Comparative evaluation of the accuracy of two electronic apex locators in determining the working length in teeth with simulated apical root resorption: An in vitro study

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Abstract

Introduction: Accurate determination of working length (WL) is a critical factor for endodontic success. This is commonly achieved using an apex locator which is influenced by the presence or absence of the apical constriction. Hence, this study was done to compare the accuracy of two generations of apex locators in teeth with simulated apical root resorption.

Materials and Methods: Forty maxillary central incisors were selected and after access preparation, were embedded in an alginate mold. On achieving partial set, teeth were removed, and a 45° oblique cut was made at the apex. The teeth were replanted and stabilized in the mold, and WL was determined using two generations of apex locators (Raypex 5 and Apex NRG XFR). Actual length of teeth (control) was determined by visual method.

Statistical Analysis: Results were subjected to statistical analysis using the paired t-test.

Results: Raypex 5 and Apex NRG was accurate for only 33.75% and 23.75% of samples, respectively. However, with ±0.5 mm acceptance limit, they showed an average accuracy of 56.2% and 57.5%, respectively. There was no significant difference in the accuracy between the two apex locators.

Conclusion: Neither of the two apex locators were 100% accurate in determining the WL.

Keywords: Apex locator; apical resorption; working length

INTRODUCTION

One of the prerequisites for successful endodontic therapy is the determination of the correct working length (WL).1 This critical, as both over- or under-filling has been shown to increase the failure rate.2−4 Although still controversial, there is general agreement that the apical constriction is the most appropriate landmark for termination of endodontic therapy. However, this landmark is not always present, especially in cases of root resorption or in teeth with open apices.

Over the years, multiple methods have been postulated to determine the WL of teeth among which, electronic apex locators (EALs) are one of the mainstays.

Today, various generations of EALs are available, with every generation “claiming” to be superior to the previous one. In this study, Raypex 55 which is a modification of a fourth generation EAL and Apex NRG XFR6 which is a fifth generation EAL were used.

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It has been concurrently established that the accuracy of all EALs is influenced by the diameter of the apical foramen.\(^5\) 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 measure the accuracy of two EALs in determining the WL in teeth with simulated apical root resorption.

**MATERIALS AND METHODS**

Ethical review board was obtained from the Institution Review Board before the commencement of the study (IEC 683/2014). Forty single-rooted maxillary central incisors were radiographically screened and randomly numbered from 1 to 40. Inclusion criteria comprised single-rooted tooth with single canal and completely formed apex and tooth devoid of any preexisting restoration, caries, or morphologic defect. Tooth with incompletely formed apex or open apex or those with root resorption/cracks were excluded from the study.

For each sample, a conventional access cavity (Endo Access Kit, Dentsply, USA) was prepared, and the incisal surface was flattened to provide a stable reference point. The teeth were then embedded up to the cementoenamel junction in freshly mixed alginate (Zelgan Plus, Dentsply, USA) prepared according to the manufacturer’s instructions and poured into a plastic mold. Simultaneously, the labial clip of the EALs was also inserted into the mold.\(^6\) Once the mold was partially set, the tooth was removed, and a 45° oblique cut was made at the apex with a disc (Dentorium, USA) such that the palatal wall was shorter than the facial wall by 3 mm. The tooth was then placed back in the alginate mold and stabilized. Following this, the canal was enlarged with a No. 15 stainless steel K-file (Mani, Matsutain Seisakusho Co., Tochigi-Ken, Japan) using 5 ml of saline (KMC Pharmacy, Manipal, India) to establish canal patency. The silicone stop on the inserted file was set to the flat anatomical reference point on the crown. The Raypex 5 (VDW, Munich, Germany) and the Apex NRG XFR (MEDICNRG, Israel) were then used sequentially to record the WL by the first observer. This was repeated by a second observer to eliminate observer bias.

For both the EALs, the readings were taken in accordance with the manufacturer’s instruction and all measurements were recorded using a measuring scale. For the Raypex 5, the file was advanced within the root canal to a point just beyond the major foramen (red bar) and then withdrawn. The reading was recorded when all three green bars were reached. For Apex NRG XFR, the file was advanced until the “APEX” signal was seen on the LED display and then withdrawn until the display showed the 0.5 mm mark. Measurements were considered to be correct if the readings remained stable for at least 5 s. Three measurements were made for each sample with each EALs by both the observers and an average was taken as the final reading. For the actual WL determination, the visual method was used, and measurements were made after placing a No. 15 Stainless Steel K-file into the root canal and progressing till the tip of the file was visible on the palatal wall. The silicone stop was then set to the same anatomical reference point previously used during the electronic measurement. The file was removed and measured using the same measuring scale. The obtained direct visual measurement was reduced by 0.5 mm and recorded. Three readings were taken by both the observers, and an average of the three readings was taken as the final reading. The actual WL measurements were considered as control.

**Statistical analysis**

Statistical analysis was performed using SPSS version 14.0 software (SPSS Inc, Chicago, USA). The analysis of the data as well as the interobserver reliability was obtained by performing the paired \(t\)-test. The level of significance was set at \(P < 0.05\).

**RESULTS**

In both the EALs and with both the examiners, the recorded WL was found to be significantly more than the actual WL.

However, considering a clinically acceptable variation of \(\pm 0.5\) mm in relation to the control as suggested by various authors,\(^7,8\) the results showed dramatic improvement in the readings of both the EALs under both the observers [Table 1]. There was no significant difference in the readings between the two observers with respect to either of the EALs \((P = 0.468\) for Raypex 5 and \(P = 0.866\) for Apex NRG.)

It was also concluded that both the EALs had similar effectiveness under the simulated conditions [Table 2].

**DISCUSSION**

Correct WL determination is critical to achieve clinical success, allowing to clean, shape, and fill the canal system as close as possible to the apical constriction. The maximum endodontic success rate is obtained when canal obturation lies within 2 mm of the radiographic apex.\(^9\) With the development of EALs, assessment of WL has become more predictable and has helped in overcoming some of the shortcomings of conventional radiographs.\(^10\) Despite having an accuracy of 80–90% in most root canals,\(^9\) the performance of EALs can be limited by multiple factors; one among them being the absence/presence of apical constriction.\(^11,12\)

Raypex 5 uses two separate frequencies of 400 Hz and 8 KHz, and its measurements are based on the root mean square of the signals.\(^13\) The manufacturers claim that this increases the accuracy and reliability of the device. Apex NRG XFR,
The Raypex 5 and Apex NRG were found to be absolutely accurate for only 33.75% and 23.75% of the samples, respectively. However, with a ±0.5 mm acceptance limit, the Raypex 5 and the Apex NRG showed an average accuracy of 56.2% and 57.5%, respectively. Thus, both the EALs showed similar accuracy values, which is in agreement with an ex vivo study carried out by Khandewal et al.\[15\].

Over the years, several electroconductive media have been used for conducting in vitro evaluation of the accuracy of apex locators to simulate the clinical situation including agar,\[16\] gelatin,\[17,18\] flower sponge soaked with 0.9% saline,\[19\] simple saline solution,\[20-22\] and alginate.\[23,24\] When the effectiveness of these various materials was compared, the performance of alginate was found to be superior for the assessment of EALs.\[25\] This result may be due to alginate’s electroconductive properties, which simulate the periodontal ligament with colloidal consistency. Alginate has also been previously shown to simulate the clinical situation better than other gelatin models as it firmly supports the teeth and remains intact for the duration of the study.\[26\] Alginic mass is also extensively used for in vitro model construction as it is economical, easy to handle, and may hide the roots, resulting in an objective and unbiased measurement.\[25\] Due to the fact that alginate mass tends to dehydrate quickly, all the measurements were performed within 30 min as suggested by Topuz et al.\[24\] to prevent any decline in the accuracy of the readings.\[24\]

Once the mold achieved an initial set, the tooth was removed, and an oblique 45° cut was made at the apex. This was done to closely mimic apical resorption which does not occur in a single plane. The tooth was then replanted back into the mold and stabilized.

Nguyen et al.\[26\] reported that the file size did not affect the accuracy of EALs. In the present investigation, all the measurements were practicable and reproducible with the inserted instruments. The same file size was used in every case (No. 15 K-file) to have comparable conditions for the in vitro measurements.

Accuracy of EALs can be determined either by in vitro or in vivo studies. In the present study, in vitro evaluation was preferred as it provides with better standardization and objective evaluation of different variables.\[27\]

CONCLUSION

Within the limitations of our study, it can be concluded that neither Raypex 5 nor Apex NRG was 100% accurate in determining the WL in teeth with simulated apical resorption.

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Conflicts of interest

There are no conflicts of interest.

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