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A Comparative In vitro Study of the Effects of Open Apex on Working Length Determination Using Cone-Beam Computed Tomography and Apex Locators

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***Abstract*: Due to severe apical resorption, thin dentinal walls, and chronic infection, teeth with open apices make it difficult to estimate the working length. Electronic apex locators help where radiographic methods are problematic and cut down on the number of radiographs needed. Also, they are useful when the radiographic apex and apical foramen are separated by some distance. Apex Locators not only minimize radiography exposure but also minimize root canal length overestimation. *Aim:* The purpose of this study is to evaluate how open apex affects the calculation of working length (WL) using cone-beam computed tomography (CBCT) and electronic apex locators (EALs). *Result:* The study's findings demonstrated a statistically significant relationship between Visual Working Length (VWL), Propex pixi, CBCT Working Length, Propex pixi, Root ZX mini, and Propex Pixi. However, there was no p>0.05 statistically significant difference between the Root ZX Mini and the CBCT working length. *Conclusion:* This study demonstrated that the CBCT working length is as precise and reliable as the gold standard, the Visual Working Length (VWL). Root ZX small had greater accuracy than Propex Pixi among the electronic apex locators utilised in my investigation.**

***Keywords*: open apex, working length, electronic apex locator, Root ZX mini, Propex Pixi, CBCT.**

1. Introduction

Thorough cleaning, shape, three-dimensional obturation of the canal, and disinfection with various irrigants all contribute to the effectiveness of our endodontic therapy. In addition, there are instances of underfilling and overfilling of root canals, which lower the success rate of endodontic treatment. So, the working time is crucial in determining the maximum amount of preparation and filling.

Open apex refers to a large root canal at the apex. It frequently occurs in developing teeth when root development is halted by necrosis, injury, or cavities. Resorption, excessive instrumentation, and root end excision are the main causes of open apex formation.

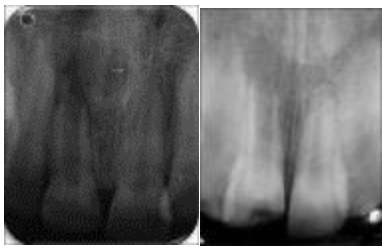

Fig. 1.

For a successful root canal treatment, we need proper instrumentation and filling if the material is beyond or if it is short resulting in failure of treatment.

It causes unintentional expulsion of the irrigants, dressing, or filling which results in pain, discomfort, and postoperative pain.

A very large apical foramen, known as an open apex, makes it difficult to complete an apical stop. The apical constriction is the main encouraging landmark to finish the WL. Nevertheless, it lost when the apex was immature.

Instrumentation of the apical portion of these canals must be maintained at a strategic distance to prevent thinning of their fragile dentinal walls. A proper working length is made by using Electronic Apex Locators.

Fig. 2. Root ZX mini (J. Morito, Tokyo, Japan)

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Apex locators made by Propex Pixi (Dentsply) feature two different frequencies: 80MHz and 800MHz. Although it has a very high level of accuracy, it is shown to be less accurate when electrolytes, pus, blood, etc. are present.

Fig. 3. Propex Pixi (Dentsply)

The gold standard for 3D root canal evaluation is always CBCT. CBCT and electronic apex locators work best when combined to get the best results and readings.

2. Armamentarium

Fig. 4.

Groups:

In this study we had taken four groups.

- Group 1: Working Length Determination by Visual Method (Control group).
- Group 2: Working Length Determination on the CBCT Scans.
- Group 3: Working Length Determination Using Root ZX mini (J Morito, Tokiyo Japan), Electronic Apex Locator Measurements.
- Group 4: Working Length Determination Using Propex Pixi (Dentsply) Electronic Apex Locator Measurements.

Methods:

1. Sample selection and open apex stimulation.
2. The imaging process and assessment of the Working Length (WL) on CBCT scans.
3. Determining the access opening and visual working length.
4. Using an electronic apex locator and embedding samples in algenate.

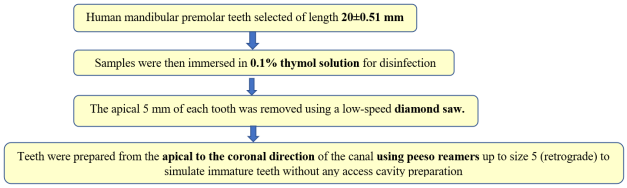
Sample Selection and Stimulation of Open Apex:

INCLUSION CRITERIA

1. Single Canal
2. Completely formed apex
3. Absence of any preexisting restoration caries or morphologic defect

EXCLUSION CRITERIA

1. Teeth with any carious lesion
2. Root resorption
3. Fractures
4. Immature apex
5. Calcification.



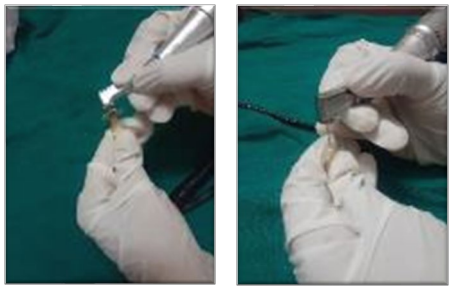
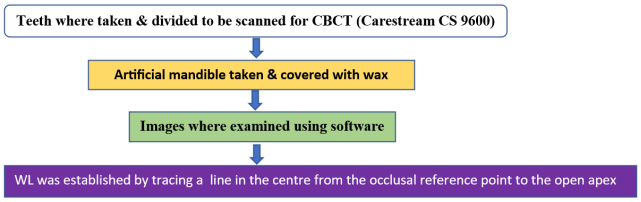


Fig. 5.

Imaging Method and Evaluation of Working Length on the CBCT Scans:



All of the teeth were removed and separated into groups in order to use the imaging approach and assess the working length on the CBCT scans. The Carestream CS 9600 is then used to scan it for CBCT. Wax was applied to an artificial mandible as seen in the figure 6.

Fig. 6.

Access Opening and Visual Working Length:

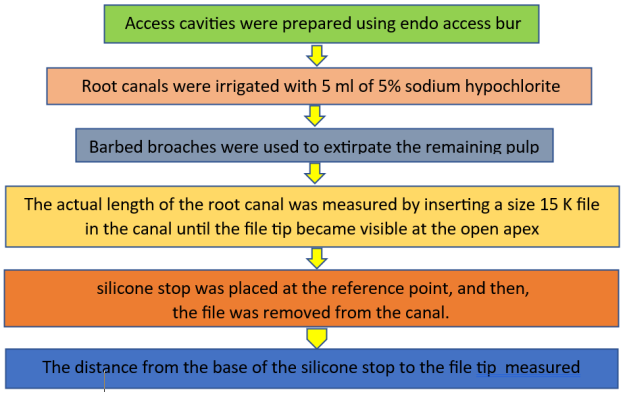


Fig. 7.

Including Sample in Electronic and Alginate Apex Locator Measurement:

Up to the cement-enamel junction, samples are immersed in a freshly prepared alginate mold. At the same time, the labial clip is put into the mold.

Fig. 8.

These samples—sodium hypochlorite, saline, blood, and saliva—were employed in our study. the saliva and blood. I directly drew blood and saliva from the patient's mouth (there are no synthetic mediators). Now a file of size 15k is taken and trimmed to the location of the apex. Using apex locators made by Root ZX small and Propex Pixi, the electrical measurements were captured.

Fig. 9.

Evaluation of Working Length Using Root ZX Mini J Morito:

The reading indicates that the sample has reached the apex after I added blood and saliva to it.

- As can be seen in the image, the reading was accurate because it reached the (mark 00).

Fig. 10. Saliva & Blood

In the second sample saline is incorporated and the reading are made. It showed that it had reached exactly till the apex as shown in the figure (mark 00).

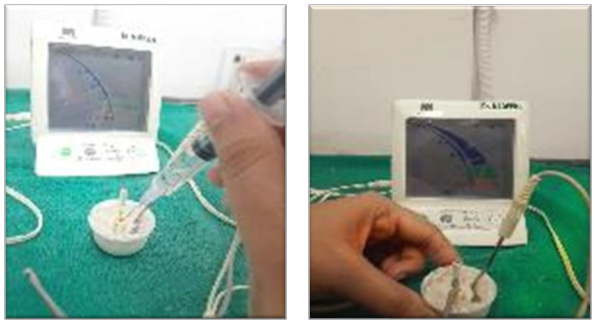


Fig. 11. Saline

In the third sample sodium hypochlorite is used. Sodium hypochlorite is incorporated to the sample and reading are made. It showed that it has reached till the apex as shown in the figure (mark 00).

Fig. 12. Sodium hypochlorite

Evaluation of Working Length Using Propex Pixi (Dentsply):

First the saline is taken and incorporated into the sample. The reading is taken and found that it has reached till the apex (mark 00).

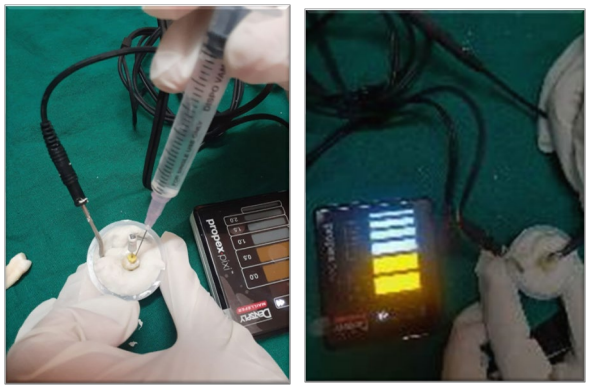


Fig. 13. Saline

In the second sample we have incorporated sodium hypochlorite and the reading are taken. In this it shows that there is 0.5mm difference in the reading as shown in the figure.

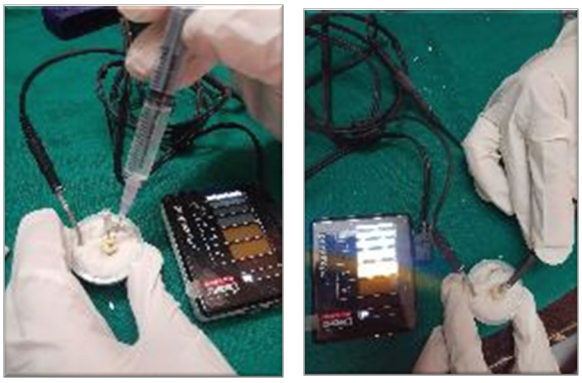


Fig. 14. Sodium Hypochlorite

In the third sample blood and saliva is incorporated and the readings are recorded. It shows that there is a 0.5mm difference in the reading as shown in the figure.

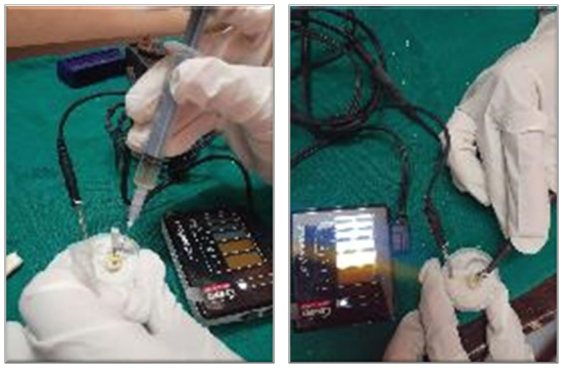


Fig. 15. Saliva & Blood

3. Statistical Analysis

After data gathering, Excel was used for data entry. Version 22 of the Statistical Package for the Social Sciences was used for data analysis (SPSS Inc, Chicago, IL). There was a non-parametric test applied. The Mann-Whitney U test was used to examine the data, and a significance level of p<0:05 was used.

Table 1
Results

Groups	N	Mean+SD	Minimum	Maximum
Visual length WL	30	15:05	12.21	17.72
CBCT WL	30	15:02	12.23	17.80
Apex locator Root ZX mini	30	15:03	12.12	17.64
Apex Locator Propex Pixi (Dentsply)	30	13:3	11.21	18.23

Mann–Whitney U test was used to analyze the data

Descriptive statistics of the Mean values of WL including minimum and maximum values recorded in different groups.

The mean differences between Visual Working Length and CBCT Working Length were statistically insignificant, according to group comparisons (p> 0:05). The average differences between Visual Working Length and Root ZX mini were likewise discovered to be statistically negligible (p > 0:05). According to the study's findings, Propex Pixi had the largest statistically significant difference from VWL, CWL, and Root ZX mini (p 0> 0:05).

The percentage of recordings measured in each group that were within 0.5 mm VWL was used to calculate accuracy. Within 0.5 mm of VWL, we observed accuracy of 100% CWL, 90% Root ZX mini, and 70% Propex Pixi in this investigation (Table 2). Figure presents the CWL measurements.

Table 2

Groups	n	Mean Difference
CBCT WL	30	0.0
Apex Locator Root ZX mini	30	0.25
Propex Pixi (Dentsply)	30	1.90

Mean difference between Visual WL and WL recorded by different Electronic Apex Locator

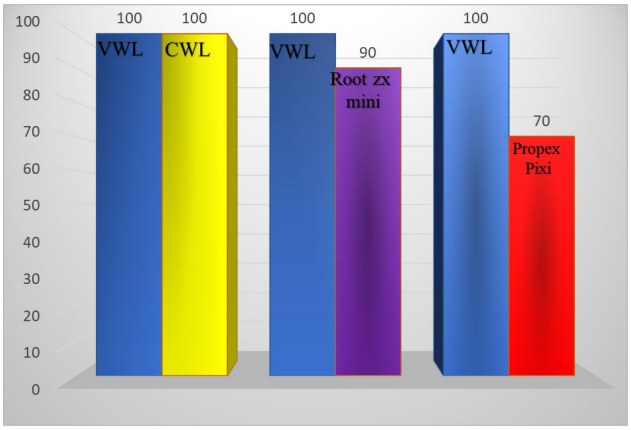


Fig. 16. Accuracy of CBCT WL, Root ZX mini, and Propex Pixi when compared with Visual WL
VWL: Visual Working Length
CWL: CBCT Working Length

4. Discussion

The correctness of the WL determines the outcome of any endodontic procedure. According to epidemiological research, effective treatment of WL is necessary for a positive endodontic result. According to histological research, the periapical tissues and root filling material should not be in direct contact for the best healing. An open apex may persist during the development stage as a result of pulpal necrosis brought on by injury or caries. Furthermore, iatrogenic over instrumentation or root section may be the cause. This results in a very large opening where it is challenging to make an apical stop.

Compared to traditional X-rays, the Electronic Apex Locator's creation made it possible to estimate the time of an operation with greater predictability. One of the most thoroughly studied Electronic Apex Locators is the Root ZX small, which serves as the benchmark for evaluating more recent EAL models. According to studies, its accuracy lies between 50% and 100%.

According to this study, CBCT Working Length is just as precise and dependable as Visual Working Length, the industry standard. In practise, it may be challenging to find CBCT machines in every dentist worldwide. Those who have an open apex can also not have CBCT records.

5. Conclusion

Of the Electronic Apex Locators, the Root ZX mini performed more accurately than the Propex Pixi. Previous CBCT scans are helpful to the physician in determining the operative length in open apex cases.

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