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REVIEW ARTICLE

A COMPARATIVE ASSESSMENT OF THE ACCURACY OF ELECTRONIC APEX LOCATOR (ROOT ZX II) IN THE PRESENCE OF DIFFERENT IRRIGATING SOLUTIONS-AN IN VITRO STUDY

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ABSTRACT

This study was aimed for determining the working length of the tooth in the presence of various commonly used irrigating solutions in the endodontics. Three irrigating solutions were taken namely - 3% sodium hypochlorite (NaOCl),2% chlorhexidine and Glyde (EDTA + Carbamide peroxide).a total of 90 teeth were selected which were divided into 3 equal groups according to the irrigating solutions. Then working lengths were obtained with the help of ROOT ZX II for the respective groups and were compared with the actual lengths. Statistical analysis were done and it was observed that there was significant difference between the groups and within the measurements of sodium hypochlorite group (Group I)

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INTRODUCTION

An accurate and a reproducible working length is an important factor in root canal treatment. It establishes the apical limit of the canal preparation and demarcates the creation of an apical stop. It enables debridement of the root canal to be performed without over instrumentation, trauma to the periapical tissues or destruction of the apical anatomy. It also establishes the apical limit for obturation. The success rate of conventional root canal treatment has been correlated with the length of the final root canal filling (Ricucci, 1998). Working length is defined as the distance from the coronal reference point to the point at which canal preparation and obturation should terminate. The apical foramen is normally present at the anatomic apex but sometimes it deviates from the anatomic apex and may end short of it (Kuttler, 1955). Transition between the pulpal tissue and periodontal ligament occurs in the cementodentinal junction region, which has been considered as a histological landmark and sometimes has no definitive location in the root (Nguyen *et al.,* 1996)

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For long it was considered that the CDJ and minor foramen are the same, but later on studies revealed that they are not always present at the same point.[1,2] The apical constriction or minor diameter is widely considered to be the ideal anatomic limit for root canal instrumentation and obturation (Ricucci, 1988; Kuttler, 1955; Dummer *et al.,* 1984). The apical constriction can be located 0.524 mm-0.659 mm coronal to the apical foramen and the apical foramen can exit as much as 1.93 mm from the root apex of the tooth (Kuttler, 1955). There are various methods of determining the working length. The use of a diagnostic file and conventional radiography remains the most common method, but there are major disadvantages like the production of two-dimensional images, high radiation exposure and a cumbersome technique in developing the films with this method. Also, as a curved canal is prepared, the working length changes so we have to do a number of radiographs and as the angulation of the X-Ray tube is changed, the relative position of the file in relation to radiographic apex changes. Moreover, paralleling technique was found to be accurate only 82% of the time (ElAyouti *et al.,* 2002). Efforts have been made to improve the technique to locate the apical constriction and to determine working length without the need to irradiate the patient and to get a near accurate working length through newer methods, one of which

is the electronic apex locators (EALs). First generation EAL were developed by Sunada in 1961, which were resistance based. It was found that electrical resistance between periodontium and mucous membrane was 6.5k ohms.[7] These generation devices were rather inaccurate which lead to development of second generation EAL, which were single frequency, alternating current based (Inoue 1973). The major disadvantage with this generation of EALs is related to the fact that they need to be recalibrated before every use and canals need to be reasonably free of electrically conductive material in order to achieve an accurate reading. These shortcomings lead to the development of the next generation apex locator. In 1991, Kobayashi et al. reported on the ratio method for measuring the root canal length. These are multiple frequency based apex locators which do not require any calibration and can be used in the wet canals. In particular, the Endex, Root ZX, Dentaport ZX/Root ZX II, Tri auto ZX come under this category. All apex locators function by using the human body to complete an electrical circuit. One side of the apex locator's circuitry is connected to an endodontic instrument. The other side is connected to the patient's body, either by a contact to the patient's lip or by an electrode held in the patient's hand. The electrical circuit is complete when the endodontic instrument is advanced apically inside the root canal until it touches periodontal tissue. The display on the apex locator indicates that the apical area has been reached. ROOT ZX II (J. Morita Mfg Corp., Kyoto, Japan) is based on the work of Kobayashi and Suda (Sunada, 1962). It requires no calibration and has the ability to work accurately in dry and wet canals. Sodium hypochlorite (NaOCl) and chlorhexidine (CHX) are extensively used in endodontics for the purpose of irrigation during root canal treatment. These irrigants have proved to be efficient in canal disinfection and debridement, therefore it was decided to use these two irrigants to check their effect on the working length measured by EAL. Third material used in this study was Glyde (EDTA and Carbamide peroxide). It is a common practice to use EDTA as a lubricant for establishing a glide path and also to decrease the chances of file breakage. Also, many manufacturers recommend the use of lubricant like Glyde with the rotary files to reduce the chance of file breakage. The main aim of this study was to test the accuracy of ROOT ZX II (J. Morita Mfg Corp., Kyoto, Japan),in the presence of different irrigating solutions namely sodium hypochlorite (NaOCl 3%), chlorhexidine (2%) and Glyde (EDTA + Carbamide peroxide).

MATERIALS AND METHODS

Ninety non-carious human maxillary central and lateral incisors extracted for periodontal reasons were collected from the department of Oral and Maxillofacial Surgery, Government Dental College and Hospital, Patiala, based on the following Inclusion and Exclusion criteria.

Inclusion Criteria

- Non-carious maxillary central and lateral incisors.
- Teeth with completely formed apices.
- Teeth with Weine's Type I canal configuration (confirmed radiographically)

Exclusion Criteria

- Incompletely formed apex
- Dilacerated root
- Pulpal calcification
- Resorption
- Open Apices
- Canals not visible Radiographically

All teeth were soaked in 3% sodium hypochlorite (Septodont) solution for 24 hours. After thorough cleaning teeth were stored in normal saline till they were used further. The 90 selected teeth were decoronated at the cementoenamel junction using a diamond disc (DFS Germany) to provide a stable reference point for all measurements. The coronal portion of each canal was preflared using sequential Gates Glidden drills #2, #3, and #4 (Mani Inc., Japan), irrigated with saline followed by pulp extirpation with a barbed broach (Mani Inc., Japan).

The teeth were randomly divided into 3 groups with following irrigants in each group:

Group I- 3% sodium hypochlorite (NaOCl).
Group II-2% chlorhexidine.
Group III- Glyde (EDTA + Carbamide peroxide).

Measurement of actual canal length (AL)

A total of 90 teeth were selected and the actual canal length (AL) was determined by introducing a number 15 K-Flexofile (Maillefer, Switzerland) into the canal until its tip was seen emerging through the major apical foramen when viewed with the help of a Dental operating microscope (Global Surgical^{tm}) with 3.5x magnification. Most coronal point of the major foramen was selected as the reference and after carefully adjusting the silicone stopper to the incisal reference point, the file was withdrawn from the root canal, and the distance between the file tip and silicone stopper was measured with a digital calliper and the reading was noted down. 0.5 mm was reduced from this reading to get actual working length. The measurements were repeated three times and the mean was taken as the definite length.

Working model for electronic working length determination

To simulate the periodontium, this study used the in vitromodel (Huang, 1987). Polystyrene bottles (20ml) were used for fixing the teeth. Bottles were filled with alginate (Septodont) and the root of the corresponding teeth was embedded in it.Canals were filled with irrigants according to the group divison as mentioned earlier. The cervical one-third of the root was exposed for stabilizing the teeth to the lid of the container with auto-polymerizing resin. The lip electrode was attached to one side of the bottle with the alginate in it. All the readings were taken within two hours of pouring alginate to avoid drying of the alginate.

Electronic working length determination-

The EAL tested in this study was Root ZX II (J. Morita Mfg. Corp., Kyoto, Japan). It was used according to manufacturer's instructions. A number 15 K-Flexofile (Maillefer Switzerland) was attached to the file holder and introduced into the canal, while the lip electrode was embedded on one side of the bottle to complete the circuit. The file was inserted slightly beyond the "APEX" signal and then withdrawn to the limit indicated by the EAL as corresponding to 0.5 mark. The silicone stopper

on the file was then carefully adjusted to this reference point, and the file was withdrawn from the canal to measure the distance between the silicone stopper and the file tip and the reading was noted down. This was recorded as the electronically measured working length (EL). All the electronic measurements were performed three times and mean was calculated. The difference between the mean of electronically measured working length (EL) and the actual working length (AL) was calculated for each tooth. The resulting difference in canal length was noted down. The obtained readings were statistically analyzed.

various methods for determining working length, but none of these are ideal so as to be considered as the perfect method. Each method has got its own advantages and disadvantages. The radiographic method is the most common method of measuring working length in root canal therapy. This procedure has the advantage of being a simple method but also has certain disadvantages like more radiation exposure, time consuming and in most cases the minor constriction does not coincide with the point 1mm short from the radiographic apex. Also, it is only able to give a two-dimensional image and simply provides reliable, but not absolutely accurate, information on the location of the radiographic apex (Kuttler, 1955).

Table 1. Showing the means (in mm) of actual lengths and electronic lengths and their differences in all the groups

Irrigants/Groups	Actual Length(AL) Mean	Electronic Length(EL) Mean	Difference AL-EL
NaOCl/ Group I	13.3617	13.0027	.35900
CHX/ Group II	13.0433	12.9735	.06983
GLYDE/ Group III	13.4213	13.3647	.05667

Table 2. Table showing the paired t-test

Paired Samples Test									
Irrigants/ Groups		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
NaOCl/ Group I	AL - EL	.35900	.38107	.06957	.21671	.50129	5.160	29	<.001**
CHX/ Group II	AL- EL	.06983	.19358	.03534	-.00245	.14212	1.976	29	.058
GLYDE/ Group III	AL- EL	.05667	.17517	.03198	-.00874	.12208	1.772	29	.087

Table 3. Showing intergroup comparison Post Hoc test

Multiple Comparisons Dependent Variable: Difference Bonferroni Method						
(I) Irrigants/ Groups	(J) Irrigants/ Groups	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
NaOCl/ Group I	CHX/Group II	.28917(*)	.06886	<.001**	.1211	.4573
	GLYDE/ Group III	.30233(*)	.06886	<.001**	.1342	.4704
CHX/Group II	NaOCl/ Group I	-.28917(*)	.06886	<.001**	-.4573	-.1211
	GLYDE/ Group III	.01317	.06886	1.000	-.1549	.1813
GLYDE/ Group III	NaOCl/ Group I	-.30233(*)	.06886	<.001**	-.4704	-.1342
	CHX/Group II	-.01317	.06886	1.000	-.1813	.1549
* The mean difference is significant at the .05 level.						

RESULTS

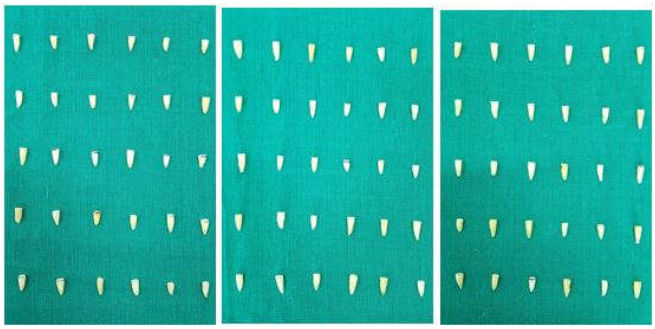
Statistical analysis was performed on the collected data. Analysis of variance test (ANOVA) was applied to compare the difference of working lengths within the groups and in between the groups. The Paired t-test was performed to check the intra group differences in all the groups (Table 2). Post hoc test was used for inter group comparison (Table 3). A p value of <0.05 was considered to indicate statistical significance. The mean difference in the actual lengths and electronic lengths are given in Table 1. Mean value of difference for group I is 0.35900, for group II it is 0.06983 and for group III it is 0.05667.Results showed a highly significant difference between the groups and the difference was also statistically significant within the group I.

DISCUSSION

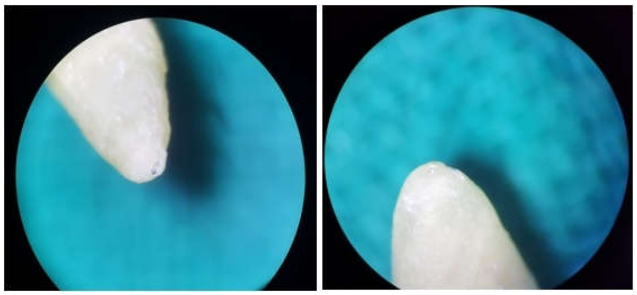
Correct working length determination is one of the most vital steps in endodontic therapy, which ensures thorough cleaning, shaping and obturation. One of the main concerns in root canal treatment is to determine how far the working instrument should be advanced within the root canal and at what point the preparation and obturation should be terminated. There are

It has been seen that radiographic determination of working length can lead to overestimation in as much as 50% of cases (ElAyouti *et al.,* 2002). In recent years, electrical devices have been developed for determining the length of the root canal. This breakthrough has brought electronic science into the traditionally empirical endodontic practice. Here, the working length is determined by comparing the electrical resistance of the periodontal ligament with that of the gingiva surrounding the tooth, both of which are similar (Tosun *et al.,* 2008). This helps to reduce the treatment time and the radiation dose. Most electronic measuring devices are based on the theory of Sunada (1958). Root ZX II/Dentaport ZX was used in this study because it has been proven to be a very accurate apex locator in various studies (Ricucci, 1998; Nguyen *et al.,* 196; Fouad and Reid, 2000; Garcia-Hererth *et al.,* 2015; Ounsi and Naaman, 1999; Silva and Alves, 2014; Ustun *et al.,* 2013). Various in vivo and in vitro studies carried out on the Root ZX II show better accuracy than most of the other EALs available in the market at present (Nguyen *et al., 1996;* Fouad and Reid, 2000; Sindreu *et al.,* 2012). The use of in vitro models in this study for the evaluation of EALs can be justified by the study conducted by Huang (Huang, 1987), who suggested that the electronic measurement of the root canal using EALs could be explained by the physical principles of electricity. The

phenomenon of a constant value for electrical resistance between the oral mucous membrane and the periodontium is not the result of the biological charge characteristics of the tissue but is caused by constant surface contact between the electrode and the oral tissues. Moreover he also proved that the results obtained with a non conducting natural tube were similar to those obtained with a tooth.



Photograph 1. Samples Prepared For Length Measurement



Photograph 2. File emerging from apical foramen (actual length)

Photograph 3. Electronic measurement of the prepared sample

This shows that the phenomenon associated with the electronic measurement of the root canal is a physical process and has nothing to do with biological characteristics (Huang,. 1987). From the statistical analysis it was seen that difference between actual length and electronic length was highly significant in group I (NaOCl) while in other two groups it was not statistically significant. Also the difference between group I and group II, group I and group III was statistically significant**.** These results showed that when sodium hypochlorite was used as an irrigant in the canals, readings shown by Root ZX II apex locator were shorter than the actual length. In case of Chlorhexidine and Glyde the difference was insignificant.

This could be attributed to

- High electro conductivity of sodium hypochlorite which can lead to decrease in the electric impedance of the canal which leads to alteration in the electric current flow.
- Sodium hypochlorite (NaOCl) ionizes in the water to sodium (Na^+ and Hypochlorite ion (OCl^-) which exist in equilibrium with Hypochlorous acid (HOCl). Presence of these ions could alter the current flow in the canal leading to inaccurate readings.

The results of this study concur with the study conducted by Jain and Kapur (2012) which showed that on comparison of NaOCl, chlorhexidine and normal saline, maximum deviation of results occur when NaOCl was used as an irrigant. The results of the present study were also in accordance with study conducted by Khattak *et al.,* (2014) who compared the actual length and electronic length in the presence of chlorhexidine, sodium hypochlorite and normal saline and found that there was high statistical difference between actual length and electronic length in the presence of NaOCl.

Conclusion

It can therefore be concluded that electronic apex locator can be used effectively and accurately to determine the working lengths in majority of cases. It can also be said that Root ZX II can be used clinically for the working length determination where radiographs cannot provide the accurate results, especially in cases of maxillary molars where zygomatic arch and maxillary sinus may produce hindrance in the radiographic measurements. The results of this study showed that Glyde and chlorhexidine showed better results when compared to sodium hypochlorite when used as an irrigant for determining the accuracy of Root ZX II/ Dentaport ZX. However this being an in vitro study, it did not completely simulate the oral environment. The oral conditions like remaining tooth structure, old restorations, salivary contamination etc. may affect the working of electronic apex locator.

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