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Evaluation of the Effect of Different Irrigation Solutions on Electronic Apex Locator Working Length Measurement

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Research Article

History

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ABSTRACT

Objectives: This in vitro study aimed to evaluate the accuracy of working length measurements obtained with the Raypex 6 electronic apex locator (EAL) in the presence of QMix, 10% citric acid, 5.25% sodium hypochlorite (NaOCl), 17% EDTA, and 2% chlorhexidine (CHX), compared with the actual working length (AWL).
Materials and Methods: Eighty caries-free mandibular premolars were used. The AWL was determined under a microscope with a size 10/.02 K-file positioned 0.5 mm short of the apical foramen. Working length measurements were obtained with the Raypex 6 EAL in canals filled with each irrigant. Data were analyzed using repeated-measures ANOVA and Bonferroni-adjusted post-hoc tests, with significance set at adjusted $p < 0.05$.
Results: There was a significant difference between the electronic working length measurements obtained in the presence of QMix, 10% citric acid, 5.25% sodium hypochlorite, and 17% EDTA and the AWL, with all these irrigants producing significantly shorter readings. In contrast, the measurements obtained in the presence of 2% chlorhexidine did not differ significantly from the AWL ($p = 0.996$).
Conclusions: Irrigation solutions with potentially higher conductivity (QMix, citric acid, NaOCl, EDTA) led to the perception of a shorter working length with Raypex 6, whereas CHX, which has a lower conductivity, yielded results closer to the AWL. Clinicians should be mindful of the selected irrigation solution when interpreting EAL measurements, especially when using highly conductive solutions, to avoid determining a short working length.

Keywords: Chlorhexidine, electronic apex locator, irrigation solutions, QMix, working length

Farklı İrrigasyon Solüsyonlarının Elektronik Apeks Bulucunun Çalışma Boyu Ölçümüne Etkisinin Değerlendirilmesi

Araştırma Makalesi

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ÖZ

Amaç: Bu in vitro çalışma, Raypex 6 elektronik apeks bulucu (EAL) ile QMix, %10 sitrik asit, %5,25 sodyum hipoklorit (NaOCl), %17 EDTA ve %2 klorheksidin (CHX) varlığında elde edilen çalışma boyu ölçümlerinin doğruluğunu, gerçek çalışma boyu (GÇB) ile karşılaştırarak değerlendirmeyi amaçlamıştır.
Gereç ve Yöntemler: Seksen adet çürüksüz mandibular premolar diş kullanıldı. GÇB, apeks foramenin 0.5 mm kısağına yerleştirilmiş bir 10/.02 K-eğesi ile mikroskop altında belirlendi. Çalışma boyu ölçümleri, her bir irriganla dolu kanallarda Raypex 6 elektronik apeks bulucu ile elde edildi. Veriler, tekrarlı ölçümler varyans analizi (ANOVA) ve Bonferroni düzeltmeli post-hoc testleri kullanılarak analiz edildi; anlamlılık düzeyi düzeltilmiş $p < 0,05$ olarak belirlendi.
Bulgular: QMix, %10 sitrik asit, %5,25 sodyum hipoklorit ve %17 EDTA varlığında elde edilen elektronik çalışma boyu ölçümleri ile GÇB arasında anlamlı bir fark bulundu. Bu irriganların tümü, istatistiksel olarak anlamlı derecede daha kısa ölçümlere neden oldu. Buna karşılık, %2 klorheksidin varlığında elde edilen ölçümler, GÇB'den anlamlı bir farklılık göstermedi ($p = 0,996$).
Sonuçlar: Potansiyel olarak daha yüksek iletkenliğe sahip irrigasyon solüsyonlarının (QMix, sitrik asit, NaOCl, EDTA) Raypex 6 ile daha kısa bir çalışma boyu algılanmasına yol açtığı, daha düşük iletkenliğe sahip olan CHX'in ise GÇB'ye daha yakın sonuçlar verdiği görüldü. Klinisyenler, özellikle yüksek iletkenliğe sahip solüsyonlar kullanırken, kısa bir çalışma boyu belirlemekten kaçınmak için EAB ölçümlerini yorumlarken seçilen irrigasyon solüsyonunun etkisini göz önünde bulundurmalıdır.

Anahtar Kelimeler: Çalışma boyu, elektronik apeks bulucu, irrigasyon solüsyonları, klorheksidin, QMix

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Introduction

The success of endodontic treatment relies upon the thorough cleaning, shaping, and obturation of the infected root canal system.[1] Accurately determining the working length to the minor apical diameter is one of the most crucial steps in this process.[2] Incorrect working length determination can lead to inadequate debridement and disinfection of the canal or damage to the periapical tissues, postoperative pain, and treatment failure.[3]

Traditionally, radiographs have been used for working length determination.[4] However, radiographs have limitations such as providing two-dimensional images, the superposition of anatomical structures, radiation exposure, and observer-dependent variability.[5] To overcome these limitations, electronic apex locators (EALs) were developed and have become essential instruments in modern endodontics.[6] EALs have been introduced to overcome some limitations of radiographs, such as two-dimensional imaging and superposition of anatomical structures. EALs are radiation-free and offer continuous feedback during the procedure.[7]

The accuracy of EALs can be affected by many factors. Anatomical features of the root canal (such as curvature and apical foramen size), tissue remnants within the canal, perforations, and especially the presence and type of irrigation solutions used, are significant variables that affect EAL measurements.[8] Root canal irrigants are essential for the removal of pulp tissue and bacterial biofilms, infection control, and the debridement of the canal walls.[9] However, these solutions can affect the EAL's principle of electrical impedance measurement because they have different chemical properties and conductivity levels. Solutions with high conductivity can cause the EAL to incorrectly detect the apical foramen at a shorter distance by completing the electrical circuit prematurely, whereas less conductive solutions may provide more accurate results.[10]

Different irrigation solutions such as citric acid, sodium hypochlorite (NaOCl), ethylenediaminetetraacetic acid (EDTA), and 2% chlorhexidine (CHX) are commonly used in endodontic treatment.[11] QMix, a relatively new solution that has not yet gained widespread clinical use, possesses both disinfectant and chelating properties. Each of these solutions has distinct disinfection and chelation characteristics. However, the effects of these solutions on the working length measurement accuracy of a modern EAL, such as the Raypex 6, need to be investigated in detail in a standardized laboratory setting. This study aims to evaluate the effect of different irrigation solutions on working length measurements obtained with an EAL, in order to provide guidance to clinicians on irrigant selection for these measurements.

Materials and Methods

The study was conducted according to the guidelines of the Declaration of Helsinki and approved by the Kahramanmaraş Sütçü İmam University Medical Research Ethics Committee (Date: 21.04.2025, Session No: 2025/14, Decision No: 07). The sample size was calculated using G*Power software (Version 3.1.9.7, Heinrich-Heine-Universität Düsseldorf, Germany). Based on a previous study by Jha et al.[10] with a similar design, an effect size of 0.40 was adopted. With an alpha error (Type I) set at 0.05 and a study power (1 - beta) of 0.80, the total sample size required was determined to be 80.

Preparation of Tooth Samples

Eighty freshly extracted, anonymized permanent human mandibular premolars with fully formed apices and single canals were used in this study. Teeth with fractures, previous root canal treatment, resorption, or anatomical anomalies were excluded. The teeth were cleaned of soft tissue and periodontal ligament remnants from their root surfaces using a sonic device (Woodpecker, Guilin, China). Following cleaning, the teeth were disinfected in a 5.25% NaOCl solution for 2 hours and stored in 0.9% physiological saline solution until the start of the study. A conventional access cavity was prepared in all teeth. Care was taken to verify the apical patency of the root canals with a 10/.02 K-type file (Dentsply Maillefer, Ballaigues, Switzerland). On the occlusal surfaces, a flat reference surface was created to stabilize the endodontic stopper during working length measurements.

Determination of the Actual Working Length

The actual working length (AWL) of each tooth was precisely defined as 0.5 mm short of the apical foramen, based on the anatomical assumption of a minor apical constriction located precisely 0.5 mm from the foramen. To determine this, a 10/.02 K-type file was gently inserted into the root canal until its tip was just visible at the apical foramen under a dental microscope (Leica, Switzerland) at 10x magnification (Figure 1). The endodontic stopper was then adjusted to the occlusal reference point. The final length, recorded as 0.5 mm shorter than this measurement, was considered the AWL. This length was measured and recorded using an electronic caliper under a dental microscope (Leica, Switzerland) at 10x magnification. All AWL measurements were performed and confirmed by two experienced endodontists.

Simulated Oral Environment Assembly

A model was developed to simulate the oral environment for EAL measurements. In this model, a foam base was placed inside a glass container, leaving a 30 mm space around the external surface of the tooth. The remainder of the container was filled with alginate (Lascod, Italy). Before the alginate set, a tooth and the lip clip of an EAL were embedded in the alginate so that both could make contact with the saline solution at the apical portion. After the alginate hardened, the underlying foam was removed and replaced with a 0.9% physiological saline solution. This ensured continuous contact between the apical region of the tooth and the lip clip with the saline solution. An air vent was created on the lateral surface of the alginate to prevent air entrapment during fluid contact. The alginate assembly was validated in a pilot study on 10 teeth, which demonstrated consistent results with AWL measurements taken at different times (Figure 2).

Working Length Measurements and Irrigation Protocol

Before initiating any measurement session, the Raypex 6 EAL (VDW, Munich, Germany) was calibrated according to the manufacturer’s instructions to ensure its accuracy and proper functioning throughout the study. Following AWL determination, each tooth underwent measurements with five irrigation solutions (QMix, 10% Citric Acid, 5.25% NaOCl, 17% EDTA and CHX) in a randomized repeated-measures design, where the order of irrigants for each tooth was determined by a computer-generated sequence. Irrigants were delivered via a 27-gauge side-vented needle and 5 mL syringe to 2 mm short of the apex (2 mL per application) and left in situ for 30 s. A standardized neutralization/rinse protocol was applied: for NaOCl, 2 mL of 5% sodium thiosulfate (30 s) followed by 3 mL of 0.9% saline; for QMix, citric acid, EDTA and CHX, 5 mL of 0.9% saline (30 s). After each rinse, canals underwent 60 s passive drainage, gentle drying with two paper points for 10 s, and a 2 min rest before the next irrigant. Working length measurements were then made to the "0.0" apical point using a size 10 K-file (apical diameter: 0.10 mm) in conjunction with a previously calibrated Raypex 6, recorded, and finally canals were flushed with 5 mL of 0.9% saline and dried prior to the subsequent cycle.

Figure 1. Microscopic view showing the tip of a 10 K-file patent at the apical foramen.

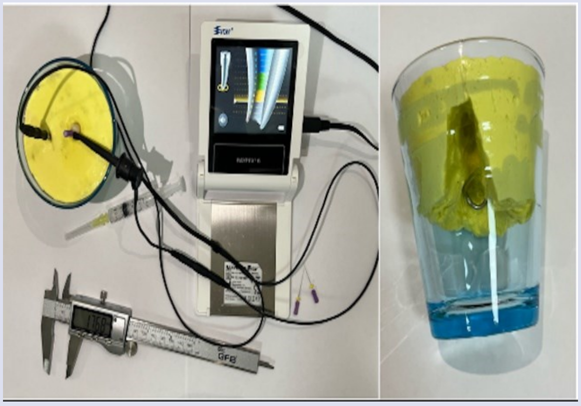

Figure 2. The experimental setup showing the Raypex 6 EAL connected to the alginate model for the measurement of the working length.

Statistical Analysis

Data analysis was performed using the Statistical Package for the Social Sciences (SPSS) 25.0 Statistics software. The normality of the data and the homogeneity of variances were assessed using the Kolmogorov-Smirnov and Levene's tests, respectively. It was determined that all groups satisfied the assumption of normal distribution ($p > 0.05$) and had homogeneous variances ($p > 0.05$). Consequently, parametric tests were performed.

Repeated Measures Analysis of Variance (RM-ANOVA) was used to evaluate the effect of different irrigation solutions on the working length measurements obtained in each tooth. The assumption of sphericity was met, as confirmed by Mauchly's Test ($p = 0.113$). Additionally, a linear mixed-effects model was used to verify the results, accounting for variations between individual teeth.

For both RM-ANOVA and the mixed-effects model, if a significant main effect was found, post-hoc pairwise comparisons were conducted with Bonferroni adjustment, using an adjusted alpha level of 0.05 for significance. Effect sizes were calculated using Cohen's d. The absolute error and the proportion of measurements within ± 0.5 mm of the AWL were computed as clinical accuracy metrics. Bland-Altman analysis was performed to assess agreement between EAL measurements and the AWL. The level of statistical significance was set at $p < 0.05$.

Results

The descriptive statistics for the root canal working length measurements, along with the results of the RM-ANOVA and post-hoc Bonferroni analysis, are presented in Table 1.

The RM-ANOVA revealed a statistically significant main effect of irrigation solution on working length measurements ($F(5, 395) = 25.42$, $p < 0.001$, $\eta p^2 = 0.24$). The linear mixed-effects model corroborated these findings, confirming a significant effect of the solution ($p < 0.001$). The intraclass correlation coefficient (ICC) from the mixed model was 0.014, indicating minimal within-subject correlation and supporting the robustness of the between-group comparisons.

Post-hoc pairwise comparisons with Bonferroni correction showed that the EAL measurements obtained after irrigation with QMix, NaOCl, EDTA, and citric acid were statistically significantly shorter than the AWL ($p < 0.001$ for all). In contrast, no significant difference was detected between the measurements obtained after irrigation with CHX and the AWL ($p = 0.996$; Table 1). The electrical conductivity values of the irrigation solutions used in our study are shown in Table 2.

The effects of the irrigation solutions on the working length are visually presented in Figure 3. While the bars for AWL and CHX are positioned at the highest level and aligned with each other (assigned to post-hoc group 'a'), the other four irrigation solutions (QMix, citric acid, NaOCl, EDTA) are clustered together at a lower level (assigned to post-hoc group 'b').

Figure 4 illustrates the distribution and density of the working length values for each solution group using a violin plot. While QMix and citric acid demonstrated similar density distributions, a comparable data density distribution was also observed in the EDTA and NaOCl groups. Although no statistically significant difference was found between the mean values of AWL and CHX, their distribution patterns were not entirely similar.

Additional clinical accuracy metrics are presented in Table 1. The absolute error was lowest for CHX (0.482 mm) and highest for NaOCl (0.554 mm). The proportion of measurements within a clinically acceptable range of ± 0.5 mm from the AWL was highest for Citric Acid (71.25%) and lowest for NaOCl (51.25%). Effect sizes (Cohen's d) indicated a large and significant shortening for QMix and NaOCl, and a medium shortening for Citric Acid and EDTA, while CHX showed a negligible effect (Table 1). The agreement between EAL measurements and the AWL was further assessed using Bland-Altman analysis (Figure 5), which confirmed a negligible bias for CHX (mean difference = -0.000 mm). In contrast, the other solutions showed a consistent negative bias (shortening), ranging from -0.220 mm for Citric Acid to -0.437 mm for NaOCl.

An examination of the minimum and maximum values revealed that the EDTA group had the widest measurement range (17.42-24.42 mm), while the narrowest range was observed in the AWL group (18.64-24.45 mm). The presence of significant differences between the groups was further supported by the non-overlapping 95% confidence intervals.

Table 1. Descriptive statistics and results of the repeated measures ANOVA for root canal working length measurements by the EAL

	n	Min	Max	Mean ± SD	% within ± 0.5 mm	% within ± 1.0 mm	Bland-Altman bias (mm)	Bland-Altman LOA (mm)	Effect size (Cohen's d) [95% CI]	p value	Post-hoc
AWL[a]	80	18.64	24.45	21.26 ± 1.36	-	-	-	-	-	-	
QMix[b]	80	17.36	24.06	20.83 ± 1.48	55.00	90.00	-0.426	-1.41 to 0.56	-0.848 [-1.106, -0.590]	<0.001	
Citric acid[b]	80	17.94	24.27	21.04 ± 1.48	71.25	93.75	-0.220	-1.30 to 0.86	-0.397 [-0.627, -0.167]	0.003	
NaOCl[b]	80	17.56	24.47	20.82 ± 1.50	51.25	86.25	-0.437	-1.53 to 0.66	-0.783 [-1.036, -0.530]	<0.001	a > b
EDTA[b]	80	17.42	24.42	20.94 ± 1.55	60.00	88.75	-0.322	-1.50 to 0.85	-0.536 [-0.773, -0.299]	<0.001	
CHX[a]	80	18.48	24.72	21.26 ± 1.45	62.50	90.00	-0.000	-1.33 to 1.33	-0.001 [-0.222, 0.221]	0.996	

Repeated Measures ANOVA Result: $F(5, 395) = 25.42$, $p < 0.001$, $\eta p^2 = 0.24$

[a,b]: Different superscript letters in each column indicate a statistically significant difference between the groups (Bonferroni-adjusted post-hoc test, adjusted p < 0.05).

n: sample size; Min: minimum; Max: maximum; mm: millimeter; SD: standard deviation; %: percent; LOA: limits of agreement; CI: confidence interval; AWL: actual working length; NaOCl: sodium hypochlorite; EDTA: ethylenediaminetetraacetic acid; CHX: chlorhexidine.

Table 2. Electrical conductivity (µS/cm) of the irrigation solutions used in our study

	Electrical conductivity (µS/cm) Mean ± SD
QMix	53801.2 ± 1012.9
Citric acid	25300.6 ± 900.3
NaOCl	111777.8 ± 669.0
EDTA	27717.7 ± 33.6
CHX	1392.5 ± 3.9

µS/cm: microsiemens/centimeter; SD: standard deviation.

Discussion

The aim of this study was to evaluate the effect of various commonly used irrigation solutions (QMix, citric acid, NaOCl, EDTA, CHX) on the accuracy of working length measurements obtained with the Raypex 6 EAL in extracted human teeth under simulated oral conditions.

The superior performance of the Raypex 6, when compared to many other EALs, has been confirmed by numerous studies.[12-15] Therefore, the Raypex 6 was selected for the present study to avoid performance-related errors in the presence of irrigation solutions.

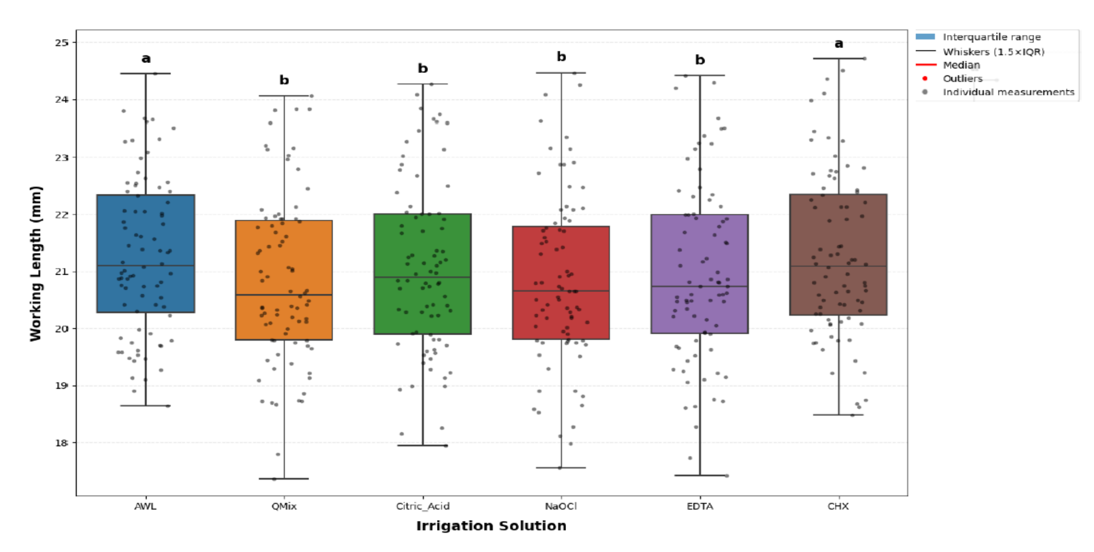

Figure 3. Comparison of mean working length measurements obtained with the Raypex 6 EAL in the presence of different irrigation solutions. Different lowercase letters (a, b) above the bars indicate statistically significant differences between groups according to Bonferroni-adjusted post-hoc tests (p < 0.05). The box represents the interquartile range (IQR, 25th-75th percentile), the line inside the box indicates the median, and whiskers extend to 1.5×IQR. AWL: actual working length; NaOCl: sodium hypochlorite; EDTA: ethylenediaminetetraacetic acid; CHX: chlorhexidine.

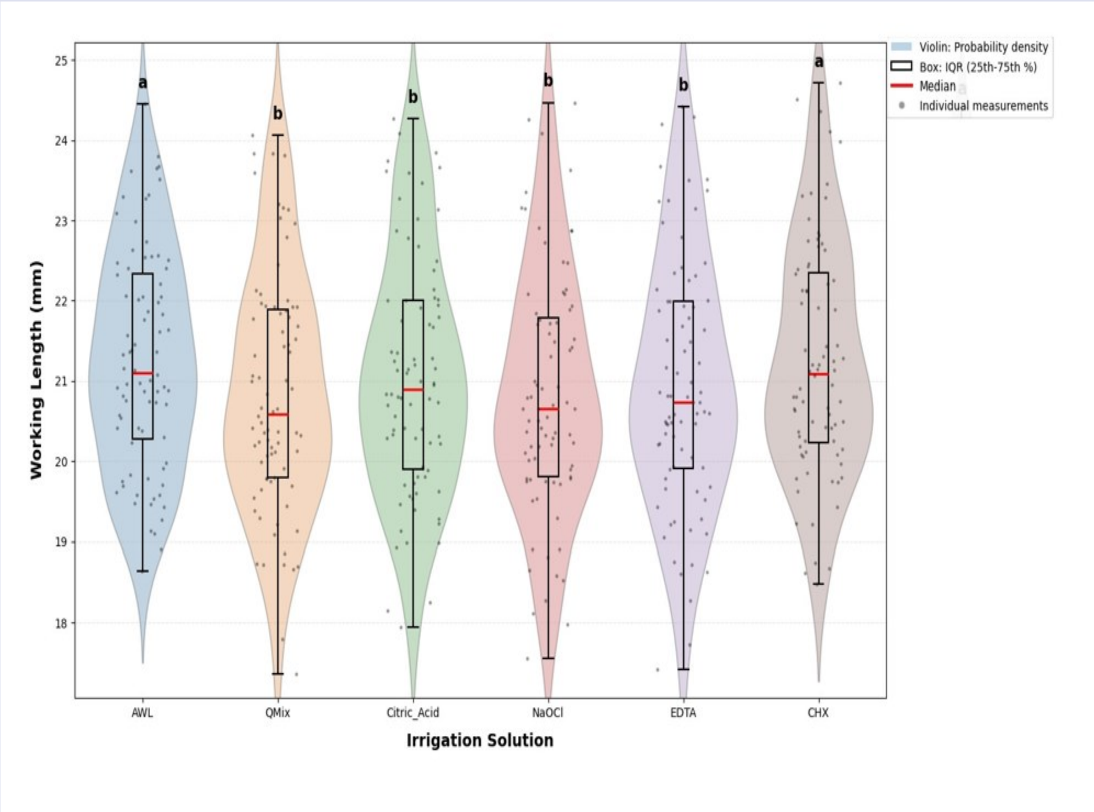

Figure 4. Violin plots showing the distribution, probability density, and descriptive statistics of working length measurements obtained with the Raypex 6 EAL for each irrigation solution. Different lowercase letters (a, b) above the bars indicate statistically significant differences between groups according to Bonferroni-adjusted post-hoc tests (p < 0.05). The red line represents the median, the thick black bar represents the interquartile range, and the shape of the violin represents the kernel probability density of the data at different values. AWL: actual working length; NaOCl: sodium hypochlorite; EDTA: ethylenediaminetetraacetic acid; CHX: chlorhexidine.

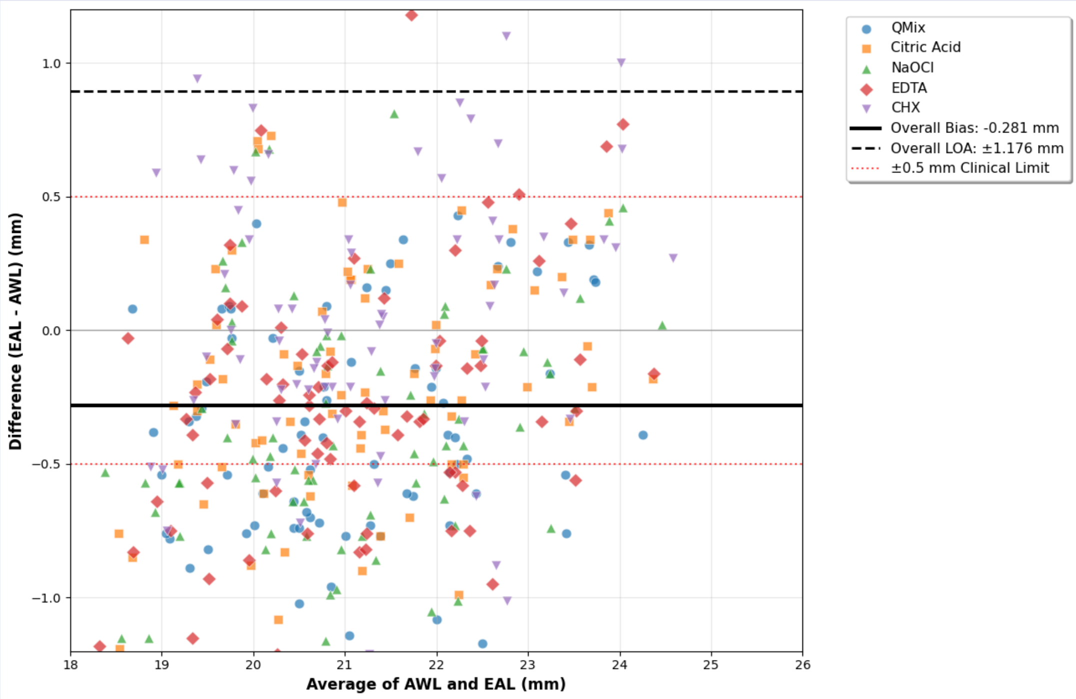

Figure 5. Bland-Altman plots demonstrating the agreement between the Raypex 6 EAL measurements and the AWL for each irrigation solution. The solid central line represents the mean difference (bias). The dotted red lines indicate the ± 0.5 mm clinical acceptability limits. The dashed black lines represent the 95% Limits of Agreement (LOA). Different markers represent different irrigation solutions: circles (QMix), squares (Citric Acid), triangles (NaOCl), diamonds (EDTA), and inverted triangles (CHX).

The conductive nature of alginate allows for its use in simulating the oral environment. In a study comparing gelatin, alginate, and saline, it was reported that the use of alginate and saline under ex vivo conditions yielded accurate results.[16] In line with these findings, the present study utilized both alginate and saline. Although alginate is a frequently chosen embedding medium, our experimental setup differs from existing models in the literature due to its unique design, which ensures continuous saline contact. The accuracy of this developed model was validated through repetitive measurements.

The measurement reliability of EALs in root canals containing irrigation solutions is an area of ongoing evaluation and debate within the scientific community. On one hand, some studies have reported that modern EALs can maintain their accuracy in the presence of irrigation solutions.[17,18] On the other hand, some authors contend that the presence of electrolyte solutions in the root canal is one of the most significant factors influencing the measurements made with EALs.[19,20]

In their study, Dumani et al.[21] investigated the effects of saline, CHX, QMix, and MTAD solutions on the AWL. They reported that while values close to the AWL were obtained in the presence of saline solution, the other solutions (CHX, QMix, MTAD) yielded values shorter than the working length. In our present study, QMix and CHX, which were also used in the study by Dumani et al., were evaluated. While QMix produced values shorter than the AWL, in contrast to the findings of Dumani *et al.,* values close to the AWL were obtained with the CHX solution. This discrepancy may be attributed to differences in the EAL model, CHX formulation, or experimental design between the studies.

In their study, Joshi et al.[22] compared the detection of artificial root canal perforations in the presence of saline, CHX, NaOCl, QMix, and MTAD, and reported that the most accurate detection was achieved with saline and CHX solutions. Although our present study focuses on apical working length determination rather than perforation detection, it exhibits a degree of consistency with the findings of Joshi et al. regarding the performance of the CHX solution. Similarly, in our study, no significant difference was found between the working length values obtained in the presence of the CHX solution and the AWL.

Khursheed et al.[23] in their combined in vivo and in vitro study, stated that the presence of NaOCl, a highly electroconductive irrigation solution, in the root canal caused the EAL to yield results shorter than the AWL. In contrast, they found that the CHX irrigation solution, which has lower electroconductivity, provided results close to the AWL. In parallel with these findings, a study conducted by Özsezer et al.[24] also reported that more accurate measurements were obtained after extirpation and in the presence of chlorhexidine gluconate solution. A similar trend was observed in our present study. While highly electroconductive solutions such as QMix, citric acid, NaOCl, and EDTA yielded values lower than the AWL, values close to the AWL were obtained with CHX, which has lower electroconductivity. It is thought that highly conductive solutions cause the apex locator to detect the foramen at a shorter distance than its actual position by completing the electrical circuit prematurely, before reaching the apical foramen.

The findings of this study indicate that irrigants with high conductivity, such as NaOCl, EDTA, QMix and citric acid, produced measurements shorter than the AWL when using the Raypex 6 EAL, which may increase the risk of inadequate treatment.[6,25] Clinicians should be cautious when interpreting EAL readings in the presence of such solutions. Before EAB measurement, the canal should be decontaminated by rinsing with saline to remove high-conductivity irrigants, or alternatively a low-conductivity solution such as CHX should be used. In clinical practice, the canal should be free of blood and exudate, and adequate hemostasis should be achieved to obtain reliable EAL readings.

Although there are studies in the literature showing that sodium hypochlorite concentration does not affect working length determination with an EAL, conflicting findings have also been reported.[26] For example, Topçuoğlu and Koçakoğlu,[27] in their study, investigated the effect of sodium hypochlorite presence on root canal working length determination with an EAL in primary teeth with and without root resorption. In their study, they reported that the presence of sodium hypochlorite in the root canal affected the working length in teeth with resorption but did not affect it in non-resorbed teeth. In our present study, however, it was found that the presence of sodium hypochlorite resulted in shorter measurements in non-resorbed teeth.

In their in vivo and in vitro study, Kara and Subay[28] compared saline, CHX, EDTA, and NaOCl solutions and found no significant difference among these solutions in apical working length determination. In our present study, however, the measurements obtained with the EAL were compared with the AWL. As a result of this comparison, while no significant difference was found between EDTA and NaOCl, a significant difference was detected between the CHX solution and both the EDTA and NaOCl solutions. The lower conductivity of the CHX solution compared to the others allows EAL to obtain more accurate results in its presence.

As this was an in vitro study, our research has several inherent limitations. This excludes the potential effects of living tissues, bleeding, and patient sensitivity on EAL measurements. Important physiological factors, such as the application of irrigation solutions at intraoral temperature, were not simulated. However, in an in vitro study by Keskin and Yalçın[12] on this topic, it was demonstrated that the temperature of irrigation solutions (from room temperature to 70°C) did not significantly affect EAL accuracy.

The use of only mandibular premolars limits the generalizability of the findings to other tooth groups. Fixing the AWL at 0.5 mm short of the apical foramen and assuming that the minor apical constriction is the same in all teeth—although Pisano et al.[29] stated that apical foramen configuration does not affect the accuracy of Root ZX mini—this fixed point assumption may not fully represent clinical variability. In the future, techniques such as micro-CT could enable more precise determination of AWL and apical constriction in individual teeth. As it is an in vitro study, preventing chemical irrigant leakage from the apical foramen was an important methodological consideration. Leakage of irrigants into the external saline bath could affect EAL readings. While materials like alginate were preferred in previous studies,[12,30] the meticulous renewal of the saline bath used in our study with each tooth change minimized this risk.

Conclusions

The findings of this in vitro study demonstrated that the irrigants used during endodontic treatment can significantly influence the accuracy of working length measurements obtained with the Raypex 6 EAL. In the presence of QMix, Citric Acid, NaOCl, and EDTA solutions the EAL measurements were found to be statistically significantly shorter than the AWL. CHX, on the other hand, yielded the measurement results closest to the AWL. Clinicians should be aware of the effect of the irrigant on EAL readings and interpret electronic working length measurements with caution, particularly when highly conductive solutions such as NaOCl, citric acid, EDTA, or QMix are present.

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None.

Conflicts of Interest Statement

The authors declare no conflict of interest.

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