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Ex Vivo Comparison of the Accuracy of Three Apex Locators in Working Length Determination

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ABSTRACT

This study aimed to compare the accuracy of working length measurement by different types of electronic devices (electronic apex locators) and compared with actual length of the root canal (the distance from a coronal reference point to an apical reference point 0.5 to 1.0 mm) short of the anatomical apical foramen. Thirty-four extracted sound, fully formed, single-rooted human teeth (Premolars), which were extracted for orthodontic purposes, were used in the current study. Within the limitations of the current study, it can be concluded that apex locators are valuable devices for the working length determination with accuracy up to 100%, and iPexII was the most accurate with the YC-RAF was the least accurate with statistically non-significant difference.

Key words: Three apex locators, Canal treatment, Ex vivo comparison

INTRODUCTION

In root canal treatment in endodontics, the determination of an accurate working length is one of the most important steps¹. Working length is defined as "the distance from a coronal reference point to an apical reference point (apical stop, apical constriction or narrowest apical diameter) at which canal preparation and obturation^{1,2} should terminate. It is generally accepted that the apical constriction is most frequently located 0.5 to 1.0 mm short of the radiographic apex, but with variations. The radiographic apex is the tip or end of the root determined radio graphically. The significances of this procedure are as follow: The calculation determines how far into the canal the instruments are placed and worked and the tissues, debris, metabolites and other unwanted items are removed from the canal. It will limit the depth to which the canal filling may be placed. It will affect the degree of pain and discomfort that patient could feel following the appointment. So, if it is calculated within correct limits, it will play an important

role in determining the success of the cleaning, shaping, and obturation of the root canal system, otherwise if it is calculated incorrectly may doom the treatment to failure⁴. The calculation of this working length can be undertaken using radiographic or electronic devices. So, this study aimed to compare the accuracy of working length measurement by different types of electronic devices (electronic apex locators) and compared with actual length of the root canal (the distance from a coronal reference point to an apical reference point (0.5 to 1.0 mm short of the anatomical apical foramen).

MATERIALS AND METHOD

Sample collection

Thirty-four extracted sound, fully formed, single-rooted human teeth (Premolars), which were extracted for orthodontic purposes, were used in the current study. Cleaning of the outer surface of the teeth was performed using pumice followed by careful rinsing with distilled water to remove the remnants of periodontal ligaments and any debris. Careful⁵ examination of the teeth was performed with a magnifying lens under a LED light to confirm the absence of any cracks or defects. Radiographs in mesio-distal and labio-lingual directions were taken to ensure the presence of one canal only. Teeth without any defect and of comparable size were

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included only, numbered and stored in distilled water at room temperature until use.

Sample preparation

Access cavity was prepared for each tooth using high-speed turbine with sufficient water cooling followed by pulp extirpation accomplished with a barbed broach. Patency of the canal was checked with a #15 stainless steel K-file (Dentsply, Maillefer) without any preparation of the canal.

Working length measurements

The actual length of the root canal system was measured using #10 K-file (Dentsply, Maillefer) by insertion inside the canal and advancing apically until the tip is visible from the apical foramen followed by the adjustment of the rubber stopper to a suitable reference point (the tip of the buccal cups), then the length of the file from the stopper to the tip was achieved using endoblock (Dentsply, Maillefer). 0.5 mm was subtracted from these measurements to refer to the apical constriction rather than to the objective apex⁶⁻¹⁰. The final length was considered as the clinical length (Clinical). To electronically measure the working length, the samples were immersed in a glass mold filled with a fresh mix of alginate¹¹ (to provide a close simulation of the periodontal tissues), while the teeth held upright until the full set of the alginate. All the working length readings were obtained within a period of two hours only with the alginate always kept humid. The labial hook of the apex locator was kept in contact with humid alginate during readings. The manufacturer recommendations were kept in mind throughout the procedure of working length determination. Every reading was repeated three times and the average was recorded and considered satisfactory if it was persistent for five seconds and increasing and decreasing while advancing or withdrawing from the canal respectively. The measurements for the three apex locators and the clinical length were done by the same investigator. All the measurements were recorded and organized in a table (Table 1). For comparison of the accuracy of apex locators used in the current study, a non-parametric test was used (Kruskal Wallis test) with chi-square to test the significance between groups.

RESULTS AND DISCUSSION

From the cumulative experience using the apex

locators in the current study, it has been noted that measurements with iPexII were a lot easier than other devices, while the measurements with (YC-RAF-1) were the most difficult ones. Results obtained from the current study were organized in Table 1. It has been found that readings from the (YC-RAF-1) were the least accurate among all devices with very close results between the iPexI and iPexII. The mean and standard error for all groups were listed in Table 2. It was determined that each sample was regarded as its own control. Statistical analysis revealed non-significant difference among the devices used in the current study regarding their ability to determine the accurate working length ($P \leq 0.05$) as can be seen in Table 3. Undoubtedly, working length estimation is a crucial step in successful endodontic treatment, where instrumentation and obturation beyond or short of the apex will dramatically worsen the scenario and lead to endodontic treatment with poor prognosis. The experimental model utilized in the current study is a modified model from a study by Leonardo¹², where the immersed samples can provide a close electrical resistance to that of the periodontal tissues¹³. Furthermore, this model is simple, readily available, easily manipulated and provide a firm control for the experimental variables to be tested but it has the drawback of incomplete simulation of the patient condition. Apex locators are regarded as precious addition to the world of endodontic¹⁴, where the newly introduced devices are able to detect the exact point where the periodontium starts at the end of the canal¹⁵. It has been reported that the accuracy of some apex locators were 100% accurate within ± 1.0 mm and from 75-91.7% accurate within ± 0.5 mm in simulated dry canals, whereas a dramatic decrease in the accuracy was reported with the increase in simulated canal diameter¹⁶. Several studies focused on the accuracy of apex locators produced comparable results with accuracy around 80% within ± 0.5 mm and almost 100% within ± 1.0 mm^{5, 17-20}. The majority of researchers considered the error range is acceptable at ± 0.5 mm and less researchers considered the ± 1.0 mm. This was due to the great variability in the shape of the apical area in addition to the fact that it is somewhat difficult to visually control the distance between the reference point and the rubber stopper. Furthermore, it is tricky to detect the exact point where the tip of the reamer exit the canal regardless of magnification used²¹. In the current study, both error ranges were adopted. Although non-significant difference was reported in the current study, the devices show some easily detected differences.

Statistically, iPexI was the most accurate device (76.5% within $\pm 0.5\text{mm}$ and 100% within $\pm 1.0\text{mm}$) compared to clinical measurements with the YC-RAF-1 was the least accurate one (17% within $\pm 0.5\text{mm}$ and 67.6% within $\pm 1.0\text{mm}$). In spite of the statistical results which showed that the iPexI is the most accurate, its mean value is

more than the clinical mean value. So, the most accurate reading was with iPexII. Within the limitations of the current study, it can be concluded that apex locators are valuable devices for the working length determination with accuracy up to 100%, and iPexII was the most accurate with the YC-RAF was the least accurate with statistically non-significant difference.

Table 1. Measurements of the working length (in mm) where the tip of the buccal cups were considered as a reference point.

No.	Clinical	iPexI	iPexII	YC	No.	Clinical	iPexI	iPexII	YC
1.	23	23	22	21.5	17.	21	20.5	20	20
2.	22.5	23	21	21	18.	21	20	20.5	20
3.	20	20.5	20	20.5	19.	23	22	22	21.5
4.	21	21	21	20	20.	23	23	22	21.5
5.	22	22	21.5	21	21.	20.5	20	20	20.5
6.	23	23.5	21.5	21	22.	21	20.5	21	20.5
7.	27.5	27	27	26.5	23.	22	22	21.5	22
8.	27.5	27.5	27	26.5	24.	21	22	20.5	20
9.	20.5	20.5	20.5	20	25.	24	23	23	22.5
10.	20.5	21	20.5	20.5	26.	23.5	23	22	22
11.	19.5	19	19	18.5	27.	21	20.5	20.5	20
12.	19	18.5	19	18	28.	21	20	19	18.5
13.	21	20.5	20.5	20.5	29.	21	21	21	20
14.	21	21	20	20	30.	24	24	24	23
15.	23	22	21.5	21	31.	20.5	21	20	19.5
16.	24	23	23	22.5	32.	19	19	19	18

Table 2. Descriptive analysis of the measurements in the current study.

Group No.	Group name	Mean	Standard error
1	Clinical	21.352941	0.3400806
2	iPexI	21.602941	0.3415516
3	iPexII	21.220588	0.3216706
4	YC-RAF-1	20.823529	0.3214567

Table 3. Statistical analysis of the measurements ($P \leq 0.05$)

Group	N	Mean rank
1	34	70.4
2	34	77.43
3	34	68.16
4	34	58.01
Chi-Square		4.314
Df		3
Asymp. Sig.		0.230

CONCLUSION

Within the limitations of the current study, it can be concluded that apex locators are valuable devices for the working length determination with accuracy up to 100%, and iPexII was the most accurate with the YC-RAF was the least accurate with statistically non-significant difference.

Financial Disclosure: There is no financial disclosure.

Conflict of Interest; None to declare.

Ethical Clearance: All experimental protocols were approved under the Faculty of Dentistry, University of Babylon, Hillah city, Iraq and all experiments were carried out in accordance with approved guidelines.

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