



Comparative evaluation of the accuracy of the AirPex and DentaPort ZX apex locators in detecting working length: An *ex vivo* study

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Introduction

During root canal therapy, shaping, cleaning and disinfection depend on accurate measurement of working length.¹ Incorrect evaluation of working length can compromise the clinical outcome of the root canal therapy.² The ideal end point of a root canal therapy has been debated by many authors.^{3,4} Clinically, when canal preparation and filling are located within 2mm from the radiographic apex, in the region of the apical constriction, a higher success rate of the root canal therapy

is achieved.^{5,6} However, the apical constriction, usually the narrowest part of the root canal, is not easy to detect.⁷ Similarly, the cementodentinal junction, the transition between the pulpal and periodontal tissue, is considered the ideal end of a root canal therapy,^{8,9} but it is variable and cannot be clinically detected.^{4,7}

Radiography, the anatomical average length of teeth, tactile sensation and moisture of a paper point are different methods used to determine working length.⁹ Radiography has been used for many years, but it has

the red bar appeared on the device and then retracted until the apical position was reached (last green bar at the 0.0 mark). When the operator used the DentaPort ZX, a size 10 K-file was introduced through the root canal until the device showed a red line on the display, indicating that the apex had been reached. It was then removed to the last green line on the display.

Measurements were considered valid if the reading remained stable for at least 5 seconds. Each measurement was repeated three times for each tooth and each EAL, and in order to reduce bias, all measurements were taken by the same operator and repeated three times. All working lengths were measured on the file using a digital caliper, and the mean value was considered the result.

All measurements recorded were expressed as means and standard deviations. Positive values indicated measurements that extruded beyond the apical foramen, and negative values indicated measurements that were short of the apical foramen. The measurements were grouped according to the device used to obtain them. Differences between the electronic working length (EWL) and the AWL were paired, and statistical analysis was performed using one-way ANOVA and Tukey tests, a significant difference set at $P < 0.05$.

Results

When considering a margin of accuracy of $\pm 0.5\text{mm}$, AirPex showed an accuracy of 84.5% and the DentaPort ZX showed an accuracy of 86.6%. Considering a margin

of accuracy of $\pm 1\text{mm}$, the two EALs showed an accuracy of 100%. The main difference between EWL and AWL was $0.09 \pm 0.33\text{mm}$ for AirPex and $0.08 \pm 0.35\text{mm}$ for the DentaPort ZX (Fig. 4). No statistically significant differences were found between AirPex and the DentaPort ZX ($P > 0.05$).

Discussion

The aim of this study was to compare *ex vivo* the accuracy of two EALs, AirPex and the DentaPort ZX. The accuracy of the two EALs was evaluated considering the major foramen more reproducible than the apical constriction.²¹ Moreover, in the present study, as electronically measured canal length was influenced by the root canal diameter, single-rooted teeth with narrow root canals were selected, and a size 10 K-file was used to obtain AWL and EWL. In fact, Ebrahim et al. reported that, when the diameter of a root canal increased, electronic measurement with a small K-file become shorter²² and that, in wide apical foramina, the EALs become more reliable at determining the working length of teeth if a tight-fit file was used.²³

Alginate was used in the present study to simulate periodontal ligament and to ensure the best medium possible for testing the EALs *ex vivo*. Alginate as a substitute for periodontal ligament was investigated by Lipski et al., who showed a 100% rate of correct measurement.²⁴ On the contrary, gelatine, agar-agar, saline and flower sponge soaked in saline showed a rate of correct measurement of 96.7%, 76.7%, 73.4% and 63.4%, respectively.²⁵

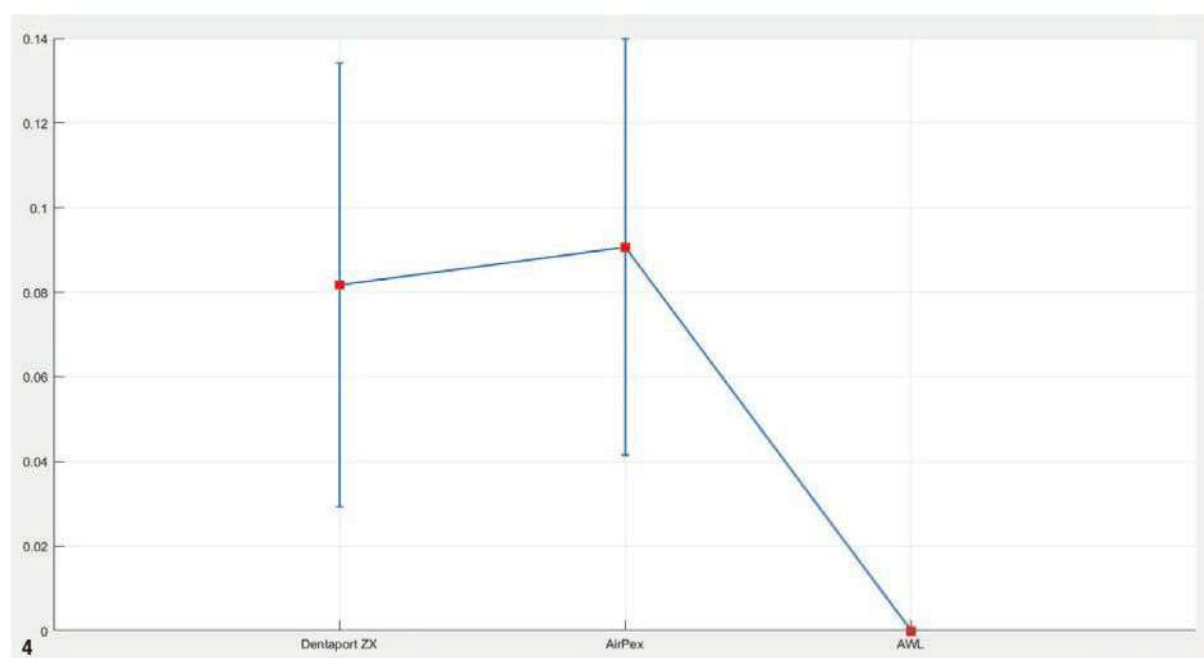


Fig. 4: Main difference and standard deviations between electronic working length and actual working length of AirPex and the DentaPort ZX and actual working length. AWL = actual working length.

the limitation of providing a 2D image of a 3D complex structure. The use of radiographs alone in working length determination led to over-instrumentation in 33% of molars and 56% of premolars.¹⁰ The introduction of electronic apex locators (EALs) into clinical practice allowed, when used with appropriate radiographs, the determination of a more predictable and accurate working length,^{11,12} and a substantially lower number of radiographs are necessary when using EALs, consequently reducing patient exposure to X-ray radiation.¹³ Vieyra et al. showed that Root ZX located minor foramina 68% of the time in premolar and anterior teeth compared with radiographs, which did so 20% and 11% of the time in anterior and premolar teeth, respectively.¹⁴

In the last decades, different generations of EALs have been developed. Several studies have been conducted on different EALs to evaluate their accuracy under different conditions.^{15–18} The DentaPort ZX (J. Morita) is a third-generation EAL based on dual frequencies (8 and 0.4kHz), and it is considered the gold standard EAL to which any new device should be compared. Several *ex vivo*¹⁹ and *in vivo*²⁰ studies have clearly demonstrated its precision. Among these studies, as an example, Connert et al. showed that, in a comparison of nine apex locators using micro-CT, the DentaPort ZX was the most accurate at detecting apical constrictions and major foramina, having an accuracy of 99% and 100%, within a tolerance of ± 0.5 mm or ± 1.0 mm, respectively.¹⁵

AirPex (Eighteenth, Changzhou Sifary Medical Technology) is a new wireless apex locator that is charged on a charging base. It weighs 15g, and its dimensions are 4.8×2.8×1.6cm. In the literature, no data is yet available on this EAL. Thus, the aim of the present *ex vivo* study was to compare the accuracy of the AirPex and the DentaPort ZX EALs in determining working length in extracted teeth.

Material and methods

In this study, 15 single-rooted teeth, extracted for periodontal or orthodontic reasons, were selected. The teeth were placed in a 5.25% sodium hypochlorite (NaOCl) solution for 2 hours in order to remove organic residue. The remaining tissue was removed from the external root surfaces using a periodontal scaling instrument. Finally, the teeth were stored in normal saline (0.9% sodium chloride) before testing.

To rule out previously treated root canals, open apices, resorbed roots, teeth with two canals or teeth filled with amalgam or composite, two digital radiographs in both buccolingual and mesiodistal projections were obtained. After standard access cavity preparation, the



Fig. 1: Determination of the actual working length under a stereomicroscope at 20× magnification. As a particular detail, a grey spot shows the file on top of the major apical foramen.

patency of the apical foramen was assessed with size 10 and 15 K-files (Dentsply Maillefer). Samples in which a size 20 K-file reached the apex were ruled out and substituted.

The actual working length (AWL) was determined by introducing a size 10 K-file into the canal until its tip emerged in the apical foramen under 20× magnification using a stereomicroscope (Zeiss Axiophot, Carl Zeiss) linked to a digital camera (Moticam Pro SMP, Motic; Fig. 1). With the aim of reducing the risk of stopper movement, two silicone stoppers were positioned on the file. After the removal of the file, the distance between the stoppers and the file tip was measured to establish the AWL.

The roots of each tooth were immersed in a plastic box filled with alginate, leaving the most coronal 5mm uncovered. Alginate was useful for obtaining an environment as analogous as possible to the oral one. The wire of the EAL was connected to the file inserted into the root canal, while the lip clip was immersed in the alginate.

AirPex (Fig. 2) and the DentaPort ZX (Fig. 3) were used according to the manufacturer's instructions. When the AirPex was used, a size 10 K-file was inserted gently until



Fig. 2: The AirPex apex locator. **Fig. 3:** The DentaPort ZX apex locator.



The presence of irrigants inside root canals does not affect the accuracy of the majority of the latest generations of EALs.²⁶ Duran-Sindreu et al. compared *in vivo* the accuracy of Root ZX and iPex in determining working length in the presence of two different irrigant solutions.²⁷ They reported statistically significant differences between the two apex locators, but their accuracy was not affected by 2.5% NaOCl or 2.0% chlorhexidine.²⁷ Çınar and Üstün compared *in vivo* the accuracy of Propex Pixi, Root ZX mini and RAYPEX 5 using micro-CT.²⁸ They found no differences in determining working length measured in the presence of blood, pulp tissue or NaOCl.²⁸ Tsesis et al., in a systematic review and meta-analysis, concluded that the presence of vital or necrotic pulp has no effect on the precision of EALs.²⁹ In the present *ex vivo* study, conducted under normal conditions, the EWL measurements were very accurate for both AirPex and the DentaPort ZX.

The results of the present study are in agreement with previous *in vivo* and *in vitro* investigations. Saatchi et al., in an *in vivo* study, reported that the DentaPort ZX showed an accuracy to within ± 0.5 mm of 93.8% in the presence of periapical periodontitis and of 93.3% in teeth with normal periapices.³⁰ Piasecki et al. showed *in vivo* that Root ZX II located the apical foramen accurately to within ± 0.5 mm in 83% of the teeth with periapical periodontitis and in 100% of the vital teeth.³¹ Stöber et al., under *in vivo* clinical conditions, measured a mean distance of 0.146 ± 0.430 mm from the AWL to the file tip and an accuracy to within ± 0.5 mm of 72% and to within ± 1.0 mm of 100%.³² Silveira et al. reported an accuracy of Root ZX of 91.7% in detecting apical constrictions *in vivo*.³³ Comparing working length determination *in vivo* and *in vitro*, Duran-Sindreu et al. reported that Root ZX was accurate to ± 0.5 mm 74% of the time *in vitro* and to ± 0.5 mm 78.3% of the time *in vivo*.³⁴ Soares et al. evaluated Root ZX II in detecting major foramina and found an accuracy to 0.5 mm *in vivo* and *in vitro* of 70% and 70% of the time, respectively.³⁵ The differences in the results shown in these studies for the accuracy of

DentaPort ZX could be explained by the different methods used to establish the AWL.

This is the first *ex vivo* study involving AirPex. No previous scientific literature has been published on this EAL. The data showed comparable results with the DentaPort ZX ($P > 0.05$).

Conclusion

In conclusion, AirPex and the DentaPort ZX were accurate in detecting working length, showed no statistically significant differences in accuracy and showed accuracy to within ± 0.5 mm.

Conflicts of interest

The authors declare that there are no conflicts of interest.

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about

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