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Comparative Evaluation of Accuracy of Two Electronic Apex Locators In The Presence Of Various Irrigants: An In Vitro Study

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Abstract: *The purpose of this study was to compare the accuracy of Raypex 6 electronic apex locator (EAL), with actual root length and with the root length determined by a more commonly used EAL, the ProPex II. An additional objective was to determine the influence of commonly used endodontic irrigants on the accuracy of these electronic apex locators. This study will add knowledge to the existing literature and to the practioners using these EALs during WL determination in their day to day endodontic practice. A total of 100 extracted single rooted teeth were selected for the study. The teeth were randomly divided into 5 groups of 20 teeth each and Electronic working length was determined in the presence of various irrigants such as Dry root canals, Saline, 2% chlorhexidine, 17% EDTA, 2.5% NaOCl as the medium in the root canals.*
The results showed that the Accuracy of Raypex 6 and ProPex II was comparable in dry conditions, indicating that irrigating solutions do have an effect on the accuracy of EALs. Electronic root canal length measurements were unpredictable when saline was used as irrigating medium, almost all the values by both the EALs were short of apex when saline was used. These might be because of high electro conductivity of the saline solution. 2% chlorhexidine has been identified as the irrigating solution with least interference to the accuracy of EALs. Raypex 6 has been proved to have better accuracy and has least interference to irrigating mediums than ProPex II.

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I. Introduction

Working length (WL) is defined as "the distance from a coronal reference point to the point at which canal preparation and obturation should terminate"[1]. The correct determination of the WL is a key factor for successful root canal treatment, because it reduces the possibility of insufficient debridement of the canal or damage to the periapical tissues due to over-instrumentation[2,3].

Traditionally, the point of termination of endodontic instrumentation and obturation has been determined by digital tactile sense, apical periodontal sensitivity, paper point measurement, and radiographic technique. None of them was singly able to accurately determine the apical constriction. To date, radiographs are the most commonly used technique, but they are subjected to distortion, magnification, lack of three-dimensional representation, increased radiation exposure to the patient, interpretation variability among the different clinicians and is time-consuming[4].

Electronic apex locators (EALs) can determine the WL more accurately than radiographic methods[5]. Their accuracy is influenced by electrical condition of the canal. The presence of tissue and conductive irrigants in the canal can change the electrical characteristics and lead to measurement error .Generation of dual frequency apex locators have attempted to minimize this problem[6].Doubt exists in the mind of operators as regards the accuracy of different available electronic apex locators. Moreover comparative evaluation of different apex locators under similar clinical/clinically simulated conditions is deficient in the literature[7]. The electronic root canal measurement has been found to be a purely physical phenomenon[8]. Alginate conducts electricity, and its electrical impedance imitates the human periodontium[9].

The purpose of this study was to compare the accuracy of Raypex 6 electronic apex locator (EAL) with actual root length and with the root length determined by a more commonly used EAL, the ProPex II. An additional objective was to determine the influence of commonly used endodontic irrigants on the accuracy of these electronic apex locators. This study will add knowledge to the existing literature and to the practioners using these EALs during WL determination in their day to day endodontic practice.

II. Materials And Methods

A total of 100 Extracted single rooted teeth collected from the Department of Oral & Maxillofacial Surgery, Govt. Dental College, Calicut, Kerala were selected for the study. This in vitro study was conducted in the Department of Conservative Dentistry & Endodontics, Govt. Dental College, Calicut, Kerala.

Inclusion Criteria:

1. Extracted single rooted human teeth

Exclusion Criteria:

1. Root fracture
2. Multiple canals
3. Root resorption
4. Immature apices.
5. Endodontically treated tooth.
6. Calcification in the root canal.
7. Metallic restoration.

Procedure Methodology

A total of 100 teeth, which were selected, based on the above said inclusion and exclusion criteria were utilised for the study. All the extracted teeth were cleaned of calculus, soft tissues, and debris with ultrasonic scaler (P5 Suprasson by Aceton, US) and stored in distilled water until used. The teeth were carefully examined under dental operating microscope (Seiler, US) at 12X magnification to check for root fractures or resorption and to confirm that apex formation was complete. The crown of each tooth was sectioned at the cementoenamel junction using a diamond disc with water cooled spray in order to simplify access to the root canal and to serve as a stable reference point for working length determination.

The coronal/middle third of the canals were flared with ProTaper rotary Sx files **(**Dentsply Maillefer, Switzerland). A ProTaper rotary S1 file was inserted into the root canal until the file tip was just visible at the level of apical foramen using a dental operating microscope at 12x magnification. The stopper of the file was adjusted with the coronal reference plane of the tooth. File was removed gently from the root and the file length from the tip to the rubber stopper was measured using Digital Vernier Calliper (Aerospace Digimatic Instruments) and recorded. Three readings were taken; their mean was calculated and recorded as the actual working length.

A mold was made using cold cure acrylic resin, natural teeth, and alginate impression material (DPI, India), to simulate oral conditions for electronic measurement of the working length[2]. Alginate was mixed into the proper consistency and poured into the cold cure acrylic mold. Sectioned roots were pressed into the alginate and then it was allowed to set. Lip clip was also embedded into the alginate. All measurements were recorded within 2 hours of mixing the alginate for best performance.

The total sample size was randomly divided by a simple lot method into 5 groups of 20 teeth, each depending on the irrigants used:

- Group I: Dry
- Group II: Saline (Nirlife, India)
- Group III: 2% Chlorhexidine (Anabond Steadman, India)
- Group IV: 17% EDTA (Deor Dental Care, India)
- Group V: 2.5% NaOCl (Prevest Denpro, India)

Each tooth was numbered for identification purposes. The irrigants were introduced into the canals using a syringe and needle. The excess liquid was removed by short blasts of air from the three way syringe. Electronic working length measurements were taken with each electronic apex locator by attaching one electrode to the lip clip embedded in the alginate and other end of the electrode to ProTaper rotary S1 file placed in the root canal. Measurements were taken with various irrigants in the root canals.The termination point used for ProPex II (Dentsply Maillefer, Switzerland). was the point where the monitor of the apex locator flashed "APEX" along with "0.0" reading and a constant audible tone. The termination point for Raypex 6 (VDW GmbH, Munich, Germany). was when the display showed a red dot with continuous audible tone. Each measurement was taken thrice and average mean was calculated which was recorded as the working length.

Statistical Analysis

On completion of the study, all the data including tooth number, actual length, length measured by each electronic apex locator and the irrigant used were entered into Excel sheet (Microsoft Corporation, Redmond, WA). and was analysed using SPSS (Version16; SPSS, Inc., Chicago, IL). ANOVA test with Bonferroni adjustment was employed for the statistical analysis.

III. Result

In Group I, No irrigants were used. The canals were dried with paper points to assure their dryness before taking electronic length measurements. When the measurements obtained by Raypex 6 were compared to actual length, all the values were within 0.5 mm of each other. The p value was 0.842 which is > 0.05 indicating that is comparison s statistically insignificant. When ProPex II was compared to the actual length, a maximum difference of +3.3 mm was seen. The p value was 0.434 (statistically insignificant). When Raypex 6 was compared to ProPex II, the values were comparable as only two values had a difference of 0.5mm (p value was 0.654) hence statistically insignificant.

In Group II, normal saline was used as irrigant. When actual length was compared with that obtained by Raypex 6, a maximum difference of 5.4 mm was seen with a minimum difference of 0.1 mm in 5 teeth. Here the p value is 0.017 which is statistically significant. When the actual length was compared with ProPex 2, a maximum difference of 4.8 mm was recorded. Here the p value is 0.000 which is highly statistically significant. When Raypex 6 was compared to ProPex II in saline, 12 values differed by more than 0.5 mm, of which 4 values differed by over 1mm. 5 of the values obtained by ProPex II were longer than those obtained by Raypex 6, rest were shorter. The p value was 0.046 which is less than 0.05, hence statistically significant.

In Group III, 2% chlorhexidine was used as irrigant. When actual length was compared with that obtained by Raypex 6, a maximum difference of 0.5 mm was seen. 18 values were within 0.5 mm. Here the p value is 0.000 which is statistically significant. When actual length was compared with ProPex II, a maximum difference of 1.2 mm was seen. Here the p value is 0.000 which is statistically significant. When Raypex 6 was compared to ProPex II, only 4 values differed by more than 0.5 mm, of which 1 values differed by over 1mm. 2 of the values obtained by ProPex II were longer than those obtained by Raypex 6, rest shorter. 2 same values were also obtained. The p value was 0.001 which is less than 0.05, hence statistically significant.

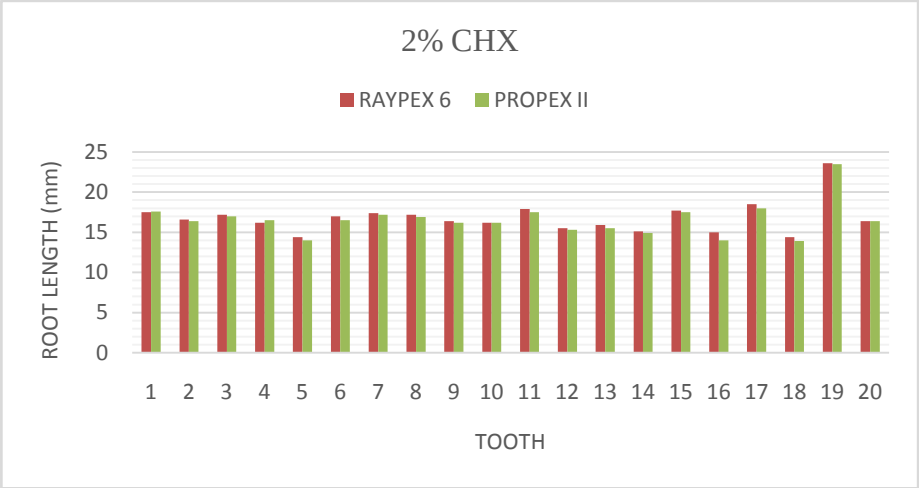
In Group IV, 17% EDTA was used as irrigant. When actual length was compared with that obtained by Raypex 6, a maximum difference of 0.9 mm was seen. When actual length was compared with ProPex II, a maximum difference of 1.0 mm was seen. Here the p value is 0.000 which is statistically significant. When Raypex 6 was compared to ProPex II in 17% EDTA, 3 values differed by more than 0.5mm. 6 of the values obtained by ProPex II were longer than those obtained by Raypex 6. 3 same values were obtained, rest were short. The p value was 0.001 which is less than 0.05, hence statistically significant.

In Group V, 2% NaOCl was used as irrigant. When the measurements obtained by Raypex 6 was compared to actual length, 11 of the values were within 0.5 mm of each other and 8 values were over 0.5 mm. The p value was 0.004 which is > 0.05 indicating that is comparison is statistically significant. When ProPex II was compared to the actual length, a maximum difference of 5 mm was seen. 7 values were out of the acceptable range of 0.5 mm but 5 were out of 1mm of the apex. Here 2 values were over apex, 17 under apex and only 1 value was same. The p value was 0.057 (not statistically significant). When Raypex 6 was compared to ProPex II in 2% NaOCl, 9 values differed by more than 0.5 mm, of which 3 values differed by over 1mm. 8 of the values obtained by ProPex II were longer than those obtained by Raypex 6, rest shorter. The p value was 0.725 which is more than 0.05, hence statistically not significant.

Table no 1: Shows Bonferroni test for Working Length Comparison.

Group	Compared Length	Comparing Length	*P Value
Dry	Actual	Raypex 6	0.842
	Actual	ProPex II	0.434
	Raypex 6	ProPex II	0.657
Normal Saline	Actual	Raypex 6	**0.017**
	Actual	ProPex II	**0.000**
	Raypex 6	ProPex II	**0.046**
2% CHX	Actual	Raypex 6	**0.000**
	Actual	ProPex II	**0.000**
	Raypex 6	ProPex II	**0.001**
17% EDTA	Actual	Raypex 6	**0.000**
	Actual	ProPex II	**0.000**
	Raypex 6	ProPex II	1.000
2.5% NaOCl	Actual	Raypex 6	**0.004**
	Actual	ProPex II	0.057
	Raypex 6	ProPex II	0.725

Graph 1: Representing comparison between (Raypex 6 vs ProPex II) when 2% Chlorhexidine was used as irrigant. *p value = 0.001 which is < .05, hence statistically significant**.**



IV. Discussion

Locating the appropriate apical position always has been a challenge in clinical endodontics. The cemento-dentinal junction (CDJ), where the pulp tissue changes into the apical tissue, is the most ideal physiologic apical limit of the working length. It also is referred to as the minor diameter or the apical constriction. However, the CDJ and apical constriction do not always coincide, particularly in senile teeth as a result of cementum deposition, which alters the position of the minor diameter The apical constriction of the root also does not coincide with the anatomic apex. It is deviated linguo-buccally or mesio-distally from the root[3–5]. If the exit deviates bucco-lingually, it is very difficult to locate accurately the position of the apical foramen using only roentgenograms, even with multidirected angles[6].

The electronic apex locator (EAL) machine has attracted a great deal of attention because it operates on the basis of the electrical impedance rather than by a visual inspection. . EALs are particularly useful when the apical portion of the canal system is obscured by certain anatomic structures, such as impacted teeth, tori, the zygomatic arch, excessive bone density, overlapping roots, or shallow palatal vaults. Indeed, EALs currently are being used to determine the working length as an important adjunct to radiography. EALs help to reduce the treatment time and the radiation dose, which may be higher with conventional radiographic measurements. However, some questions still exist as to whether the accuracy of EAL can be affected by the different types of electrolytes[7–9].

Raypex 6 is the latest electronic apex locator from VDW GmbH, Munich, Germany. They claim accurate root canal length determination due to the use of latest multi-frequency apex locator technology. Since not many studies have been documented to check its accuracy under different irrigating solutions, it was decided to use this EAL as the subject of this study. It was decided to compare its accuracy with that of a more commonly used EAL, the ProPex II (Dentsply Maillefer, Switzerland). It is claimed to be a fourth generation EAL and is also based on multi frequency technology. One important characteristic of ProPex II is that the calculation of working length is based on the energy off the signal whereas the other apex locators usually use the amplitude of the signal. The manufactures claim that the energy measurement is more precise. It detects the canal terminus by determining a sudden change in the dominant characteristic (capacitive) of the impedance. It has been claimed to be unaffected by either dry or moist condition of the canals[10]. Kaufman et al in 1997 developed the alginate model which was used in other studies also. Alginate is a good medium to establish the necessary electric circuit for a correct EAL measurement, because it mimics well the electric impedance of the human periodontium[11].

In the first group (dry), Raypex 6 showed better accuracy with 100% of its readings within ±0.5 mm limit, compared to 90% by ProPex II. Raypex 6 correctly determined the apex in 26% of the teeth, whereas ProPex II could correctly identify them in only 15% of the cases. In Group II, the irrigant used was normal saline (0.9%W/V). It is the most commonly used root canal irrigant. 60% of the values by Raypex 6 were within 0.5 mm whereas only 30% of values by ProPex II were within 0.5 mm. Li He et al found out that in saline 91.5% of values given by Raypex 5 were within 0.5 mm of apex[12]. The results of this study are different from what we found, still Raypex 6 was more accurate that ProPex II. Ozsezer et al evaluated the performance of the ProPex in different irrigation solutions, they reported that the chlorhexidine group gave the most accurate results and saline gave the worst[13]. This finding is in concurrence with our results.

In Group III, 2% chlorhexidine was used as the irrigant. Here all the values by Raypex 6 were within 0.5 mm mark. But, only 45% of ProPex II values was within 0.5 mm, even though 85% of the values were within 1mm.the amount of values short of apex was 90% and 95% respectively for Raypex 6 and ProPex II. In Group IV, 17% EDTA was used as irrigant. It is the most commonly used chelating agent in endodontics. When EDTA was used 70% of the values by Raypex 6 were within 0.5 mm, which increased to 100% within 1 mm. Similarly when ProPex II was used 60% values were within 0.5 mm from apex. Li He et al found that for Raypex 5 when 17% EDTA was used 97.8% of the values were within 0.5 mm of the apex[12]. This is in accordance with our findings as 70% of Raypex 6 values were within 0.5 mm, more than that of ProPex II.

In Group V, 2.5% NaOCl was used. 75% of the values of Raypex 6 were within 0.5 mm from apex compared to 65% of ProPex II. 90% of the values of both the EALs were within 1mm from the apex. In this study, maximum Raypex 6 readings within 0.5 mm of the apex was in the dry group and in 2% chlorhexidine group. This is in concurrence with the findings of Joshi et al in 2011[14]. For ProPex II maximum readings within 0.5 mm of the apex were from the dry group followed by 2.5% NaOCl. In our study, worst performance was seen in normal saline solution for both the EALs. Raypex 6 detected apex within 0.5 mm 60% of the time whereas ProPex II could do it only 30% of the time. This could be attributed to the high electrical conductivity of the normal saline solution as compared to other irrigants. The irrigating solutions that least affected Raypex 6 apex determination was 2% chlorhexidine (100% within 0.5 mm), followed by 2.5% NaOCl at 75% within 0.5 mm and finally 17% EDTA at 70%.

V. Conclusion

In summary, Raypex 6 was found to be more accurate than ProPex II electronic apex locator, especially in cases where 2% chlorhexidine was used as irrigant. Raypex 6 is a newer generation apex locator with more advanced technologies, would be better to compensate for the effects of the irrigating solution. Also 2% CHX and 2.5% NaOCl was found to be most reliable as irrigants when using EALs for working length measurements.

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