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Measurement of the Root Canal Length by Endometers ES-02 and ES-03

Silvana Juki• Krmek (1), Dragana Mihaljevi• (2), Paris Simeon (1), Zoran Karlovi•(1)

1 - Department of Endodontics and Restorative Dentistry, School of Dental Medicine, University of Zagreb, Gunduli•eva 5, Zagreb, Croatia

2 - Student of 5th year study School of Dental Medicine University of Zagreb

Address for correspondence:
Silvana Juki• Krmek
Department of Endodontics and Restorative Dentistry,
School of Dental Medicine, University of Zagreb,
Gunduli•eva 5
HR-10 000 Zagreb, Croatia
Tel:01 4802 126
Fax: 01 4802 159
E-mail: jukic@sfzg.hr

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Abstract

The aim of this study was to compare the accuracy of measurements of endometers ES-02 and ES-03 in dry canals and canals filled with sodium-hypochlorite and ethylenediaminetetraacetic acid (EDTA). For the experiment 31 one-rooted human extracted teeth were used. Working length of the root canal was determined visually using a #15 reamer as a control measurement. After that the teeth were embedded in vial with freshly mixed alginate and the measurements were made with both devices. Two measurements were made in dry canal and canal filled with sodium-hypochlorite and EDTA for each device. The first value was the working length determined according to the sign -1,0 on the scale and display, respectively, which corresponds to the apical constriction. The second value was measured according to the sign 0,0 which corresponds to the external foramen. Results were analyzed statistically by MANOVA test, and as post-hoc test Student-t test was used. The measurements same as control were in 65% for ES-02 device, and 61%, for ES-03 device at point -1,0 in dry canal, although the difference was not statistically significant. Fluids in root canal statistically significant negatively influence on accuracy of measurements but that significance was 10 times greater at point of measurement -1,0 than at 0,0.

Key Words: Root Canal Preparation, Tooth Apex, Root Canal Therapy, Sodium Hypoclorite, Chelating Agents

Article Outline

Introduction

Determination of root canal length is a very important part of endodontic treatment that strongly influences its final result. Root canal length traditionally was determined by: 1) knowledge about anatomy of the tooth and root canal, and average values of root canal length for each type of the tooth; 2) tactile sensation; 3) moisture on the tip of the paper point and; 4) radiographic method (1).

It was on the radiographs that the point at which the instrumentation and root canal filling should terminate was determined. However, a radiograph provides a two-dimensional image of a three-dimensional structure, so this technique of interpretation of position of the apical foramen is less sensitive (1). Dense bone structure and superimposition of anatomical features such as zygomatic arch could obscure the position of the apical foramen (2). Frequently, the radiological foramen does not coincide with anatomical termination of the canal (3), and the apposition of the secondary dentin and cementum contributes to the false determination of the root canal ending point (4). Tactile-sensory method has a lot of limitation, starting with anatomical variety of the apical constriction to different approach of the sensation interpretation on the apical constriction by various clinicians. Seidberg et al. (5) found the accuracy of this method to be around 60%, even for experienced clinicians.

Development of the electronic apex locators made the endodontic treatment faster, safer and more accurate. Electronic apex locator (endometer) is the device for determination of the root canal working length during endodontic therapy with three parts: 1) labial electrode, 2) electrode attached to the endodontic file in the root canal, 3) the device itself with display that shows the movement of the file to the apical foramen.

Endometer works on the base of the electrical conductivity of the tissue. Electrodes attached to the oral mucosa and endodontic file should establish the electric cycle. When the file reaches the apical foramen region, the device gives some kind of signal, mostly the audio. The accuracy of these devices is the highest in the area of 0,5 mm from the apex (6).

Custer first investigated electronic method of the root canal measurement in 1918, followed by Suzuki in 1942, who studied the flow of direct current through the tooth. He registrated the values of the electrical resistance between the endodontic instrument in the root canal and electrode on oral mucosa, supposing this could be used for the possible root canal length measurement. Sunada (7) constructed a simple device using these principles for the root canal length measurement, based on the current resistance of the mucosa membranes and periodontal ligament which is constant and 6,0 kΩ (7). Direct current caused instability of the measurement because of the polarization of the endodontic instrument.

Development of the apex locators goes through few generations, by improving their characteristics. There are two major groups of studies that investigate accuracy of the apex locators: in vitro and in vivo. Investigations in vivo include cementation of the endodontic instrument inside the root canal at the measured point. After tooth extraction, the position of the instrument tip is examined. These studies stimulate clinical conditions (1,8,9). If the extraction is not possible, the position of the instrument tip could be determined on radiographs. This method introduces the problems associated with radiographic working length assessment (10). Studies in vitro use the electro conductive materials to simulate clinical conditions. Investigations revealed that materials such as alginate, gel, agar and saline solutions are appropriate media for apex locator studies. Some of these media could leak through the apical foramen into the canal and cause premature readings. It seems that some in vitro investigations give more accurate results than clinical investigations (1). The aim of this study was to compare the accuracy of ES-02 and ES-03 endometers for the root canal measurement in dry canals and canals filled with sodium hypochlorite and ethilenediaminotetraacetic acid.

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Materials and methods

The endometers ES-02 (Artronic, Zagreb, Croatia) and ES-03 (Artronic, Zagreb, Croatia) were used in this investigation.

For the experiment 31 were used extracted human one-rooted teeth, without visible radicular resorption and fracture. The teeth were stored in formalin solution since the extraction. The crowns were removed by diamond disc with water-cooling, disclosing orifices of the canals. After that the teeth were stored in saline solution. To check the patency, the file #10 (Maillefer, Ballaigues, Switzerland) was inserted in the root canal. As control, the root canal length was first determined visually by endodontic file #15 (Maillefer, Ballaigues, Switzerland), rubber stopper and endodontic ruler. After that the roots and labial electrode of endometer were inserted in the freshly mixed alginate (VivaINF, Ivoclar Vivadent, Shaan, Liechtenstein) (figure 1). The measurements were carried out for both devices on each sample in dry canal, canal filled with sodium hypochlorite (NaOCl) and chelator, ethilenediaminotetraacetic acid – EDTA (Calcinase, Lege artis, Dettenhausen, Germany). First measurement was performed according to the sign -1,0 on the scale or display of endometers as the point of the apical constriction, e.g. foramen internum. The second measurement point was 0,0 on the device scale or display as the outer orifice of the canal. During the measurement the audio signal confirmed the position of the instrument tip in the apical region. The measurements were performed successively with different devices. If the measurement was longer than control the difference was signed as positive, and if it was shorter the difference was signed as negative. The results were statistically analyzed by MANOVA test. As post-hoc test Student-t test was used.

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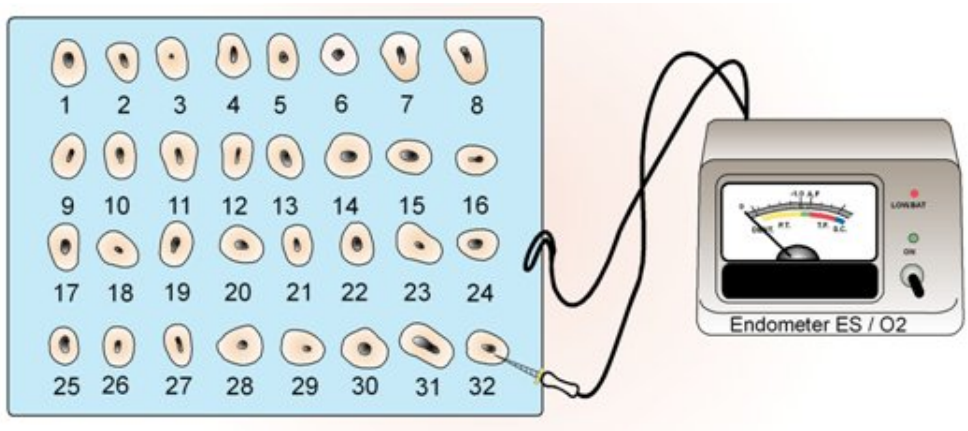

Figure 1. Schematic of the root canal measurement

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Results

The differences between visual measurements and these with apex locators are shown in tables 1 and 2. The most accurate measurements were at the point -1,0 from apex in dry canal. The endometer ES-02 was accurate in 65%, and ES-03 in 61% canals under these conditions, although the difference between devices was not statistically significant. The moisture in canal significantly influence the accuracy of measurement at the point -1,0 and ES-02 showed the highest number of accurate results (27 % in the canal filled with NaOCl and 10% in canals with EDTA). But if the point of measurement was 0,0 the accuracy of reading was lower for the dry canal (55% for ES-02 and 45% for ES-03), but the influence of fluids in canal on accuracy is also lower. The difference in measurement of canals filled with EDTA is ten times lower if the ending point was 0,0 with smaller distribution of the results. The readings longer than control were in higher percentage if the measurement point was 0,0 in dry and moisture canals, differently from the -1,0 reading point where the longer reading was noticed only in dry canals. There is no statistically significant difference between endometers in dry canals at both measurement points, in contrast to canals filled with NaOCl and EDTA. This is depicted in table 3.

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Table 1. Distribution of frequency of differences in measurement between direct measurement according to the visual method and electronic measurements by endometers ES-02 and ES-03 in dry canal and canal filled by sodium hypochlorite and chelator at measurement point -1,0 from outer canal orifice.

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	Difference in measurement (mm)	ES-02						ES-03					
		Dry canal		Canal filled with		Canal filled with chelator		Dry canal		Canal filled with		Canal filled with chelator	
		n	%	n	%	n	%	n	%	n	%	n	%
1.	(+) 0,0-0,5	9	**29**					3	**10**				
2.	0,0	20	**65**	8	**27**	3	**10**	19	**61**	1	**3**	1	**3**
3.	(-) 0,1-0,5	1	**3**	7	**22**	11	**36**	6	**20**	7	**23**	1	**3**
4.	(-) 0,6-1,0	1	**3**	9	**29**	4	**13**	2	**6**	6	**20**	4	**13**
5.	(-) 1,1-1,5			5	**16**	3	**10**	1	**3**	4	**13**	1	**3**
6.	(-) 1,6-2,0			1	**3**					1	**3**	2	**6**
7.	(-) 2,1-2,5			1	**3**								
8.	(-) 2,6-3,0									4	**13**	2	**6**
9.	(-) 3,1-3,5					1	**3**					1	**3**
10.	(-) 3,5-4,0					2	**6**			2	**6**	1	**3**
11.	(-) 4,1-4,5					1	**3**					1	**3**
12.	(-) 4,6-5,0											1	**3**
13.	(-) 5,1-5,5											2	**6**
14.	(-) 5,6-6,0											2	**6**
15.	(-) 6,1-6,5					1	**3**					1	**3**
16.	(-) 6,6-7,0									1	**3**		
17.	(-) >7,0					5	**16**			5	**16**	19	**61**
Totat %			**100**		**100**		**100**				**100**		**100**

Legend: n – number of samples

Table 2. Distribution of frequency of differences in measurement between direct measurement according to the visual method and electronic measurements by endometers ES-02 and ES-03 in dry canal and canal filled by sodium hypochlorite and chelator at measurement point -0,0 from outer canal orifice.

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	Difference in measurement (mm)	ES-02						ES-03					
		Dry canal		Canal filled with		Canal filled with chelator		Dry canal		Canal filled with 1		Canal filled with chelator	
		n	%	n	%	n	%	n	%	n	%	n	%
1.	(+) 0,0-0,5	7	**26**	3	**10**	2	**6**	6	**19**	1	**3**	1	**3**
2.	0,0	17	**55**	13	**42**	10	**33**	14	**45**	13	**42**	8	**26**
3.	(-) 0,1-0,5	6	**19**	13	**42**	13	**42**	11	**36**	15	**49**	13	**42**
4.	(-) 0,6-1,0			2	**6**	3	**10**			1	**3**	6	**19**
5.	(-) 1,1-1,5					1	**3**						
6.	(-) 1,6-2,0									1	**3**		
7.	(-) 2,1-2,5												
8.	(-) 2,6-3,0												
9.	(-) 3,1-3,5												
10.	(-) 3,5-4,0												
11.	(-) 4,1-4,5												
12.	(-) 4,6-5,0					1	**3**						
13.	(-) 5,1-5,5												
14.	(-) 5,6-6,0												
15.	(-) 6,1-6,5												
16.	(-) 6,6-7,0												
17.	(-) >7,0					1	**3**					2	**6**
Total %			**100**		**100**		**100**		**100**		**100**		**100**

Legend: n – number of samples

Table 3. Student t-test for paired samples (p>0,05).

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	Mean	Stand. deviation	Stand. Error Mean	t	df	Sig. (2-tailed)
Pair 1 reamer - ES02 0,0 SK	-3,87E-02	,243	4,367E-02	-,886	30	*,382
Pair 2 reamer - ES02 0,0 HK	,203	,316	5,670E-02	3,584	30	,001
Pair 3 reamer - ES02 0,0 ED	,768	1,608	,289	2,658	30	,012
Pair 4 reamer - ES02 -1,0 SK	-7,74E-02	,265	4,768E-02	-1,624	30	*,115
Pair 5 reamer - ES02 -1,0HK	,726	,659	,118	6,134	30	,000
Pair 6 reamer - ES02 -1,0 ED	3,126	4,591	,825	3,791	30	,001
Pair 7 reamer - ES03 0,0 SK	5,806E-02	,246	4,418E-02	1,314	30	*,199
Pair 8 reamer - ES03 0,0 HK	,277	,404	7,254E-02	3,824	30	,001
Pair 9 reamer - ES03 0,0 ED	,660	1,614	,295	2,240	30	,033
Pair 10 reamer - ES03 -1,0 SK	,106	,360	6,458E-02	1,648	30	*,110
Pair 11 reamer- ES03 -1,0 HK	3,787	5,164	,928	4,083	30	,000
Pair 12 reamer - ES03 -1,0 ED	6,353	4,867	,889	7,150	29	,000

Legend:
* - statistically significant difference
SK – dry canal
HK – canal filled with sodium hyposhlorite
ED – canal filled with ethylenediaminotetraacetic acid

Discussion

Endometers ES-02 and ES-03 are based on the measuring of the distinct range of the impendence in root canal, using one frequency. ES-03 is new version and, according to the manufacturer, with improved measuring process (use of sinusoidal instead of right-angled voltage) and digital display.

The results of this investigation showed the differences in readings of root canal working length between devices. ES-02 showed the higher consistence with previously measured values in dry canal. The most manufacturers of the new apex locators claim that the fluids in canal do not influence on their accuracy (3,4), Haung (12) showed that two major factors determine the accuracy: fluids in the canal and diameter of the apical foramen. The smaller the apical diameter, the influence of the fluids of apex locators is diminished. Chelators are used in the narrow and mineralized canals, which decreases its influence on determination of the working length. The measurement in our study was performed with reamer #15, which means that the canal was wider. This could explain the failures in readings in moisture conditions. The measurements of both apex locators were more accurate if the end-point of the measurement was -1,0 from the outer orifice of the canal in dry canal, but the failures in wet canal are also more frequent. In the case when the outer orifice of the canal (0,0) was chosen as the end-point of measurement, the presence of fluids influence less on accuracy, but there were more measurements beyond apex. The most endometers are calibrated to show the value on scale or display -1,0 when the file tip is at apical constriction, which should be end-point of the canal instrumentation and filling, and it is confirmed by visual control method. This could explain more readings beyond apex at point 0,0. Decreased influence of fluids e.g. electrolytes at point 0,0 could be explained by predominance of periradicular tissue impedance over the conductivity of fluid. The outer orifice of the canal, i.e. the value displayed on the endometer, is more accurate measurement point than apical constriction if the working length assessment is carried out in canal filled with fluids.

Clinical examination was carried out only for ES-02 device (13), in contrast to ES-03 that is not clinically studied. The accuracy of working length assessment in clinical conditions was 92-98 % depending on diagnosis and treatment. The most accurate results were obtained when the mortal extirpation was performed. When the diagnosis was necrosis the results were less accurate, and the worst measurements were gained with vital extirpation (13). The advantage of clinical investigations compared to our in vitro is in dealing with different diagnosis and working conditions that are the same as every-day practice. Disadvantage is unsure method of determination of accurate measurement because of problems associated with radiographic interpretation (1,2,10). In clinical investigations accurate result is considered to be 1 – 1,5 mm from radiographic apex which does not necessarily coincide with apical constriction. Foramen internum, i.e. apical constriction could be situated 3 mm from outer orifice of the canal (14). Generally it is considered that the distance from the apical constriction to the outer orifice is 0,5 mm in younger persons, and 0,8 mm in adults. The distance from the apical constriction to the apex increases from front to posterior teeth with age. If these discrepancies of apical constriction position and range of clinically accurate working length assessment (till 3 mm from apex) are applied to this study, then both investigated apex locators are 100 % accurate in dry canal. Considering the manual manipulation with files during the measurement, the failures in reading of 0,5 mm are insignificant.

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Conclusions

The results of this study showed that the endometers ES-02 and ES-03 do not differ significantly in the working length measurements in dry canal. The results are statistically significant different if the measurement is performed in canal filled with NaOCl or EDTA, but that difference is lower if the end-point of assessment is outer orifice of the root canal.

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