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To Evaluate the Accuracy Between Two Different Electronic Apex Locators to Detect the Root Canal Perforation During Retreatment - An Ex-Vivo Study

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Abstract

Objectives: To evaluate the accuracy between two different electronic apex locators in detecting the root canal perforation in the middle and apical portion during retreatment. **Methods:** Sixty freshly extracted mandibular premolars were taken in to this study, which were divided into three groups of twenty each. Group I: Control Group, Group II: Positive control without perforation, Group III: Negative control with perforation. In all the groups, access cavity preparation was done followed by cleaning and shaping using X smart Endomotor and Protaper Gold file system (Dentsply Maillefer, Switzerland). The specimens were prepared such that perforation was made in group III on the mesial side of the root at middle portion approximately 5mm from the apex after determining working length by direct visualization and stored for the database. All the specimens were obturated by using AH plus sealer and F3 Protaper gold gutta percha points and later stored in incubator at temperature of 37°C for 7days. After 7 days, gutta percha was removed from group III samples using gutta percha solvent (Xylene), Neo-Endo retreatment files. These teeth were mounted on Protrain Endodontic training kit (Simit Dental, Italy) and perforation were detected using apex locators Dentaport Root ZX (J, Morita) and Propex Pixi (Dentsply Maillefer, Switzerland). The apical perforation were made at a distance 2mm from apex after the middle perforation were restored by using Type II GIC by keeping the 35 K file inside the canal and apical perforations were detected and the reading were recorded and stored for the database. **Statistical Analysis:** The data obtained were analyzed by using descriptive statistics, ANOVA (Analysis of Variance), Paired t test through SPSS for window (version 22.0). **Findings:** In case of middle third perforation of the root canal Dentaport Root ZX showed accuracy of 87.37% and Propex

pixi 82.89%. In apical perforations the accuracies of Root ZX and Propex Pixi are 89.28% and 79.76% respectively. In the both the perforations, there was a statistically significant difference ($P < 0.05$). In both the perforations, Dentaport Root ZX showed more accuracy in detecting the perforation when compared with Propex Pixi apex locator. **Novelty** : This study provides a novel approach as it compares the accuracy between the Dentaport Root Zx and Propex Pixi in detection of middle and apical perforation during retreatment in Ex Vivo study.

Keywords: Dentaport root ZX; Electronic apex locator (EAL); Propex pixi; Protrain endodontic training kit; Root canal perforation

1 Introduction

For an endodontic therapy to be successful there should not be presence of any clinical symptoms and radiological evidence which includes bone loss and non-healing lesions. If these symptoms persist the case may be considered for retreatment, the main causes of endodontic failure are:⁽¹⁾

1. Incomplete removal of remnants of the pulp tissue in isthmus
2. Missed canals
3. Apical transposition and root perforation
4. Reinfection and flare ups

The success rates of endodontic therapy can be influenced by root perforations which is one of the most difficult procedures to deal with during retreatment.⁽¹⁾ Perforation can either be due to caries or resorptive process or could be iatrogenic(3-10%). Many factors contribute to the healing of these perforation sites, including the time from detection of the perforation and its closure, the size and shape of the perforation, and its location. Small perforations are easier to cure and hence have a better chance of healing predictably.^(2,3) There are various methods to detect these perforations such as paper points, radiographs and electronic apex locators.

Radiographs can be a supplementary aid in detecting perforations but their diagnostic ability is limited as they are 2-dimensional and it is difficult to locate if present buccally or palatally. Electronic apex locators can work as an excellent aid to radiograph in detecting these perforations with accuracy of around (75-90%).⁽⁴⁾ Also due to growing concerns about radiation hazard and patient safety, electronic apex locators can be a feasible option, economical as well as more accurate.^(5,6)

Thus this study is an ex-vivo study which aims to detect accuracy between two different apex locators Dentaport Root ZX and Propex Pixi in detecting root canal perforation during retreatment.

2 Methodology

2.1 Settings and Design

Sixty extracted human mandibular premolars were selected and stored in physiological saline solution throughout all the experimental procedures.⁽⁷⁾ Tooth inclusion criteria includes single rooted mandibular premolar, recently extracted teeth, teeth extracted due to periodontal or orthodontic reasons, teeth free from caries, teeth without calcified canals, teeth without any type of fractures. Tooth which were excluded in this study were carious teeth, attrited teeth, fractured teeth, teeth with developmental defects, teeth with internal and external resorption.

2.2 Sample Collection and storage

- **Human teeth collection**
 - Human mandibular permanent premolar teeth were provided by JSS Dental College and Hospital, Mysore's "Department of Oral and Maxillofacial Surgery.
- **Storage**
 - A total of 60 single-rooted mandibular premolars were gathered, all of which were found to be in good condition, devoid of caries, cracks, wear lesions, or developmental anomalies. They were then washed with regular saline. Teeth were inspected under a stereomicroscope (Lawrence and Mayo) at 20x magnification by after cleaning to find any exterior cracks.
 - They were examined and then stored in a 0.9 percent sodium chloride water solution at room temperature for one week before being used.⁽⁷⁾

2.3 Access Opening followed by Cleaning and Shaping

- After proper selection of the tooth samples, access cavity preparation was performed in all the given samples by using 0.5mm round and carbide point burs.
- After that working length was determined by using #10 K file by Direct Visualization Method keeping it 0.5mm short of apex was recorded.
- Later, Cleaning and shaping was performed initially by hand files starting from 10 k ,15k and till 20k by using proper chelating agents such as EDTA gels followed by intermittent irrigating solutions such as 1.25% NaOCl and finally rinsed by normal saline
- After that, cleaning and shaping was done by using Protaper Gold rotary files till F3. Each file was used five times only with proper torque and speed given by manufacturer's recommendation by using crown down technique with intermittent irrigation by 1.25% NaOCl.

2.4 Procedure and Grouping

- Specimens were sorted into three groups of 20 samples each
- The Groups include:
 - Control Group (n=20)
 - Group (A) Positive Control without perforation (n=20)
 - Group (B) Negative Control with perforation (n=20)
- In the **Group (A)** the cavity was prepared for access, and the working length was measured by using direct visualization method, followed by cleaning and shaping by using hand and rotary files till F3. These were later obturated by coating with AH Plus sealer by using F3 Gutta Percha cone
- In the **Group (B)** access cavity preparation and working length was measured by using direct visualization method after which two perforations were done on mesial side of the root. The apical third of the root and middle third of the root area 5mm and 3 mm from the apex respectively with 0.5mm round bur by using slow speed micromotor handpiece.
- The canal was prepared and cleaned and shaped using hand and rotary files till F3
- Perforation was checked by passive passage of file through the perforation

2.5 Making Middle Perforation

- With the help of 0.5mm round and straight fissure bur perforations were made such that the bur could move easily in the site of perforation on the mesial side of the root approximately at around 5mm from the apex of the root
- Perforation were made such that 10k file was very passively moving through the perforation

2.6 Obturation and placing in the incubator

- Then Later, Obturation was done using single cone technique using F3 gutta percha cone and AH plus sealer.
- After that, all the teeth samples were incubated for 37°C, 100% humidity for 7 days.

2.7 Gutta percha removal and mounting

- After 7 days Gutta percha were removed by using Neo-Endo Rotary Re-treatment Files from N1 (30/09) in the coronal part, N2 (25/08) in the middle one third and N3 till 20 / .07 in apical one third at a speed of 350 RPM of Torque: 1.5Ncm and the canals were later checked for complete removal of gutta percha under an operating microscope. Later, teeth were mounted on the Protrain Endodontic training kit (Simit Dental, Italy) in which normal saline was used as a standard electroconductive solution.
- One end of the electronic apex locators, i.e. the negative electrode, was connected to the endodontic training system, and The apex locator's positive electrode was coupled to the file through a file holder put into the training kit's tooth
- Here, two electronic apex locators were used to check the accuracy between them
 - Dentaport Root ZX (J. Morita, Japan)
 - Propex Pixi (Dentsply, Switzerland)

2.8 Detecting the Middle Perforation

- After removing the gutta percha and mounting the tooth in the endodontic training system. The circuit consisting of apex locators and endodontic training system was complete using a MANI 10 k file for the detection of the middle perforation
- In case of Root ZX apex locator the perforation detection was shown as "APEX" on the screen and for Propex Pixi the perforation detection was shown as OVER reading on the screen and this was achieved and verified when the length of the file was 5mm less as that of the initial working length which was taken by direct visualization method
- The reading of all the samples were recorded by Root ZX and Propex Pixi and were stored for the data base

2.9 Making Apical Perforation

- Apical perforation was done by using the 0.5mm round bur made at 2mm distance from the apex of the root

2.10 Detecting Apical Perforation

- Before starting the procedure the middle perforation was sealed by using Type II glass ionomer cement in order to reduce the error for the reading between the two different perforations
- Size 30 k file (MANI) was placed inside the canal and the middle perforation was restored by type II restorative GIC
- After 24 hrs, the tooth was mounted on the endodontic training system with the completion of the circuit as performed in the phase I
- Then, by using two different apex locators reading were recorded and perforation detection was verified by reducing 2mm from the initial working length reading
- In this way all the reading of the samples were recorded and stored in the data base

3 Statistical Analysis

All the data were subjected to Statistical analysis, One way Anova with a p value <0.05 was used to determine significance. Paired t test was used to find comparison between all the groups. All the statistical analysis were carried out using SPSS for windows version 22.

4 Results and Discussion

In case of middle perforation Dentaport Root ZX showed accuracy of 87.37% and Propex pixi 82.89%. In apical perforations the accuracies of Root ZX and Propex Pixi are 89.28% and 79.76% respectively. In the both the perforations, there was a statistically significant difference i.e (P < 0.05)

Graph and table of descriptive statistics of middle and apical perforations detected by Dentaport Root ZX and Propex Pixi (Tables 1 and 2)

Table 1. The mean values of the middle perforation between direct length and two different apex locators

| | |
|------------|---------|
| Mid_Direct | 14.9833 |
| Mid_Rootz | 13.6167 |
| Mid_Pixi | 13.0333 |

Table 2. The mean values of the apical perforation between direct length and two different apex locators

| | |
|------------|---------|
| Api_Direct | 18.7167 |
| Api_Rootz | 16.7667 |
| Api_Pixi | 14.1833 |



Fig 1. Image of passive movement of 10 K file through the middle perforation



Fig 2. Image of apical perforation and passive movement of file through the perforation



Fig 3. Image of experimental setup of the Propex Pixi (Dentsply Sirona) apex locator for detecting the middle and apical perforation



Fig 4. Image of experimental setup of the Dentaport Root ZX (J Morita) apex locator for detecting the middle and apical perforation

4.1 Discussion

Root canal perforation is a complication which can occur during root canal treatment.⁽⁷⁾ This can occur either pathologically due to resorptive process or caries or iatrogenically which can occur during root canal treatment. During access cavity preparation, root canal cleaning and shaping, and post-space preparation, iatrogenic root perforations are most common.⁽⁸⁾ According to American Association of Endodontics (AAE), perforations can be defined as a mechanical or pathological communication which occurs between root canal and external surface of the tooth.⁽¹⁾

Pathological perforations are detected during routine clinical examination, whereas iatrogenic root perforations are generally noted during operative procedures. Endodontic therapy failure can happen from procedural operating errors at any moment during root canal treatment. These can be detected with the help of many tools and devices such as radiographs, CBCT, dental operating microscopes and apex locators⁽⁸⁾

Generally, Apex locators are used for the working length determination as an alternative to radiographs which reduces the patient exposure to radiation, and also reduces the operator's chair time.⁽⁹⁾ According to another study, apex locators are the best devices which serve as a useful guide for working length determination when compared with conventional radiograph and tactile sensation.⁽⁹⁾ EAL efficiencies range from 81.5 to 97% when compared with radiographs as also shown in many clinical studies⁽⁹⁾

Basically, there are seven generations of the apex locators, Root ZX apex locators belong to third generation apex locator. The device runs on comparative impedance and has a high powerful microprocessor designed by J. Morita (JAPAN) which showed the best accuracy amongst all the apex locators to detect the working length⁽¹⁰⁾

There are more advanced generations of the apex locators in the present time which includes, Propex Pixi which is the 5th generation apex locator from the Dentsply Maillefer, Ballaigues, Switzerland has also proved to be efficient in determination of working length during conventional root canal preparation as well as during retreatment⁽¹¹⁾

When compared to previous generations of EAL, third generation EAL have powerful microprocessors that handle the mathematical quotient and algorithm computations that must be performed in order to obtain accurate readings and Dentaport Root ZX has been shown to give accurate measurements. This has also been confirmed in previous studies^(12,13)

Dentaport Root ZX works on the principle of two-frequency impedance (0.4 and 8 kHz). When the file is in the canal, the ratio of these two frequencies has a definite value; however, as the file gets closer to the apical constriction (AC), the ratio decreases and has a value of 0.72 at the apical constriction⁽¹¹⁾. In another study it was confirmed that, Dentaport Root ZX works by computing the impedance ratio of 0.72 perceptible at 0.5 mm short of the (apical foramen) AF⁽¹¹⁾

Root ZX shows 90% and 89% accuracy in the middle perforation and apical perforations because, in this situation, the perforation site acts as the narrowest canal i.e. apical constriction (minor diameter) and the cleaned and shaped canal, acts as apical foramen i.e. (Major diameter). This was also confirmed by a study done by Manual Harrera et al.⁽¹²⁾

Propex Pixi is 5th generation apex locator known as adaptive type apex locators which give readings in dry as well as moist canals. A study conducted by Shori Deepa et al, states that in closed apex cases, Root ZX and Propex Pixi are equivalent, but Propex Pixi is more accurate in open apex cases⁽¹³⁾.

According to one study, EAL accuracy in retreatment cases was 83.3% for Dentaport ZX, 83.4% for Propex Pixi, and 80% for iPex II within a tolerance of 0.5 mm of the AWL.⁽¹⁴⁾

In this study, Propex pixi in the middle root canal perforation showed 86% accuracy and 75% accuracy in the Apical root canal perforation detection which is less as compared with the Dentaport Root ZX apex locator which showed around 90% and 89% accuracy respectively. ⁽¹⁵⁾ This might be due to the presence of irrigating solutions or penetration of the conducting media into the root canal. ⁽¹⁶⁾ Due to this there might be the chances of inaccurate readings, as mentioned in the manufacturer's recommendations. Another study also confirmed that presence of irrigating solutions affected the accuracy of the propex pixi in middle as well as in the apical perforations as compared with the Dentaport Root ZX. ^(16,17)

5 Conclusion

- This study presents a novel approach which compares the accuracy between the Dentaport Root Zx and Propex Pixi in detection of middle and apical perforation during retreatment. Dentaport Root ZX apex locator (J. Morita Co., Kyoto, Japan) has been extensively used for in vivo and ex vivo studies and has become the gold standard to which new devices are compared. ⁽¹⁸⁾
- Dentaport Root ZX apex locator showed more accuracy in detecting the apical and middle root canal perforation when compared with the Propex pixi apex locator.

6 Limitations of the Study

- Since this was an ex vivo study the results obtained here, cannot be directly correlated to clinical situations.
- Mandibular premolars were selected for this study, if other tooth were taken then study would have facilitated more validation of the results.

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