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Comparative evaluation of the accuracy of three different apex locators in working length determination using Radiovisiography : An in vivo study

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Abstract

Introduction: A key step in endodontic treatment is accurately determining the working length (WL). This can be achieved through several methods, including the use of an electronic apex locator (EAL).

Aim: The aim of this study was to determine the accuracy of three EALs, i.e. AirPex, i-ROOT, Propex PiXi for WL estimation in the mandibular first molars.

Material and Method: The study included 90 root canals with symptomatic irreversible pulpitis, divided into three groups using different apex locators. WL determination was compared with intraoral periapical radiographs. Results were categorized as accurate, short, or long. The data were statistically analyzed.

Results: Propex PiXi had an accuracy of 96.7%, i-ROOT had an accuracy of 93.3%, AirPex had an accuracy of 90.0%, respectively. There was a statistically nonsignificant difference between groups ($P < 0.05$).

Conclusion: Newly developed apex locators, such as the AirPex, have shown accuracy comparable to well-established EALs like the Propex PiXi . This highlights the importance of conducting more extensive, large-scale research to confirm and validate their effectiveness.

Keywords: Apex locators; intraoral periapical radiographs; multirooted teeth; radiographic apex; working length

Introduction

A successful endodontic treatment hinges on a deep understanding of root canal anatomy, meticulous cleaning and shaping, and the precise three-dimensional filling of the root canal space. [1]

During the cleaning, shaping, and obturation of root canals, instrumentation should be confined to the apical

constriction (AC) (Kuttler 1955) to promote optimal periapical healing. Achieving this requires accurate determination of the working length (WL), which can be accomplished through tactile sensation, radiographic imaging, and the use of electronic apex locators (EALs).

Among the methods for determining working length (WL), radiographs are the most commonly used. However, this approach has several limitations, including the production of two-dimensional images, exposure of patients to radiation, potential image distortion, superimposition of anatomical structures, and a degree of subjectivity in interpretation.[2]

This has led to the development of electronic root length measuring devices, i.e., apex locators. Suzuki's 1942 discovery that the electrical resistance between the periodontal ligament and oral mucosa remains constant and measurable using two electrodes laid the groundwork for the development of the first apex locator. Building on this principle, Sunada introduced the first apex locator in 1962.[3]

Today, a variety of apex locators are available, utilizing principles such as resistance, impedance, and multi- or dual-frequency technology. However, clinical studies assessing the accuracy of these modern apex locators, particularly in multirooted teeth, remain limited. Therefore, this in vivo study was planned to compare and evaluate the accuracy of three different apex locators, namely, AirPex, i-ROOT, Propex PiXi with Radiovisiography in multirooted teeth.

Materials And Methods

The study was conducted in the department of conservative dentistry and endodontics, and institutional ethical approval was obtained for the study.

Methodology: The study included thirty root canals from maxillary and mandibular molars, exhibiting a 1–1 or 2–2 configuration according to Vertucci's classification, all of which were diagnosed with symptomatic irreversible pulpitis. Patients aged 17 to 30 years, regardless of gender, with a noncontributory medical history, were selected for the study. Preoperative intraoral periapical (IOPA) radiographs were taken to assess and measure root curvature. Selection of patients was based on specific inclusion and exclusion criteria.

Inclusion criteria

The study included patients aged 17 to 30 years, irrespective of gender, whose teeth were diagnosed with symptomatic irreversible pulpitis. Only teeth with a distinct single canal and a root curvature of no more than 5°–10° according to the Schneider method were selected. Additionally, only patients who voluntarily agreed to participate and provided informed consent were included in the study.

Exclusion criteria

Patients were excluded from the study if they presented with a canal configuration other than 1–1 or 2–2 according to Vertucci's classification, either radiographically or after access opening. Other exclusion criteria included the presence of any implanted electronic devices, such as cardiac pacemakers, Pregnant patients, radiographic evidence of resorption (external or internal) or calcification, and root curvature greater than 10 degrees as shown on radiographs after initial patient selection.

Sample size Calculation

The sample size was calculated on the basis of the mean between these groups with the help of the formula given by Rosner. [4] The minimum sample size per group is 27. A 10% attrition rate is added, so the final sample size is 30 patent single-root canals per group.

The procedure was explained to each patient, and written consent was obtained. Patients were then randomly

assigned to one of six different groups using a lottery method. All procedures were carried out independently by a single operator.

Local anesthesia (2% lignocaine with 1:100,000 adrenaline) was administere,Access cavity preparation was performed under rubber dam isolation. The canal was explored, and patency was established using a size #10 K-file.

Following this, a 15 K-file was used in a watch-winding motion to the same point within the canal. A K-file, sized according to the canal width, was introduced, and the rubber stopper was adjusted to a reference point. Readings were taken twice with each electronic apex locator (EAL) following the manufacturer's instructions, and the average value was recorded as the working length (WL). Additionally, three radiographs were taken using the bisecting angle technique from straight, mesial, and distal angulations, with the average of these measurements calculated for each canal. These radiographic measurements were then compared with the EAL readings, and the data were statistically analyzed.

The samples were categorized using the following scoring criteria[5] :

Acceptable: 0–1 mm short of the radiographic apex

Short: More than 1 mm short of the radiographic apex

Long/Beyond: Beyond the radiographic apex

Table 1 and Graph 1 give an overview of the comparison of accuracies among the three different apex locators.

Results

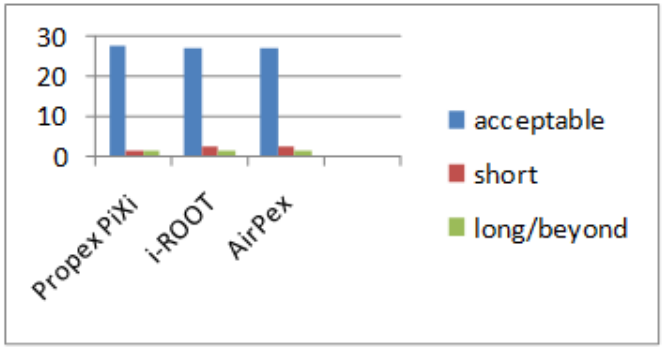
Data was entered into Microsoft Excel and analyzed using SPSS version 27.0. The comparison of the accuracy of different apex locators was compared by using the Chi-square test. The level of statistical significance was set at $P \leq 0.05$.

A total of 90 canals (30 canals per group) were evaluated in this study, and it was observed that WL estimations were acceptable in 82 canals short in 5 canals and beyond in three canals.

The Propex PiXi had the highest accuracy at 93.3%, followed by the i-ROOT, AirPex with accuracies of 90.0%, 90.0%, respectively.

Table 1: Comparison of the accuracy of three

Group	Canals	Acceptable (%)	Short (%)	Long/ beyond (%)
Propex PiXi	30	28 (93.3)	1 (3.3)	1 (3.3)
i-ROOT	30	27 (90.0)	2 (6.7)	1(3.3)
AirPex	30	27 (90.0)	2 (6.7)	1(3.3)
Total	90	82 (91.1)	5 (5.5)	3(3.3)



Graph 1: Comparison of the accuracy of six different apex locators

Discussion

Successful endodontic therapy hinges on three critical factors: a well-designed access cavity, thorough canal preparation, and achieving a three-dimensional seal during canal obturation. Accurate cleaning, shaping, and obturation are only possible when the working length (WL) is determined with precision. (1)

The Glossary of Endodontic Terms defines the working length (WL) as "the distance from a coronal reference point to the point at which canal preparation and obturation should terminate." (6) According to Grove, the ideal end point for root canal procedures is the

cementodentinal junction (CDJ), where the dentin meets the cementum, marking the transition from pulp tissue to the periodontal ligament. However, detecting the CDJ clinically is challenging and unpredictable.[7] Therefore, the apical constriction (AC), the narrowest part of the root apex, is often considered the optimal location to end root canal treatment. Completing the procedure at the AC minimizes contact between the filling material and apical tissues, reducing the risk of inflammatory responses and foreign body reactions.[5]

Various methods have been employed to locate the apical constriction (AC) and measure the working length (WL) of root canals. These methods include tactile sensation, the use of paper points, conventional periapical radiographs, and electronic apex locators (EALs). Among these, conventional periapical radiographs are the most commonly used for measuring WL. However, this method has several limitations, such as producing two-dimensional images, image magnification, distortion errors, radiation exposure, and the superimposition of anatomical structures. [2]

To address the limitations of conventional radiographic methods, apex locators were developed, providing a less invasive way to determine the electronic working length (EWL).[8] According to the Glossary of Endodontic Terms, an electronic apex locator (EAL) is "an electronic device used in endodontics to determine the position of the apical constriction (AC) and thus determine the length of the root canal space." Apex locators offer several advantages over conventional radiographic methods, including being easier and faster to use, and they can be repeated without exposing the patient to radiation. In addition to accurately measuring the working length, apex locators can also detect over-instrumentation and perforations, whether iatrogenic or natural. Studies have shown that apex locators are more accurate than conventional intraoral radiographs for these purposes.[9]

Apex locators are highly effective in precisely measuring the electronic working length (EWL) by accurately locating the apical constriction (AC), which serves as an optimal endpoint for root canal preparation and obturation. However, combining radiographic and electronic WL determination has been shown to further enhance accuracy. Taking a working length radiograph after determining the EWL can help reduce the risk of over-instrumentation and provide a clear mapping of the AC. In certain clinical situations, such as cases involving an immature apex, calcified canals, root resorption, or perforation, radiographic verification of the electronic WL is advisable, as apex locators may occasionally produce false readings.[10]

Numerous electronic apex locators (EALs) have been introduced to the market, each claiming to offer improved accuracy. Our study aimed to evaluate the accuracy of three different EALs named AirPex, i-ROOT, and Propex PiXi compared to radiovisiography in multirooted teeth. The mandibular first molars were selected for this study because they are commonly treated in endodontic procedures and present significant challenges for working length (WL) determination due to their complex anatomical features and root patterns.[11]

Teeth diagnosed with symptomatic irreversible pulpitis were chosen for the study, as this is the most common pulpal pathology requiring endodontic therapy.[12,13]

In the present study, the bisecting angle technique was employed to minimize errors in positioning that could arise from the presence of a rubber dam, rubber dam clamp, or root canal instruments. Kuttler, in 1950, noted that the apical constriction (AC) typically varies but is generally located 0.5–1 mm short of the apical foramen. For this study, a range of 0–1 mm short of the

radiographic apex was considered acceptable, based on Weine's modification of Ingle's radiographic method for determining the working length (WL).[14]

Propex PiXi demonstrated an accuracy of 93% in our study. This finding aligns with a study conducted by Serna Peña et al., which also evaluated the accuracy of three different electronic apex locators.[15]

In our study, AirPex demonstrated an accuracy of 90.0%, which is similar to a study conducted by Diana R et al., wherein it was found to be 93.3%. [16] The accuracy of i-ROOT was comparatively less then pixi and similar to airpex 90.0%, which is in agreement with the study by Saraf PA., where it was found to be 93.3%.[17]

A newly introduced EAL, lacks extensive research evaluating its accuracy. Recognizing this gap, we conducted this study to address the limited existing research on its precision and effectiveness. We observed that the accuracy of AirPex, i-ROOT and Propex PiXi was comparable, three achieving a remarkable 93.3%,90.0%,90.% respectively. Importantly, there was no statistically significant difference noticed among the three groups. Keeping in mind the limitations of our study due to the in vivo settings, it can be concluded that apex locators, such as AirPex, i-ROOT and Propex PiXi exhibit same level of accuracy. There is necessity for further research on a larger scale to substantiate and validate their efficiency.

Conclusion

Determining the working length (WL) is a crucial part of root canal treatment. No single method for measuring WL is entirely infallible. Among the three electronic apex locators (EALs) evaluated, Propex PiXi demonstrated the highest accuracy, with AirPex and i-ROOT following. However, the differences in accuracy among these devices were statistically insignificant. While apex locators generally provide accurate WL measurements, it is essential to consider radiographs as an adjunct to enhance the overall accuracy of the procedure.

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All of the authors have read and approved this manuscript, all of the writers have satisfied the standards previously indicated in this document for authorship, and each author believes the work portrays sincere labor.

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