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AN *In-vitro* EVALUATION OF ACCURACY OF THREE ELECTRONIC APEX LOCATORS IN THE PRESENCE OF 3% SODIUM HYPOCHLORITE

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AUTHORS' CONTRIBUTIONS

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The condition known as the variation of the apical foramen and asymmetrical root canal opening is identified when the main foramen of the root canal is not situated at the anatomical apex. Under these conditions, it is possible to determine the working length incorrectly, which might result in many issues that could compromise the effectiveness of the endodontic procedure. In this work, we examined the apical foramen detection accuracies of these three EALs in 3% sodium hypochlorite (NaClO).

Materials and Procedures: To clean the teeth and remove organic material stuck to the exterior root surfaces, they were placed in a solution of 3% sodium hypochlorite for six hours. A #15, K-File was used to randomly choose teeth from 1 to 80 for measuring (Mani).

Results: Three apex locators failed to detect the apical foramen in the presence of 3% sodium hypochlorite, according to Newman-Keuls multiple posthoc procedures. Dentaport ZX was 90% accurate in finding the apical foramen, Apex NRG was 87.5% accurate, and Propex II was 81.25% accurate within 0.5 mm of the acceptable therapeutic range.

Conclusion: EALs may function on an electrical basis rather than the biological characteristics of the tissues involved, according to some research. In vitro models that have periodontium-like electrical resistance may thus provide useful information.

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1. INTRODUCTION

One of the key criteria for endodontic success, which relies on accurately determining the working length, is the cleaning and shaping of the root canal system. When the principal foramen of the root canal is not found at the anatomical apex, it is known as the asymmetrical root canal opening phenomenon or deviation of the apical foramen [1]. The main apical foramen's degree of departure is unexpected and may deviate greatly from the norm. Under these conditions, it may be difficult to accurately determine the work duration, which may result in a number of issues that might compromise the effectiveness of the endodontic procedure. Under-instrumentation causes the root canal system to be insufficiently cleaned, which may lead to microbial infection, post-operative discomfort, and endodontic failure [2,3].

The working length has historically been determined using a variety of approaches, including the tactile sense method, apical periodontal sensitivity, paper point measurements, and radiographic procedures [4]. Radiographs are now the most widely used method, although they only provide a two-dimensional representation of a three-dimensional structure.

The reliability of the electronic apex locator (EAL) performance may be impacted by high electroconductive media such as blood, saline, a local anaesthetic solution, irrigant fluids, and sodium hypochlorite [5]. Due to its ability to dissolve tissue, sodium hypochlorite is one of these irrigants most commonly utilised in endodontic procedures. So, sodium hypochlorite is employed in this research.

In this work, we examined how well each of these 3 EALs detected the apical foramen when there was 3% sodium hypochlorite present.

1.1 Aim and Objective

Comparison of Dentaport ZX, Propex II & Apex NRG to locate the apical foramen in the presence of 3% sodium hypochlorite.

2. LITERATURE REVIEW

Abdelsalam and Hashem [6] conducted several tests on patients and found that regardless of the patient's age or the shape and kind of teeth, the electrical resistance among the oral mucous membrane and Periodontium remained constant. The resistance concept was the foundation for the first generation of apex locators. The resistance among the two electrodes was measured by these apex locators.

In yet another research, Iontophorosis was the subject of experimental research [7]. He concluded that there is a continuous electrical resistance of around 6.5 Kilo ohms between the mouth mucosa and the periodontal membrane.

The influence of foramen shape on the apex locator was studied by [8]. According to the authors, the use of EALs was marginally more reliable than the radiographic approach.

In order to determine if the current electronic apex locators are accurate in determining root canal working length [9]. The four EAL tested (Root ZX, Endy, Justy II, and Endox) had varying degrees of accuracy in determining working lengths, but generally, current EAL provided a trustworthy approach for determining endodontic working lengths.

An *In vitro* evaluation of the accuracy of three electronic apex locators was performed by [10]. The authors claimed that the recommended electronic root canal measuring was a reliable, objective method.

Ex vivo investigation of the capability of four distinct electronic apex locators to measure the working length of teeth with differing foramen diameters was carried out by [11]. It was determined that, while utilising a small size file, the four EALs were unreliable for estimating the working length of teeth with large apical foramen. If a tight-fit file is utilised, the Root ZX and Foramatron D10 may be more accurate in determining the working length of teeth with a large apical foramen. These two EAls performed much better than the other two (Apex NRG, Apit 7).

3. METHODOLOGY

3.1 Data Source

This *In vitro* study was carried out in the Department of Conservative Dentistry and Endodontics, School of Dental Sciences, Karad. 80 freshly extracted human single-rooted premolars were selected for the study. Teeth with fully formed apices, intact root with no cracks, no calcification, no internal resorption or previous root canal treatment

3.2 Preparation of Samples

The teeth were stored in 3% sodium hypochlorite solution for 6 hours to remove organic debris, which adhered to external root surfaces and disinfected. The

samples were stored in sterile 0.9 % saline until use. The coronal portion of each canal was flared using sequential Gates Glidden drills, #3, #2 and #1, in a crown-down fashion using Gates Glidden drills in a low-speed contra-angle handpiece.

3.2.1 Measurement of actual working length

A #15, K-File was used to randomly choose teeth from 1 to 80 for measuring (Mani). The file was moved until the tip could be seen under 2.5x resolution with the magnifying lenses, right within the apical foramen. Electronic callipers were used to measure the distance between the tip of the file and the base of the stopper. Only five measurements were made using files and stoppers, which were then discarded.

To irrigate the canals, 3% sodium hypochlorite was employed, and cotton pellets were applied to dry the tooth surface as well as remove any extra irrigation fluid. When the signal on the monitor flashed "APEX" or "0.0," a metal lip clip was put in contact with the alginate and a 15# K-file was connected to the file holder subsequently inserted into the canal. If a measurement remained steady for at least five seconds, it was deemed to be reliable. Three measurements were made for each tooth. Each electronic apex locator's findings (in mm) were recorded in separate tables.

Three apex locators were used to electronically determine the working length of each tooth amongst eighty specimens. A single operator carried out the whole procedure as well as recorded the test readings.

Fig. 1. Tools and materials for the study

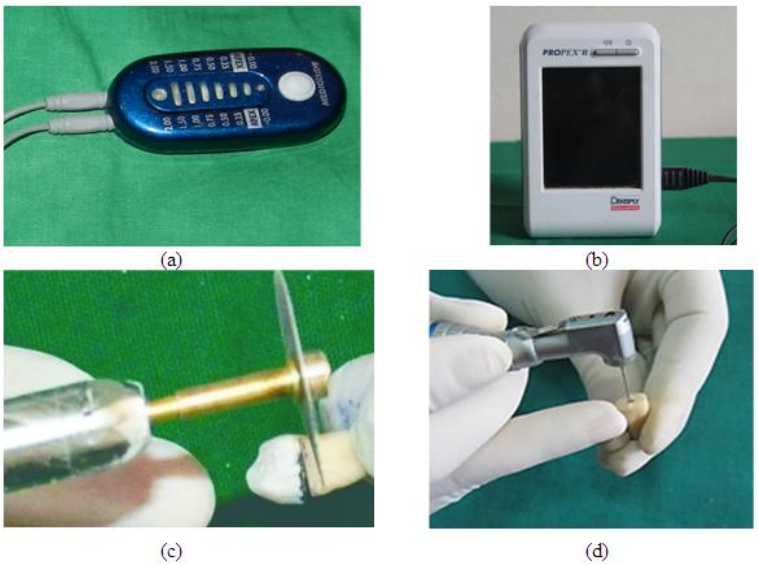

Fig. 2. Apex locators and procedure a) Apex NRG, b) Propex II, c) Decoronation with the diamond disk, d) Gates Glidden Drills #3, #2, #1 for third coronal preparation

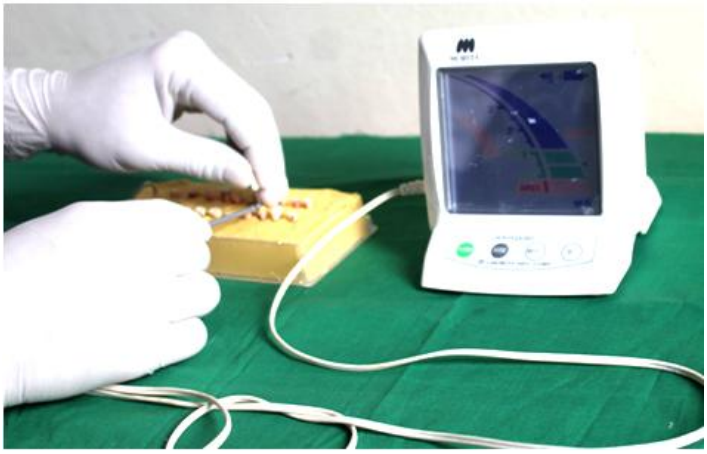

Fig. 3. Locating apical foramen using Dentaport ZX apex locator in the presence of irrigant

The alternating current source in the impedance ratio-based apex locators is once again a two-frequency source, comprising of 2 sine waves with a low a and high frequency (fL and fH, respectively).

$$\text{Ratio} = \frac{Z(fH)}{Z(fL)}$$

The impedance of the model is measured at each frequency, and the position of the file is determined from the ratio between these two impedances.

4. RESULTS

The comparison of apex locators with real functioning lengths was done using a one-way ANOVA test (Table 1 – Table 4). The capacity of Dentaport ZX, Apex NRG, and Propex II EALs to precisely find the apical foramen in the presence of 3% sodium hypochlorite was not significantly different, according to statistical analysis. Dentaport ZX, Apex NRG, and Propex II had mean discrepancies between electronic and real lengths of 0.10 mm, 0.15 mm, and 0.15 mm, respectively.

Three apex locators failed to detect the apical foramen in the presence of 3% sodium hypochlorite, according to Newman-Keuls multiple posthoc procedures.

Dentaport ZX was 90% accurate in finding the apical foramen, Apex NRG was 87.5% accurate, and Propex II was 81.25% accurate within 0.5 mm of the clinically acceptable range.

In 8 samples (within 0.5 mm of the clinically acceptable range), Root ZX was unable to find major foramen; of these, five samples had working lengths that were overstated, and 3 samples had working lengths that were underestimated (Table 3).

In 10 samples, Apex NRG failed to find major foramen (within 0.5 mm of clinically acceptable range), of which 8 indicated excessive length and 2 showed working length that was underestimated.

In 15 samples (within 0.5 mm of the clinically acceptable range), Propex II was unable to find major foramen; of these, ten samples indicated overstated length and 5, underestimated working length.

Table 1. Mean, SD, SE of length (in mm) in four groups

Groups	N	Mean	Std.Dev.	Std. Error
Control group	80	13.89	1.98	0.22
Dentaport ZX group	80	13.99	1.98	0.22
Apex NRG group	80	14.04	1.99	0.22
Propex II group	80	14.04	1.94	0.22

Table 2. Comparison of four groups with respect to length (in mm) by one way ANOVA test

Sources of variation	Sum of squares	Degrees of freedom	Mean sum of squares	F-value	p-value
Between groups	1.14	3	0.38	0.0973	0.9615
Within groups	1229.25	316	3.89		
Total	1230.39	319			

Table 3. Pair wise comparison of four groups with respect to length (in mm) by Newman-Keuls multiple posthoc procedures

Groups	Control group	Dentaport ZX group	Apex NRG group	Propex II group
Mean	13.8913	13.9863	14.0378	14.0365
Std.Dev.	1.9846	1.9759	1.9920	1.9362
Control group group	-			
Dentaport ZX group	P=0.7607	-		
Apex NRG group	P=0.9657	P=0.9851	-	
Propex II group	P=0.8873	P=0.8720	P=0.9968	-

Table 4. Pair wise comparison of four groups with respect to differences of length (in mm) from actual length by Newman-Keuls multiple posthoc procedures

Groups	Dentaport ZX group	Apex NRG group	Propex II group
Mean	0.3720	0.4629	0.4957
Std.Dev.	0.0416	0.0518	0.0554
Dentaport ZX group	-		
Apex NRG group	P=0.7461	-	-
Propex II group	P=0.4767	P=0.9859	

5. DISCUSSION

It is impossible to understand foramen that finish on the buccal or lingual sides. The quality of the radiographs is influenced by radiographic technique and the radiograph producing process. Several anatomical features, such as impacted teeth, tori, the zygomatic arch, excessive bone mass, overlapping roots, or shallow palatal vaults, may block the view of the apical region of the canal system [3]. All of these things reduce how effective radiographs are.

Endodontic failure cases have been shown to occur beyond the foramen even though the canal looked to be filled up to the apex on radiographs. According to apicoplasties and subsequent histological sections, the obturation material protruded further into the periodontal ligament from a foramen on the radiograph that ended a few millimetres short of the apex. This failure may cause the patient pain, infection, or the obturation of material beyond the canal's boundaries [9]. Therefore, the precise location of the apical foramen must be precisely established in order to avoid misunderstanding of the working length and consequent difficulties of over-instrumentation and over-filling of the root canal.

Third-generation apex locators have the primary benefit of performing effectively even in the presence of pus or electroconductive conditions in the canal [7]. However, a drawback of the different approach is that calibration must be performed repeatedly.

There have been initiatives to further improve apex locators' accuracy. Using more than two frequencies to assess the impedance characteristics was one idea. Fourth-generation apex locators are what these devices are known as. Five distinct frequencies have been employed in the Endo Analyzer 8005 (Analytic Endodontics, Sybron Dental, Orange, CA, USA) and AFA Apex Finder 7005 (Analytic Endodontics), and each frequency's impedance is measured for both its phase and amplitude [12]. The position of the foramen is then determined by analysing these data.

The current in vitro study's comparison of Dentaport ZX's (Group II), Apex NRG's (Group III), and Propex II's (Group IV) apical foramen locator performance in the presence of 3% NaClO as its main goal. Actual lengths from the three groups were analysed using the visual assessment approach (Group I). Statistics revealed that the ability of Root ZX, Apex NRG, as well as Propex II EALs to correctly locate the apical foramen did not vary significantly from one another. Dentaport ZX was 90% accurate, Apex NRG was 87.5% accurate, and Propex II was 81.25% accurate with +/- 0.5 mm of clinically acceptable accuracy in finding the apical foramen. Their precision may be due to improved operating mechanisms.

6. CONCLUSION

In this work, we assessed the three apex locators' capacity to identify the apical foramen in the presence of 3% NaClO. The research comprised teeth with completely developed apices, undamaged roots without fissures, no calcification, no internal resorption, or prior root canal therapy. There is no statistically significant difference between the Dentaport ZX, Propex II, and Apex NRG apex locators' abilities to locate the apical foramen in the

presence of 3% sodium hypochlorite. A follow-up in vivo investigation is necessary to determine if three apex locators can detect the apical foramen when different irrigants are present since just one irrigant was employed in the study. Consequently, EALs may function on an electrical basis rather than the biological characteristics of the tissues involved, according to some research. In vitro models that have periodontium-like electrical resistance may thus provide useful information.

CONSENT

As per international standard or university standard, patient(s) written consent has been collected and preserved by the author(s).

ETHICAL APPROVAL

As per international standard or university standard written ethical approval has been collected and preserved by the author(s).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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