

Evaluation of the Use of Sixth Generation Apex Locators as a Diagnostic Tool to Detect Root Perforations

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ABSTRACT

Aim: The sixth generation apex locators served as an efficient diagnostic tool for detecting root perforations as these are based on the principle of impedance rather than the conventional gradient method. However, their diagnostic accuracy not evaluated well. In the existing study, we assessed and compared the efficacy of two apex locators for diagnostic perspective.

Materials and Methods: A total of 32 extracted teeth were perforated and mounted using alginate (Alginate Impression Material, 3M ESPE, USA). Two different apex locators - Raypex® 6 Apex Locator (VDW) and ProPex Pixi (Dentsply, USA) were used to detect the intentionally created root perforations (i.e., distance from file tips to external outline of the root surface). The two apex locators measured the same root perforations and compared statistically. **Results:** The mean distance from file tips to external outline of the root surface was found significantly different and lower (59.9%) in Raypex® 6 Apex Locator as compared to Propex Pixi (mean ± standard deviation: 0.39 ± 0.04 vs. 0.16 ± 0.02, $t = 30.57$, $P < 0.001$).

Conclusion: We found Raypex® 6 Apex Locator better for root perforations.

Key words: Apex locators, diagnostic tool, over instrumentation, root perforations, sixth generation


INTRODUCTION

Root canal perforations can be explained as an artificial communication between the root canal system and the supporting tissues of the teeth or the oral cavity.^[1] Root canal length (working length, root length, tooth length) during the endodontic procedure and its determination is an important step in root canal treatment. Correct working length determination is one of the main factors leading to success in root canal treatment. Endodontic anatomy of primary

teeth, in particular of molars is difficult to predict because the resorption of the roots causes the shape, dimension and position of the root apex to change continuously. This makes it difficult to determine the exact location of the actual apex. Very often, the cause is iatrogenic due to misaligned application of rotary burs during endodontic access preparation and search for root canal orifices in the root canal treatment.^[2-4] Accidental root perforations may complicate the endodontic treatment, for example, during efforts to negotiate calcified and curved canals as well as following the lateral extension of the canal preparation to a so-called strip-perforation.^[5] Inaccurate post space preparation for the permanent restoration of endodontically treated teeth is another common iatrogenic cause of root perforation and non-iatrogenic causes include root resorption and caries.^[3,4,6-9]

Accidental root perforations may have serious implications. They occur in approximately 2-12% of endodontically treated teeth.^[4,10-14] Bacterial infection emanating in teeth or apex

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of teeth either from the root canal or from the periodontal tissues, or both, prevents healing and brings about inflammatory sequelae where exposure of the supporting tissues is inflicted. Thus, it results in painful conditions, suppurations resulting in tender teeth, periapical abscesses, and fistulae including bone resorptive processes may follow.

Once an infectious process has entrenched itself during the endodontics procedure at the site of perforation in the teeth, the prognosis for treatment is precarious, and thus the complication may result for the extraction of the affected tooth.^[10,15] Yet if the infection process is diagnosed early and properly managed, prolonged survival of the tooth is possible.

The anatomy of the pulp space is very complex. To achieve success in endodontics, the variations in the internal anatomy should be thoroughly understood. A simple classification has been put forth by Vertucci to explain the various patterns which a pulp space may present. It is of immense importance to differentiate between anatomic apex, apical foramen, and apical constriction. An endodontist has no concern beyond the constriction in conventional endodontic therapy. The principle design and development of electronic apex locators (EALs) date back to research undertaken by Suzuki in 1942.^[16,17] He found that electrical resistance between the periodontium and oral mucous membrane in dogs was a constant value.

This study relates specifically to the diagnosis of root perforations with the aid of apex locators. We hypothesized that there may be a significant difference in root perforations between two apex locators (Propex Pixi and Raypex® 6 Apex Locator).

MATERIALS AND METHODS

The present study was conducted to evaluate the accuracy of two EALs, Raypex® 6 Apex Locator (VDW) and Propex Pixi (Dentsply, USA) in detecting root perforations. About 32 extracted teeth were perforated in the middle third of the root and embedded in alginate. Determination of root perforations in all the samples were carried out using #25 K-files attached to the apex locator selected.

A stepwise guide to use apex locators while suspecting a perforation:

A #10 file is connected to the device and is inserted into the suspected perforation



A dramatic increase in the electrical resistance immediately will be noticed if a true perforation is present



The apex locator’s analog readout shows a dramatic increase in the electrical resistance that is indicative of a “perforation.” This is in direct contrast to the gradual increase in the electrical resistance obtained while negotiating an intact root canal system.

Typical “in Canal” Reading

The file is introduced in the canal [Figure 1a] the analog readout shows only a little increase of the electrical resistance.

As the file advances, [Figure 1b] a gradual increase is noted.

The device [Figure 1c] indicates that the apical foramen has been reached.

Statistical Analysis

Data were summarized as mean ± standard deviation (SD). Distance from file tips to external outline of the root surface of two apex locators were compared by Student’s t-test. A two-tailed P < 0.05 was considered statistically significant.

RESULTS

The distance (mm) from file tips to external outline of the root surface was evaluated for both the sixth generation apex locators and summarized in Table 1 and also depicted in Figure 2. The distance in Propex Pixi and Raypex® 6 Apex Locator ranged from 0.32 to 0.47 mm and 0.10 to 0.20 mm, respectively, with mean (±SD) 0.39 ± 0.04 mm and 0.16 ± 0.02 mm, respectively. The mean distance in Raypex®

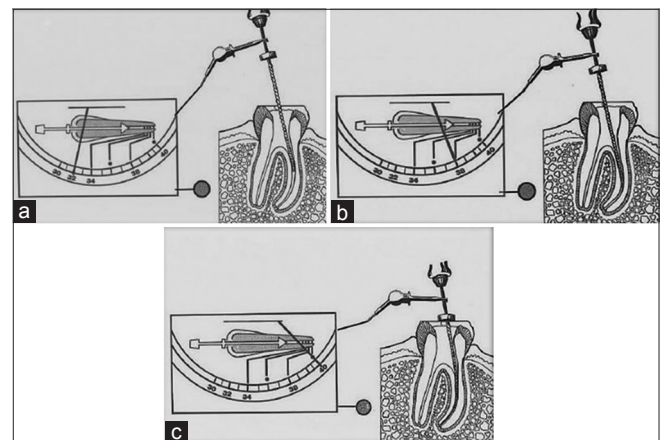


Figure 1: (a-c) Steps of use of Apex Locator

Table 1: Distance (mean±SD, n=32) from file tips to external outline of the root surface of two apex locators

Propex Pixi	Raypex® 6 Apex Locator	t value	P value
0.39±0.04 (0.32-0.47)	0.16±0.02 (0.10-0.20)	30.57	<0.001

Values in parenthesis indicates the range (min-max)

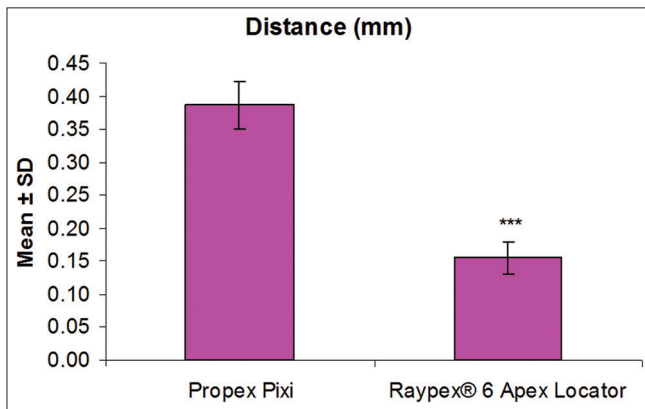


Figure 2: Distance from file tips to external outline of the root surface of two apex locators. *** $P < 0.001$ - as compared to Propex Pixi

6 Apex Locator was comparatively lower than Propex Pixi. Comparing the mean distance between locators, *t*-test revealed significantly different and lower (59.9%) distance in Raypex® 6 Apex Locator as compared to Propex Pixi (0.39 ± 0.04 vs. 0.16 ± 0.02 , $t = 30.57$, $P < 0.001$).

As Raypex® 6 Apex Locator detected root perforations more significantly thus may be better than Propex Pixi and hence can be used a reliable diagnostic tool to detect root perforations during endodontic treatment.

DISCUSSION

When clinical inspection and the conventional radiographic evidence are inconclusive in determining whether the root or pulpal floor is perforated, the apex locator can be used as a diagnostic tool to determine the exact extent of the root perforation so that it can be retreated and corrected until that point and avoid overfilling or under filling. Sixth generation apex locators, especially, Raypex® 6 Apex Locator has proved to be an efficient diagnostic tool in detecting root perforations.

Accurate detection of root perforations [Figure 3] and determination of location are crucial to the treatment outcome, certain signs, and tools must be recognized in making the diagnosis. Sudden bleeding and pain during instrumentation of root canals or post preparations in teeth are warning signals of a potential root perforation.^[18-22] The appearance of blood on paper points may also be indicative, but unreliable as bleeding may originate from the apical foramen or from residues of vital pulp tissue.^[23-25] To enhance radiographic detection, it has been proposed to place a highly radiopaque calcium hydroxide paste, by the inclusion of barium sulfate, in the root canal.^[26]

However, caution should be exercised in crestal perforations as this measure can result in extrusion of the material into the periodontal tissues and cause unnecessary mechanical

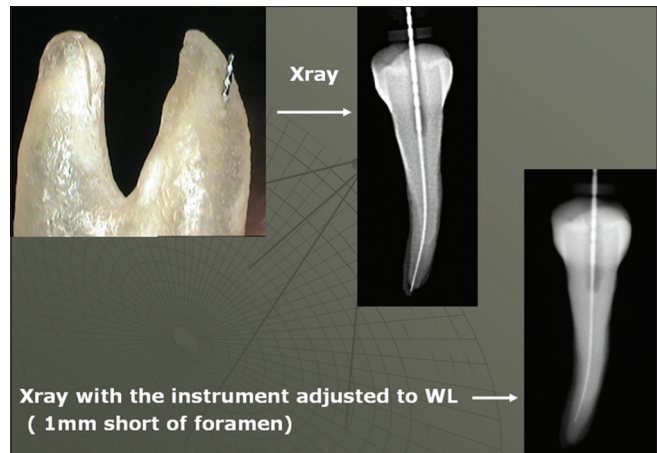


Figure 3: The mid-root region perforations in sectioned mandibular teeth

and chemical irritation impairing the treatment prognosis. Radiographs taken at different angles with radiopaque instruments in the root canal are a better option and may confirm the presence of a root perforation. However, when the perforation is located at the buccal or palatal aspects of the root, the diagnostic value of radiographs is limited.

Anatomical structures, as well as radiopaque materials superimposing on the image of the root, may also obscure the perforation site. EALs can accurately determine the location of root perforations, making them significantly more reliable than radiographs. After root instrumentation, it is recommended that the working length be verified with EALs. Readings, those are significantly shorter than the original length can be an indication of perforation.^[27]

A dental operating microscope is another helpful tool effective in detecting root perforations during orthograde root canal therapy and in surgical endodontic treatments.^[28,29] High magnification with coaxial illumination allows precise detection and visualization of perforations along straight non-curved root canals.

Apex locators are divided into first, second, third, fourth, fifth, and sixth generation.

The first generation apex location devices, also known as resistance apex locators, measure opposition to the flow of direct current or resistance. When the tip of the reamer reaches the apex in the canal, the resistance value is 6.5 kΩ (current 40 mA).

The second generation apex locators, also known as impedance apex locators, measure opposition to the flow of alternating current or impedance.

The third generation: The principle on which third generation apex locators are based requires a brief introduction. In biologic settings, the reactive component facilitates the

flow of alternating current, more for a higher than for lower frequencies. Thus, a tissue through which two alternating currents of differing frequencies are flowing will impede the lower frequency current more than the higher frequency current. Since the impedance of a given circuit may be substantially influenced by the frequency of the current flow, these devices have been called “frequency dependent.” Since it is impedance, not frequency that is measured by these devices, and since the relative magnitudes of the impedances are converted into “length” information, the term “comparative impedance” may be more appropriate.

The proposed “fourth-generation” apex locators are marketed by Sybron Endo and apex locators that determine the impedance at five frequencies and both have built-in electronic pulp testers.

Currently, fourth and fifth generation devices are mostly employed. What is typical of the fourth generation devices is that they measure and compare the complex electrical characteristic features of the root canal through two or more frequencies of electrical impulses.^[13,25] A significant disadvantage of the fourth generation devices is that they need to perform in relatively dry or in partially dried canals. In some cases, this necessitates additional drying, and with heavy exudates or blood, the method becomes inapplicable.

To cope with those problems, a measuring method has been developed based on comparisons of the data taken of the electrical characteristics of the canal and additional mathematical processing.^[13,30-32] Apex locators of this type, which are known as fifth generation devices, increase accuracy in determining the place of apical foramen by several percent. Devices employing this method perform very well in the presence of blood and exudate, but they experience considerable difficulties while operating in dry canals.

The prolonged direct and juxtaposing studies have made it possible to create a steady algorithm for adapting the method for measuring the working length of the root canal depending on the canal’s moisture characteristics. The method has been implemented in the apex locator of the so-called “sixth generation” – the adaptive type.

Apex locators can be used to determine if the perforation communicates with the periodontal membrane, this is based on Sunada’s findings that the electrical resistance between the mucous membrane and the periodontium can be considered to have a constant relationship. Older apex locators worked under this principle (impedance method). Newer apex locators that work under different principles (gradient method, ratio method, etc.) essentially do the same. Once the measuring probe (a file or a reamer) touches the periodontal ligament, the apex locator will indicate that the apex has been reached.

The development and production of sixth generation apex locator (EALs) for locating the root canal have been a major break with traditions in the field of conservative and endodontic procedures. Custer^[33] was the first to instigate an electrical method of detecting the apical foramen. Suzuki^[33] discovered that electrical resistance between the periodontal ligament and oral mucosa has a constant value of 6.5 k Ω ; this led to the development by Sunada^[33,34] of the first EAL. Since then, different generations of EALs have been developed to measure root canal length. First and second generations of EAL devices used a single direct or a single frequency alternating current as the measuring signal.^[33,35] However, these devices provided inaccurate measurements as a result of the presence of pulp tissue, blood, exudates or moisture in the root canal.^[9,34] Modern EALs determine the WL by measuring impedance with two or more different frequencies. The canal does not need to be dried before modern EALs are used because they can work in the presence of electrolytes.^[10,33,36,37] Therefore, practitioners have widely accepted modern EALs because they have high reliability, have high accuracy and reduce the number of radiographs for required WL determination.

Thus, through the course of this study, it could be successfully claimed that EALs could be used as a diagnostic tool to determine root perforations and proved to be much more convenient and less hazardous than conventional intra-oral periapical radiographs.

CONCLUSION

The present study found Raypex® 6 Apex Locator is better than ProPex Pixi for root perforations. However, the findings of the present study need further validation on larger sample size.

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