DOI: 10.7860/JCDR/2017/31271.10745

Original Article

Dentistry Section

Clinical Evaluation of Effect of Instrument Size and Type on the Accuracy of Electronic Apex Locator on Upper Premolars

BASAWARAJ CHANNABASAPPA BIRADAR[1], SUDHARANI BASAWARAJ BIRADAR[2], SAI S KALYAN[3], RASHMIKUMAR B VORA[4], ARVIND MOHAN SUBRAMANI[5]

ABSTRACT

Introduction: Root canal treatment is a standard procedure for pulpal diseases and dental injuries. Working length determination is significantly important for successful outcome of root canal treatment.

Aim: The aim of this in vivo study was to evaluate the effect of instrument Size and Type on the accuracy of Electronic Apex Locator (EAL) on upper premolars.

Materials and Methods: One hundred and twenty root canals from 98 patients scheduled for endodontic treatment were included in this study and informed consent was obtained. Electronic measurements were made using Root ZX apex locator with stainless steel ISO k-file #8, #10, #15 and Nickel Titanium (NiTi) ISO k-file #8, #10, #15 in sequence and also radiographic length was measured. Statistical analysis was analysed with One-way ANOVA and Post-Hoc Tukey HSD tests.

Results: It was found that a highly significant difference was found between Ingle's method and apex locator measured with stainless steel and NiTi #8 files and significant difference with Ingle's method and apex locator measured with NiTi#10. There was no significant difference found between Ingle's method and apex locator measured with stainless steel and NiTi #15 files and stainless steel #10 file.

Conclusion: Stainless steel files showed more accurate results compared to their corresponding NiTi files. This study has concluded that the use of steel instruments whose size corresponds to master apical file brings the best results.

Keywords: Ingle's method, NiTi files, Stainless steel files, Working length

INTRODUCTION

Root canal treatment is a standard procedure for pulp disease and dental injuries. Working length determination is significantly important for successful outcome of root canal treatment. Root canal preparation and obturation should be performed till the apical constriction (minor apical diameter) which is located 0.5–1.0mm short of radiographic apex [1]. Instrumenting the canal short of working length results in residual (necrotic or vital) tissue in the root canal, incomplete root canal preparation and obturation, and formation of periapical lesions, post-treatment pain, and the spread of infection. An increase in working length may lead to injury to the apical periodontal tissues, excessive bleeding, mild to moderate pain, extended treatment period and a chances of over obturation [2,3]. Therefore, measurement of the root canal length plays an important role in endodontic treatment [4].

The root canal working length estimation is based on two methods: Radiographic and Endometric methods. The drawbacks of radiographic method include lack of possibility to reflect the actual length of the root, difficulty with setting the proper projection, two-dimensional image, necessity for exposure to radiation, and occurrence of interpretational differences [2]. The Endometric method determines the working length of the root canal with the use of electric devices, called as Electronic Apex Locators (EALs).

EALs are characterized by very low sensitivity to fluid, they allow recording measurements in the presence of remaining pulp and tissue fluid, and multiple repetitions of the examination can be done without any negative impact on the patient's health. Moreover, they locate the apical constriction which is the proper termination point for the root canal preparation and filling [4].

Root ZX was selected for this study as it is a useful, versatile, and accurate device for the determination of canal length [5]. The Root ZX (J. Morita Co. Kyoto, Japan), a third Generation Electronic Apex Locator that uses dual-frequency and comparative impedance principles was described by Kobayashi C and Suda H [6].

Recently, with advancement in the flexible files many clinicians are using stainless steel files along with nickel-titanium files for root canal treatment. Use of stainless steel and nickel-titanium files for determining working length with an apex locator seems clinically relevant.A literature review on this topic failed to reveal any in vivo study which had compared the influence of various sizes of stainless steel and nickel titanium files on the accuracy of apex locators [7]. The null hypothesis was adapted to this study.

The purpose of this clinical study was to evaluate the effect of instrument size and type on the accuracy of time tested Root ZX apex locator.

MATERIALS AND METHODS

An in vivo experimental study was conducted on 120 canals from 98 maxillary premolar teeth scheduled for endodontic treatment from July 2013 to June 2014. The study was performed in the Department of Conservative Dentistry and Endodontics, Rural Dental College, Loni, Maharashtra, India, after obtaining an institutional ethical clearance (Reg No. RDC/RC/2013/45). Sample size was calculated using Raosoft online sample size calculator [8]. The power of the study was set at 80%.

Two variables such as the type of metal and the apical size of the instruments were evaluated. Teeth with open apices, internal or external root resorption, severe curvatures, calcified canals (confirmed by using preoperative Radiovisiograph) and patients with heart pacemakers or had a contributory medical history were

excluded.

After detailed case history, patient was informed about the procedure and consent was taken. Teeth were isolated under rubber dam and standard access cavities were prepared. After checking the patency of the root canal with #10K file, the coronal portion of each canal was preflared using sequential Gates Glidden drills #4, #3, and #2 (Mani Inc. Japan) later the canal was irrigated with 10 ml 2.6% Sodium hypochlorite solution (Chen Chems, Chennai, India) and pulp extirpated with a barbed broach (Spirocolorinox, Dentsply). Working Length was estimated by using Root ZX apex locator as per manufacturer's instructions with stainless steel and NiTi #8, #10 and #15 ISO K files.

Electronic measurements were made (in sequence) until there were stable reading for at least five seconds and the values were recorded. The actual working length was established by Direct Digital Radiographic Method (Radiovisiography or RVG) for each canal which is 0.5 mm short of the radiographic apex by using Ingle's method and recorded separately [9].

STATISTICAL ANALYSIS

The results were analysed using one-way ANOVA and Post-hoc Tukey HSD tests. Significance was set at $p<0.05$. The analysis was carried out using Statistical Package for the Social Sciences (SPSS 16.0, SPSS Inc., Chicago, IL, USA).

RESULTS

[Table/Fig-1] shows mean and standard deviation of the various groups and [Table/Fig-2] show a highly significant difference between

Groups	Mean	Std. Deviation	N
Stainless steel #8	20.1167	± 1.49190	120
Stainless steel #10	20.7208	± 2.10721	120
Stainless steel #15	21.0625	± 1.48035	120
Ni-Ti #8	19.2583	± 2.18761	120
Ni-Ti #10	20.5000	± 1.56914	120
Ni-Ti #15	21.0125	± 1.48729	120
Ingle's method	21.0875	± 1.47195	120
Total	20.5369	± 1.81237	840

[Table/Fig-1]: Mean and Standard Deviation of the various groups.

VAR00001 (I)	VAR00001 (J)	Mean Difference (I-J)	Std. Error	Significant difference	95% Confidence Interval	
					Lower Bound	Upper Bound
Stainless steel #8	Stainless steel #10	-0.6042	0.22084	0.091	-1.2569	0.0485
	Stainless steel #15	-0.9458*	0.22084	0.01	-1.5985	-0.2931
	Ni-Ti #8	0.8583*	0.22084	0.002	0.2056	1.5110
	Ni-Ti #10	-0.3833	0.22084	0.592	-1.0360	0.2694
	Ni-Ti #15	-0.8958*	0.22084	<.001	-1.5485	-0.2431
	Ingle's method	-0.9708*	0.22084	<.001	-1.6235	-0.3181
Stainless steel #10	Stainless steel #8	0.6042	0.22084	0.091	-0.0485	1.2569
	Stainless steel #15	-0.3417	0.22084	0.716	-0.9944	0.3110
	Ni-Ti #8	1.4625*	0.22084	0.000	0.8098	2.1152
	Ni-Ti #10	0.2208	0.22084	0.954	-0.4319	0.8735
	Ni-Ti #15	-0.2917	0.22084	0.842	-0.9444	0.3610
	Ingle's method	-0.3667	0.22084	0.643	-1.0194	0.2860
Stainless steel #15	Stainless steel #8	0.9458*	0.22084	<.001	0.2931	1.5985
	Stainless steel #10	0.3417	0.22084	0.716	-0.3110	0.9944
	Ni-Ti #8	1.8042*	0.22084	<.001	1.1515	2.4569
	Ni-Ti #10	0.5625	0.22084	0.144	-0.0902	1.2152
	Ni-Ti #15	0.0500	0.22084	1.000	-0.6027	0.7027
	Ingle's method	-0.0250	0.22084	1.000	-0.6777	0.6277
Ni-Ti #8	Stainless steel #8	-0.8583*	0.22084	0.002	-1.5110	-0.2056
	Stainless steel #10	-1.4625*	0.22084	<.001	-2.1152	-0.8098
	Stainless steel #15	-1.8042*	0.22084	<.001	-2.4569	-1.1515
	Ni-Ti #10	-1.2417*	0.22084	<.001	-1.8944	-0.5890
	Ni-Ti #15	-1.7542*	0.22084	<.001	-2.4069	-1.1015
	Ingle's method	-1.8292*	0.22084	<.001	-2.4819	-1.1765
Ni-Ti #10	Stainless steel #8	0.3833	0.22084	0.592	-0.2694	1.0360
	Stainless steel #10	-0.2208	0.22084	0.954	-0.8735	0.4319
	Stainless steel #15	-0.5625	0.22084	0.144	-1.2152	0.0902
	Ni-Ti #8	1.2417*	0.22084	<.001	0.5890	1.8944
	Ni-Ti #15	-0.5125	0.22084	0.235	-1.1652	0.1402
	Ingle's method	-0.5875	0.22084	0.110	-1.2402	0.0652
Ni-Ti #15	Stainless steel #8	0.8958*	0.22084	0.001	0.2431	1.5485
	Stainless steel #10	0.2917	0.22084	0.842	-0.3610	0.9444
	Stainless steel #15	-0.0500	0.22084	1.000	-0.7027	0.6027
	Ni-Ti #8	1.7542*	0.22084	<.001	1.1015	2.4069
	Ni-Ti #10	0.5125	0.22084	0.235	-0.1402	1.1652
	Ingle's method	-0.0750	0.22084	1.000	-0.7277	0.5777
Ingle's method	Stainless steel #8	0.9708*	0.22084	<.001	0.3181	1.6235
	Stainless steel #10	0.3667	0.22084	0.643	-0.2860	1.0194
	Stainless steel #15	0.0250	0.22084	1.000	-0.6277	0.6777
	Ni-Ti #8	1.8292*	0.22084	<.001	1.1765	2.4819
	Ni-Ti #10	0.5875	0.22084	0.110	-0.0652	1.2402
	Ni-Ti #15	0.0750	0.22084	1.000	-0.5777	0.7277

[Table/Fig-2]: Intergroup comparison of the samples Using one-way ANOVA and Post-Hoc Tukey HSD test.
* The mean difference is significant at the .05 level

Ingle's method and apex locator measured with stainless steel and NiTi #8 files and significant difference between Ingle's method and apex locator measured with NiTi#10 files (p <0.110).

There was no significant difference found between Ingle's method and apex locator measured with stainless steel and NiTi #15 files and stainless steel #10 file (p <0.643). Stainless steel files showed more accurate results compared to their corresponding NiTi files. In intergroup comparison #15 files showed more accurate length and #8 files showed least accurate length in both stainless steel and NiTi file system.

DISCUSSION

The accuracy of the measurements performed with the use of electrical methods depends on several factors including the type and size of the root canal instrument used for taking the measurement, the shape of the root canal, the diameter of the apical foramen and the type of irrigation solution [10]. Many authors report that the width of the apical foramen and the type of endodontic instrument determine the obtained result. Ebrahim's study showed that, the working length with the smaller size files determined shorter working length when root canal diameter was increased [11]. Herrera M et al., also did not find any significant influence of the width of the apical opening which was above 0.2mm on the accuracy of determination of the working length [12].

The size of the foramen, surface of contact of the active electrode with the walls and enlargement of the apical foramen diameter can contribute to the errors in determining working length [13].

Maxillary premolars were selected for this study as Root ZX located the minor apical diameter more correctly in anterior and premolar teeth than molar teeth [14].

The type of instrument and the material it is made of may also have an influence on the accuracy of the measurements. Various instruments were used in endodontic treatment which is made of stainless steel (73% iron, 9% nickel, and 18% chromium), carbon steel, chromium and nickel alloys and nickel titanium (54% nickel and 46% titanium) alloys. In the present study, stainless steel files showed more accurate result than NiTi files. Reason for this might be NiTi files effect voltage gradient of apex locator more compared to stainless steel files [15]. Nekoofar MH et al., evaluated the accuracy of Neosono Ultima EZ apex locator using nickel-titanium and stainless steel files. The accuracy of the nickel-titanium and stainless steel was 94% and 91%, respectively, and there was no statistically significant difference [16]. In this study, In comparison to the steel instruments, NiTi instruments showed more deviation in the working length determination this may be due to increased flexibility of NiTi instruments [4]. So, our null hypothesis was rejected.

The Root ZX and Foramatron D10 showed significantly better scores than the Apex NRG and Apit 7, and may be reliable to determine the working length of teeth with a wide apical foramen if a tight-fit file is used [17]. McDonald NJ recommended the use of files with sizes comparable with the root canal diameter, claiming that this would result in more accurate readings. The length of the enlarged canals was measured using small-sized files and large size files matching the canal diameter. They found that the Root ZX was accurate even when the file was much smaller than the diameter of the canal and the measured lengths obtained with small and large size files were comparable [18]. The results of the present study showed significant differences when smaller NiTi and Stainless steel files (ISO no. #8 NiTi and Stainless steel files, ISO no. #10 NiTi files) were used. The ISO no.15 NiTi and Stainless steel files were more reliable in estimating the working length.

Further, the canals were initially preflared to improve the accuracy of determining working length by increasing the Canal patency and decreasing the accumulation of dentin debris. These factors may disrupt the electrical resistance between the inside of the canal and the periodontal ligament leading to inconsistent EAL readings. Constant recapitulation was also performed as it ensures accurate electronic length readings during instrumentation [19].

LIMITATION

The limitation of the study were the inabilty to include different groups of teeth and failing to evaluate the effect of the various test variables in different root canal enviroments. Further studies are required to evaluate the effect of instrument size and type on the accuracy of EAL on various groups of teeth and in different root canal environments.

CONCLUSION

Under the limitations of this invivo study, stainless steel and NiTi instruments with apical size similar to diameter of apical constriction yielded the best results. Stainless steel files yielded better results when compared to NiTi files. The knowledge of these factors may help in correct determination of the working length which facilitate proper root canal treatment; prevent complications, and help to obtain satisfactory results.

ACKNOWLEDGEMENTS

We acknowledge Rural Dental College, Loni and Pravara Institute of Medical science providing the material used for conducting this study.

REFERENCES

[1] Marroquin BB, El-Sayed MA, Willershausen-Zönnchen B. Morphology of the physiological foramen: I. Maxillary and mandibular molars. J Endod. 2014;30:321-28.
[2] Raghu KN, Daniel JG, Razvi S, Vinaychandra R, Kini A, Nandakishore KJ. In vivo evaluation of the accuracy of working length determination using an electronic apex locater IPEX (NSK) on vital uninfected teeth and teeth with radiographic evidence of periapical lesions. J IntSoc Prev Community Dent. 2014;4:S204-08.
[3] Santhosh L, Raiththa P, Aswathanarayana S, Panchajanya S, Reddy JT, Susheela SR. Influence of root canal curvature on the accuracy of an electronic apex locator: An in vitro study. J Conserv Dent. 2014;17:583-86.
[4] Janeczek M, Kosior P, Piesiak-Pańczyszyn D, Dudek K, Chrószcz A, Czajczyńska-Waszkiewicz A, et al. The effect of file size and type and irrigation solutions on the accuracy of electronic apex locators: an in vitro study on canine teeth. Biomed Res Int. 2016;2016:8594087.
[5] Jenkins JA, Walker WA 3rd, Schindler WG, Flores CM. An in vitro evaluation of the accuracy of the root ZX in the presence of various irrigants. J Endod. 2001;27(3):209-11.
[6] Kobayashi C, Suda H. New electronic canal measuring device based on the ratio method. J Endod. 1994;20:111-14.
[7] Thomas AS, Hartwell GR, Moon PC. The accuracy of the Root ZX electronic apex locator using stainless-steel and nickel-titanium files. J Endod. 2003;29:662-63.
[8] Raosoft sample size calculator [Online].; 2004 acessed on 2013 june 13. Available from: www.raosoft.com/samplesize.html.
[9] Ingle JI, Bakland LK. Endodontics, 5th ed. Elsevier: Canada; 2002.
[10] Marroquin BB, Frajlich S, Goldberg F, Willershausen B. Influence of instrument size on the accuracy of different apex locators: an in vitro study. J Endod. 2008;34:698-702.
[11] Ebrahim AK, Yoshioka T, Kobayashi C, Suda H. The effects of file size, sodium hypochlorite and blood on the accuracy of Root ZX apex locator in enlarged root canals: an in vitro study. Aust Dent J. 2006;51:153-57.
[12] Herrera M, Abalos C, Planas AJ, Llamas R. Influence of apical constriction diameter on root ZX Apex locator precision. J Endod. 2007;33:995-98.
[13] Aydin U, Karatasliogluu E, Aksoy F, Yildirim C. In vitro evaluation of Root ZX and Raypex 6 in teeth with different apical diameters. J Conserv Dent. 2015;18:66-69.
[14] Vieyra JP, Acosta J, Mondaca JM. Comparison of working length determination with radiographs and two electronic apex locators. Int Endod J. 2010;43(1):16-20.

[15] Ushiyama J, Nakamura M, Nakamura Y. A Clinical Evaluation of the Voltage Gradient Method of Measuring the Root Canal Length. J Endod. 1988;14:283-7.
[16] Nekoofar MH, Sadeghi K, SadighiAkha E, Namazikhah MS. The accuracy of the NeosonoUltima EZ apex locator using files of different alloys: an in vitro study. J Calif Dent Assoc. 2002;30:681-84.
[17] Ebrahim AK, Wadachi R, Suda H. Ex vivo evaluation of the ability of four different electronic apex locators to determine the working length in teeth with various foramen diameters. Aust Dent J. 2006;51:258-62.
[18] McDonald NJ. The electronic determination of working length. Dent Clin North Am. 1992;36(2):293-307.
[19] Rivera EM, Seraji MK. Effect of recapitulation on accuracy of electronically determined canal length. Oral Surg Oral Med Oral Pathol. 1993;76:225-30.

PARTICULARS OF CONTRIBUTORS:
1. Reader, Department of Conservative Dentistry and Endodontics, Rural Dental College, Loni, Rahata, Maharashtra, India.
2. Senior Lecturer, Department of Oral Medicine and Radiology, Rural Dental College, Loni, Maharashtra, India.
3. Reader, Department of Conservative Dentistry and Endodontics, Rural Dental College, Loni, Maharashtra, India.
4. Professor and Head, Department of Conservative Dentistry and Endodontics, Rural Dental College, Loni, Maharashtra, India.
5. Professor, Department of Conservative Dentistry and Endodontics, RKDF Dental College, Bhopal, India.

NAME, ADDRESS, E-MAIL ID OF THE CORRESPONDING AUTHOR:
Dr. Basawaraj Channabasappa Biradar,
525/3/25, PMT Loni, Tal. Rahata, Ahmadnagar Dist, Loni-413736, Maharashtra, India.
E-mail: dr.basawaraj@rediffmail.com

FINANCIAL OR OTHER COMPETING INTERESTS: None.

Date of Submission: **Jul 01, 2017**
Date of Peer Review: **Aug 12, 2017**
Date of Acceptance: **Oct 03, 2017**
Date of Publishing: **Nov 01, 2017**