Original Research Article

Comparative analysis of two electronic apex locators in working length determination using stainless steel and nickel titanium hand files in permanent teeth with simulated apical root resorption - An in vitro study

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Abstract

Background: Exact estimation of root canal length is imperative for the achievement of root canal treatment. Working length (WL) has been defined as ‘‘the distance from a coronal reference point to the point at which canal preparation and obturation should terminate’’.

Aim: The aim of this study was to evaluate and compare the accuracy of two generations of apex locators in teeth with simulated apical root resorption using stainless steel and nickel titanium hand files.

Materials and methods: Eighty single-rooted, maxillary anterior teeth were selected. The extracted teeth were soaked in 5% sodium hypochlorite for 6 hours and then in sterile 0.9% saline until use. An oblique cut of 45 degree was made from facial to palatal wall. Access cavities were prepared and the

Visual Working Length (VWL) was measured. The samples were then embedded in alginate and the electronic measurements were recorded using stainless steel and nickel titanium hand files. Statistical analysis was done by Analysis of variance (ANOVA) followed by Tukey HSD test were used for statistical analysis.

Results: There was no statistically significant difference seen with DentaPort ZX and i-Root along with the use of stainless steel and NiTi hand files.

Conclusion: In the present study, DentaPort ZX and i-Root apex locators showed similar efficacy in determining working length with the use of both stainless steel and NiTi hand files under present study conditions.

Key words

Apex locator, Apical resorption, DentaPort ZX, i-Root, NiTi hand files, Stainless steel hand files, Working length.

Key Message

An astute clinician should be able to determine correct working length in challenging case of root resorption. This study showed that the recent generations of apex locators can be reliably used with concomitant use of both stainless steel and nickel titanium hand files in recording accurate working length in cases of root resorptions.

Introduction

Exact estimation of root canal length is imperative for the achievement of root canal treatment. Working length (WL) has been defined as ‘‘the distance from a coronal reference point to the point at which canal preparation and obturation should terminate’’ [1].

Correlation amongst radiography and electronic estimations demonstrates apex locators to be more precise and reliable by gauging the length of the root canal to the end of the apical constriction and not to the radiographic apex [2]. Suzuki’s [3] discovery that electrical resistances between the periodontal ligament and oral mucosa registered constant values of 6.5 kΩ led to the development of the first EAL by Sunada [4]. Today, various generations of EALs are available, with each generation guaranteeing to be better than the previous one.

DentaPort ZX (J. Morita Mfg. Corp., Kyoto, Japan), is a third generation apex locator, which use the ratio method by calculatting of a quotient that expresses the position of the file tip in the canal. i-Root (S-Denti, Seoul, Korea) is a fifth generation EAL which uses multiple frequencies for detection of the apical constriction [5].

Both stainless-steel and nickel-titanium hand files are utilized reciprocally amid endodontic treatment. Given the boundless utilization of nickel-titanium files, an examination of the accuracy in determining WL with an apex locator using stainless-steel and nickel-titanium hand files appears to be clinically pertinent.

It has been concurrently established that the accuracy of all EALs is influenced by the diameter of the apical foramen [6]. However, there is very little literature available on the impact of apical resorption on the efficiency of EALs in permanent teeth. Hence, the aim of this study was to evaluate the accuracy of two different generations of EAL’s using stainless steel and NiTi hand files in teeth with simulated apical root resorption. The first null hypothesis tested was that there is no difference in recording working length with both EAL’s. The second null hypothesis tested was that there is no difference in recording the working length with EAL’s using stainless steel and NiTi hand files.

Materials and methods

This study was approved by the Dental Ethics Committee (EA/203/2017), KSA. Eighty single-rooted, human maxillary incisors were selected for this study. The extracted teeth were carefully examined under ×5 magnifications using a magnifying glass. The teeth were cleaned of calculus, soft tissues and debris with hand instruments and soaked in 5% sodium hypochlorite (NaOCl) for 6 hours to remove the periodontal ligament followed by storage in sterile 0.9% saline until used. Inclusion criteria comprised single-rooted tooth with single canal and completely formed apex and tooth devoid of any pre-existing restoration, caries, or morphologic defect. Tooth with incompletely formed apex or open apex or those with root resorption/ cracks were excluded from the study.

Conventional access cavity was prepared (Endo Access Kit, Dentsply, USA) and to provide a flat stable reference point, the occlusal surface was ground with diamond discs (Mani, Inc.). After the identification of the root canal orifice, the canals were cleansed of debris by irrigating with 5 ml of 5% NaOCl using a 27 gauge needle. The canal patency was evaluated using a size 10 K-file (Mani, Inc.). Pulp tissues were extirpated using barbed broach and a final irrigation was done with 5 ml of 5% NaOCl.

Silicon square cube mould of 20 mm was filled with alginate. The teeth were embedded up to the CEJ and the lip clip was also placed in alginate mould. When the alginate was partially set, the tooth was removed and a 45° oblique cut was made at the apex with a disc (Dentorium, USA). The facial wall was kept greater than the palatal wall by 3mm. The tooth was then placed back in the alginate mould and stabilized. All the samples (n=80) were subjected to following five groups to measure the working length:

Group 1 - Control (VWL)
Group 2 - DentaPort ZX using stainless steel file
Group 3 - DentaPort ZX using NiTi file
Group 4 - i-Root using stainless steel file
Group 5 - i-Root using NiTi file

Visual working length (VWL) was measured for all the samples which acted as control (group 1) against which all other groups were compared. To obtain VWL, the silicon stopper of 15 K stainless steel file was placed at flat reference point and inserted into the canal until the file tip became visible palatally. The file was measured with endoblock millimetric ruler (Mani, Inc.) to the accuracy of 0.01 mm and from this length 0.5 mm was subtracted and recorded as VWL.

Both EAL readings were taken in accordance with the manufacturer. Here also, the silicone stopper of the inserted file was set at flat reference point and inserted into the canal. Each file was used for ten measurements only and discarded. Measurements were considered valid if the reading remained stable for at least 5 seconds and were repeated 3 times to calculate the mean for all the groups. The whole experiment was carried out by a single operator to eliminate any bias. All the measurements were recorded within 2 hours to maintain the moisture content of alginate. The recorded EAL values were compared with the VWL values. The results were tabulated and subjected to statistical analysis using ANOVA and Tukey HSD multiple comparison test using Statistical Package for Social Sciences software, 16.0 Version (SPSS, Chicago, Illinois, U.S.A.) with level of significance as 5%.

Results

ANOVA test was used to evaluate mean working length values of respective groups (**Table – 1**). Data with the control group did not prove to be significant for the mean EAL values. Intergroup comparison was done using Tukey HSD test. Group 1 showed the highest mean value and group 3 showed the lowest mean value. However, the results were statistically insignificant ($p>0.05$) (**Table 2**).

Discussion

The development and improvement of electronic devices for finding apical terminus have been a

significant advancement in root canal treatment. Latest generations of EAL's have upgraded precision, better patient acceptance and more user friendly [7, 8]. Despite having an accuracy of 80– 90% [9] the use of EALs can be restricted by numerous variables like presence or absence of apical constriction.

Table - 1: Mean (SD) values of VWL and length determined by apex locators with both types of hand files (n=80).

Group	Mean	Standard Deviation
1 (Control-VWL)	19.72	1.79
2 (DentaPort ZX using stainless steel file)	19.62	1.89
3 (DentaPort ZX using NiTi file)	19.37	1.61
4 (i-Root using stainless steel file)	19.54	1.77
5 (i-Root using NiTi file)	19.51	1.78

Table - 2: Intergroup comparison of both electronic apex locators using Tukey HSD multiple comparison test. (*P > 0.05- Not significant)

Groups		Mean difference	Statistical significance "p"
Group 1	Group 2	0.1019	0.996*
	Group 3	0.3475	0.727*
	Group 4	0.1756	0.971*
	Group 5	0.2131	0.941*
Group 2	Group 3	0.2456	0.905*
	Group 4	0.0738	0.999*
	Group 5	0.1112	0.995*
Group 3	Group 4	-0.1719	0.973*
	Group 5	-0.1344	0.989*
Group 4	Group 5	0.0375	1.000*

The exactness of all EALs is affected by the width of the apical foramen. However, there is very little literature on the effect of apical resorption on the effectiveness of EALs in permanent teeth. Hence, this prompted us to undertake this study.

Various generations of EALs, with enhanced functions and more noteworthy clinical applications, have entered the market over couple of decades. The most widely investigated, Root ZX, is considered as the gold standard against, which the new apex locators are being looked at. It has demonstrated high consistency even in the presence of different irrigants [10-12].

DentaPort ZX (J. Morita Mfg. Corp., Kyoto, Japan), works on the same principle as Root ZX and is showcased by the same company J. Morita, Japan. There is not much difference between DentaPort ZX and Root ZX mechanism, with the exception that DentaPort ZX has an accessible port for connection of endomotor [13]. It is a third-generation apex locator, which measures the impedance of 2 frequencies (0.4 and 8 kHz) simultaneously and calculates the quotient of the impedances. The calculated ratio is expressed as the position of the file inside the canal [14].

i-Root (S-Denti Co. Ltd Seoul, Korea) apex locator is a fifth-generation apex locator. It has distinctive frequencies of 5 KHz and 500 Hz. The manufacturer guarantees that its exactness is good even in presence of various canal contents [15].

In the present study, once the alginate achieved its initial setting time in the silicone mould, root resorption was mimicked by expelling the tooth from the mould and making an oblique 45° cut at the apex. This was done to firmly emulate apical resorption which does not happen in a solitary plane. The tooth was then replanted once again into the mould and settled as depicted by Saraswathi, et al. [16]. The actual canal length referred as visual working length (VWL-control) was determined by introducing a size 15 K stainless steel file into the canal up to the major foramen under magnification of ×5. Nguyen, et al. [17] detailed that the file size did not

influence the precision of EALs. So, the same file size was used in every case (No. 15 K-file) to have practically identical conditions for the in vitro measurements.

Alginate has been portrayed as the perfect embedding media since its moderately firm consistency prevents intrusion of material into the apical foramen and opposes forces applied by mechanical movement of the file, thus enabling the operator to precisely measure working length [18]. The fundamental drawback was in its constrained working time on the grounds that the alginate had a tendency to dessicate unless kept in a moist environment [19]. In our investigation, all estimations were made inside 2 hours of the model being set up with a specific end goal to guarantee that alginate was kept sufficiently humid as reported by Lucena-Martin, et al. [20] and D'Assuncao, et al. [21].

While advancing the file for electronic canal length measurement, the file was taken marginally past the apex as indicated by the apex locator and withdrew to a point where the EAL showed the file to lie 0.5 mm short of the apical foramen. This expanded the perusing precision of EAL's and guaranteed the operator of a patent canal [22, 23].

The first null hypothesis was accepted as there were no significant differences between the DentaPort ZX and i-Root in determining WL. Contradictory to the findings of our study, Saraswathi et al [16] found that EAL's were not 100% accurate in determining the working length in cases of apical resorption. This may be attributed to the different apexlocators used in their study. Also, there were no significant differences found between stainless steel and NiTi hand files. Therefore, the second null hypothesis was accepted. Our findings are in accordance with the findings of Thomas, et al. [24] who suggested that these files may be used without compromising the working length. Another study by Silva EJ, et al. [25] showed insignificant results using both stainless steel files and NiTi hand or rotary files to determine the working length using the Root ZX II.

The results of our study emphatically recommend that both DentaPort ZX and i-Root can be precisely utilized as a part WL determination in teeth with apical root resorption with the exchangeable utilization of both stainless steel and NiTi hand files.

Conclusion

Within the limitation of present study, it was concluded that Both DentaPort ZX and i-Root showed adequate accuracy in determining working length in teeth with simulated apical resorption. No significant differences were seen between the use of stainless steel and NiTi hand files in determining working length with both DentaPort ZX and i-Root.

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