle placed as deep as possible without obstructing the canal. The pulp chamber was then gently dried with a cotton pellet.
Using the Raypex5 according to the manufacturer's instruction, the file was advanced within the root canal to just region of the apical constriction, as indicated by the linear high resolution scale of the APEX ZOOM with its 3 green segments.
The silicone stop was then adjusted and the distance from the base of the silicone stop to the file tip was measured with a digital caliper to the nearest 0.01 mm.
After electronic tooth length measurement, the file was left in the root canal and a periapical radiograph was taken. While the teeth were in up-right position in alginate model, a film was aligned so that the long axis of the root canal was parallel to the surface of the film and the x-ray tube, and thus the central x-ray beam was perpendicular to the root canal. Radiographs of each tooth were exposed using E-speed film (Kodak, Rochester, NY, USA) and a dental X-ray machine (Planmeca, Finland). The X-ray machine was set at 65 kV and 7.5 mA, and the films were exposed 0.5 s for the single-rooted teeth and 0.65 s for multirooted teeth with a source-object distance of 8 cm and film-object distance of 5 mm. The films were uniformly developed manually for 20 s, fixed for 60 s, and washed under running water for 10 min. The

Table 1- Mean differences between EWL and RWL compared to AWL (mm*)

Group	Straight canals	Curved canals
Raypex 5 (EWL) n=20	-0.042 (0.85) **	- 0.626 (0.78)
Radiographic (RWL) n=20	-0.62 (1.32)	- 0.889(1.07)
P value	0.006	0.229

**Negative value indicates measurements short of the actual working length (AWL) **Mean (standard deviation)*

radiographs were viewed using a standard viewing box and a prism magnifier with a 3.6 x magnification (Zeiss, Aalen, Germany) and the radiographic working length (RWL) was measured.

Finally, collected data was analyzed by ANOVA with repeated measurements and Least Significant Difference (LSD) test at a significant level of $P<0.05$.

Results

The mean and standard deviation of the difference between actual working length and the values obtained with electronic apex locator and radiography are illustrated in Table-1. The corresponding percentage values of electronic and radiographic canal measurements are presented in Table-2.

There was no significant difference between electronic and actual working length determination for straight canals ($p=0.74$). For curved canals the difference between electronic and actual working length was significant ($p<0.0001$). There was a significant difference between radiographic and actual working length determination either for straight and curved canals ($p=0.024$, $p<0.0001$). The difference between radiographic and electronic working length determination was also significant for straight canals ($p=0.006$).

Table-2 shows that the percentage of electronic measurements within ± 0.5 of AWL was 70% for straight canals and 35% for curved root canals. The percentage of radiographic measurements within ± 0.5 of AWL was 50% for straight canals and 25% for curved root canals.

Discussion

All known factors that influence the accuracy of the apex locators were kept constant in the present study. Electronic apex locators were frequently used with a small size 15 stainless-steel endodontic hand file and numerous apex locator studies have used this file for testing purposes without considering the apical terminus size of the canals. In the present study a size 15 K-file connected to the EAL was used in all cases. As electronic working length determination was influenced by the size of the canal at the apical terminus (8, 16, 17), maxillary central teeth with apical terminus size 30- 35 file and mesiobuccal canals of mandibular teeth with apical terminus size 15-20 file and Schneider angle 25-35 degree were chosen to control this parameter.

Table 2- Frequency of radiographic (RWL) and electronic (EWL) working length measurements

Distance from actual length (mm)*	Straight canals		Curved canals	
	EWL	RWL	EWL	RWL
>1	0 (0)**	1 (5)	0 (0)	0 (0)
01.0 to 0.5	2 (10)	0 (0)	0 (0)	2 (10)
0.5 to 0.01	9 (45)	2 (10)	5 (25)	1 (5)
0	0 (0)	0 (0)	0 (0)	0 (0)
-0.5 to -0.01	5 (25)	8 (40)	3 (15)	3 (15)
-1 to -0.5	3 (15)	3 (15)	7 (35)	5 (25)
<-1	1 (5)	6 (30)	5 (25)	9 (45)

** Negative value indicates measurements short of the actual working length (AWL)*
*** Number (percent)*

Alginate model and extracted human teeth were used to demonstrate electronic working length measurement because it is simple, inexpensive, and stable for hours and the root apices can not be seen. The relative stiffness of the alginate mould prevented fluid movement inside the canal that is responsible of premature electronic readings registered with previous models (18, 19).

Normal saline was used as the root canal irrigant and electrical conductive media because previous studies showed that in the presence of EDTA and saline measurements were closer to the actual length (7).

The ± 0.5 mm to the foramen range has been considered as the strictest acceptable range (18, 20). Thus measurements attained within this tolerance are considered highly accurate. On the other hand, root canals do not always end with an apical constriction, a clear minor and major diameter or an apical foramen at the

exact base of the cemental cone. This is why some authors prefer the ±1 mm range as the acceptable range (21, 22).

According to the result of this study, the percentage of electronic measurements within ± 0.5 of AWL was 70% for straight canals and 35% for curved root canals. This was almost in accordance with Wrbas *et al.*, who reported accuracy rate of 80% for determining WL in anterior teeth by means of Raypex5 (11). However, the accuracy of the device was decreased in curved posterior teeth, probably as a result of anatomical difference between straight anterior and curved posterior teeth. The curved canals had less taper and smaller apical terminus which could affect the EWL measurements.

The result of this in vitro study needs to be verified in an in vivo study. Clinically, a higher variation of measurements is expected because in contrast to in vitro studies favorable circumstances for precise measurements are not available.

Conclusion

Under the conditions of this *in vitro* study it was concluded that Raypex5 registered measurements more accurately in straight canal.

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