Original Article

AN IN VIVO STUDY TO EVALUATE THE EFFICACY OF ELECTRONIC APEX LOCATORS IN THE DETERMINATION OF WORKING LENGTH

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ABSTRACT

Objectives: *The aim of this study was to determine whether the performance of electronic apex locators can equal or outdo the radiographic technique and establish itself as a standard baseline entity for the determination of working length.*

Methodology: *One hundred and seventy five canals of 84 patients were included in this study at the Department of Operative Dentistry, Khyber College of Dentistry for the preparation phase of root canal treatment. The canals were dried and the Joypex 5 apex locator was used to record the working length. The patients were sent for a periapical radiograph and radiographic working length was calculated. Both values were recorded on specially designed proforma; the difference was noted and subjected to statistical analysis using a Paired-samples T test with a critical p-value of* <0.05.

Results: *Out of 175 canals measured, the radiographic working length coincided with the electronic working length in 101 (60.0%) cases. In 31 cases (17.7%), the electronic working length was short by 0.5mm and in 24 cases (13.7%) the electronic working length was over by 0.5mm. In 7 cases (4%) the electronic working length was short by 1mm and over by 1mm in 4 cases (2.3%). In 2 cases each, the apex locator underestimated the working length by 2 and 3mm (1.1 % each). Overall, the difference between the working lengths measured by the two methods was statistically insignificant* ($p = 0.294$)

Conclusion: *The difference between the two working lengths obtained was not significant* ($p = 0.294$). *The apex locator was able to locate the apical foramen to within* ± 0.5*mm in 91.1% of the cases. However its solo application for determining working length is discouraged and must be used in tandem with conventional radiography.*

Keywords: *Efficacy, Electronic apex locator, Working length*

INTRODUCTION

The cornerstone of a successful root canal treatment is the accurate assessment of working length.[1] The working length of a root canal has traditionally been determined using radiographic means. There have been concerns on the accuracy of radiographic working length as the apical foramen does not coincide with the tooth apex in most cases and is 0.5-1mm shorter than the apex, and in some cases up to 3mm.[2] Custer was the first person who introduced the apex locator as an alternative to radiographs.[1] Suzuki[3] was the first person to apply direct current in teeth of dogs as a method of determining canal length. Sunada[4] suggested that the apical foramen could be localized using direct current. From 1969 to date, up to six generations of apex locators have been introduced.[5,6] The development of apex locators has lead to less radiographic exposure, better assessment and increased predictability of the working length.[7]

The question arises whether electronic apex locators can replace radiographic method of determining working length. There have been concerns regarding apex locators because accurate readings were not always obtained in the presence of vital pulp tissue, root canal irrigants and intracanal fluids such as serous, purulent or haemorrhagic exudates. These short-

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comings were claimed to have been rectified in the latter generations of apex locators.[8] Despite these improvements, the electronic apex locators suffer a significant flaw in the form of poor performance in teeth with immature roots and potential for interference with cardiac pacemakers.[9, 10] Sole use of electronic apex locators without thorough radiographic examination was also found to result in failure of root canal therapy due to missed canals.[11]

The aim of this study was to determine whether the performance of electronic apex locators can equal or out do the radiographic technique and establish itself as a standard baseline entity for the determination of working length.

MATERIALS AND METHODS

This study was carried out on 175 canals in 84 patients who reported to the Department of Operative Dentistry, Khyber College of Dentistry for the preparation phase of Root canal treatment. The approval for the study was granted by the Ethical Review Committee, Khyber College of Dentistry. Purposive non probability sampling technique was used for selection of the sample. A pre-operative Periapical radiograph was taken to exclude those patients from the sample with pulpal calcifications, broken instruments, and immature roots. Patients fitted with cardiac pacemakers were also excluded from the study.

The access cavity was opened, isolation was achieved with cotton rolls, and the canals were located and thoroughly irrigated with normal saline. Papers points were used to dry the canals. The Joypex 5 (4th generation Denjoy Dental Co., Ltd. China) Apex locator was used with size 15K files and inserted into each canal till the Joypex 5 indicated that the apical foramen had been reached. The stoppers were adjusted to the appropriate reference points and lengths were measured and recorded in a specially designed proforma. The patients were then sent for a periapical radiograph (Cone shift technique for posterior teeth and Ingle's method for anterior teeth) and the radiographic working length was measured by subtracting 1mm from the distance of the radiographic apex from the coronal reference point. One millimeter safety allowance was also included to compensate for image distortion and magnification. The difference between the two working lengths was determined and noted in the study proforma. The data collected were analysed using SPSS version 17.

RESULTS

The sample comprised of 175 canals in 84 patients reporting for preparation phase of root canal treatment. Out of these, 47 (56%) patients were male and 37 (44%) were female with a male to female ratio of 1.27:1. The age range of the sample was 15-60 years with a mean age of 31.81±10.84 years. The majority of patients fell in the 3rd decade of life (33.33%) followed by 32.14% in the 4th decade of life. The details of age distribution are given in Table 1.

Table 1: Age distribution

Age in years	n	Percentage
11-20	13	15.40
21-30	28	33.33
31-40	27	32.14
41-50	11	13.09
51-60	5	5.95
Total	**84**	**100**

The teeth reporting with the highest frequency were 1st molars (34.52%), followed by 2nd premolars (19.04%). Table 2 shows the details of the distribution of the teeth involved.

Table 2: Tooth involved

Tooth involved	Frequency	Percentage
1st Molar	29	34.52
2nd Premolar	16	19.04
1st Premolar	10	11.90
2nd Molar	9	10.71
Canine	7	8.33
Central Incisor	7	8.33
Lateral Incisor	6	7.14
Total	**84**	**100**

Out of 175 canals measured, the radiographic working length coincided with the electronic working length in 101 (60%) cases. In 31 cases (17.7%), the electronic working length was short by 0.5mm and in 24 cases (13.7%) the electronic working length was over by 0.5mm. In 7 cases (4%) the electronic work-

ing length was short by 1mm and over by 1mm in 4 cases (2.3%). In 2 cases each, the apex locator underestimated the working length by 2 and 3mm (1.1 % each). The details are given in Figure 1.

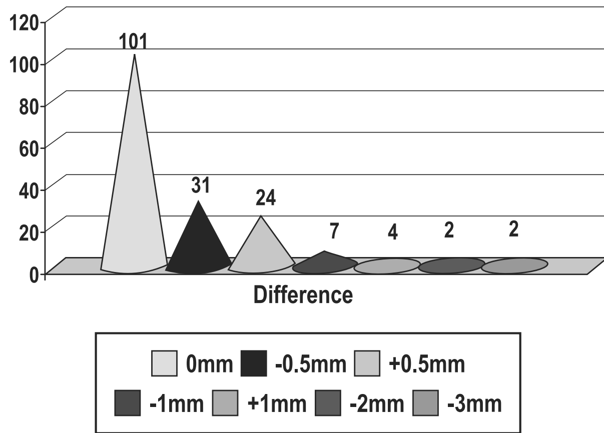

Fig. 1: Distribution of differences between radiographic and electronic working length

These results showed that the Joypex 5 was able to locate the apical foramen to within ±0.5mm in 91.1% of the cases (Figure 2). The calculated p-value of the mean of the two working lengths determined by the paired sample T-test was found to be 0.294 which is not statistically significant (critical $p < 0.05$).

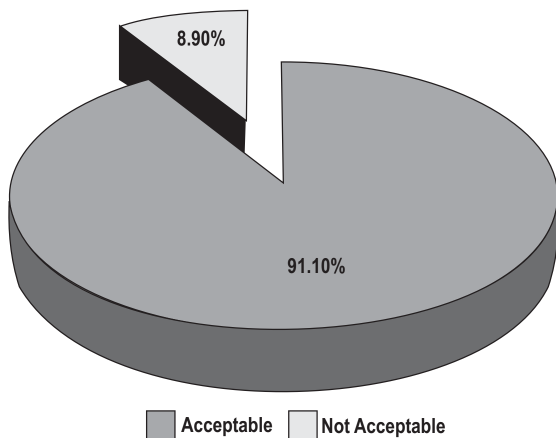

Fig. 2: Measurements obtained with the Joypex 5 apex locator

DISCUSSION

This study showed that the apex locator under investigation was very reliable in the determination of working length by locating the apical foramen up to ±0.5mm in 91.1% of the cases. The 8.9% variation in working length determination was found to be not significant. This proved that the working lengths determined by the electronic method were as accurate as those determined by radiographic technique, yet it also reaffirmed that apex locators cannot be used as a gold standard entity in root canal treatment.

The study incorporated both anterior and posterior teeth; hence the results of the study were applicable to both sets of teeth, unlike most studies that included anterior teeth only. Inclusion of posterior teeth was a double edged sword as posterior teeth comprised the majority of teeth that required root canal treatment; hence it assisted in the completion of the target sample within 2½ months. However, posterior teeth inclusion presented a problem in accurately determining the radiographic terminus in the lingual canals due to substandard quality of radiographs and superimposition of anatomic structures.

The literature shows that with continuing evolution of the apex locators, 1st to current 6th generation, have shown improvement in recording the working length in teeth with the presence of conducting and non conducting fluids which was a significant drawback with the earlier generation devices.[12,13] Several studies have utilized ±0.5mm clinical tolerance range for determining an accurate assessment of working length.[14] In that aspect, the present study was in accordance with Qazi et al[15] which also utilized a 4th generation apex locator (Sybron Endo) and produced acceptable results in 90% of their sample, though that study was confined to 30 anterior teeth only. McDonald[16] also conducted a study similar to Qazi et al on single rooted teeth which showed that electronic apex locators produced accurate results in the range of 83-93.4%.

Shanmugaraj et al[17] conducted a study on single rooted teeth and used the Foramatron-IV digital apex locator which deduced the apical foramen to within ±0.5mm in 86.7% of the 30 teeth. They also incorporated an ex vivo component in their study to determine the actual working length which was not a part of our study. Frank and Torabinjad[18] conducted a study on forms of working length measurements other than radiography due to radiation hazards. They utilized the Endex apex locator (3rd generation) which located the apical foramen within a ±0.5mm clinical tolerance in 89.64% of the canals. The results and sample size correlated with our study.

Pommer et al[19] studied the influence of canal contents on electronic working length measurement. AFA apex finder was used on 107 teeth with 171 canals in which the file tip was judged to be ±0.5mm short of the radiographic apex in 86% of cases. The results and sample size were in agreement with our study. Mayeda[20] conducted a similar study using vital or necrotic pulps and reported 88% accuracy for a ±0.5mm clinical tolerance. Both studies also examined the effect of canal contents on the determination of electronic working length but that aspect was not determined as part of our study.

All the studies advocated the use of electronic apex locators as an adjunct to radiography and did not encourage its use as an alternative due to its various shortcomings such as an inability to visualize root curvature, root length, extra canals and assess the crown to root ratio .[15]

CONCLUSIONS & RECOMMENDATIONS

This study concluded that no statistical significance difference was found in the working lengths measured by both radiographic and electronic means. While apex locators currently lack the capacity to be a single baseline entity in endodontic treatment, its accurate assessment of the working length and reduced radiation exposure require that radiography must be supplemented with apex locators to deliver the best possible endodontic care to the patients.

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