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# Effects of Intracanal Medicaments on the Measurement Accuracy of Four Apex Locators: An *In Vitro* Study

## Kanal İçi İlaçların Dört Apeks Bulucunun Ölçüm Doğruluğu Üzerindeki Etkileri: *In Vitro* Çalışma

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## Abstract

**Objective:** This study aimed to examine the effect of various intracanal medicaments on the precision of four electronic apex locators (EALs).

**Materials and Methods:** This study comprised 160 maxillary central incisors. After root canal preparation, a 25-K file was carefully introduced into the root canal until it was perceptible through the apex, and 0.5 mm was subtracted from this amount to determine the actual length. Samples were divided into four groups: calcium hydroxide, double antibiotic paste, triple antibiotic paste, and the control groups. Intracanal medications were removed with EDTA ten days later, and electronic measurements were performed. Chi-square ($\chi^2$) test was used to assess the precision of EALs within the margins of ±0.5 and ±1 mm ($\alpha$=0.05).

**Results:** The accuracies of the four EALs did not vary significantly for different intracanal drugs within the bounds of ±0.5 and ±1 mm ($\chi^2$ tests, p>0.05).

**Conclusion:** The EALs used in this study obtained reliable readings of working length in the context of varying intracanal medications.

**Keywords:** Calcium hydroxide, antibiotics, root canal medicaments, electronic apex locator

## Öz

**Amaç:** Bu çalışma, çeşitli kanal içi ilaçların dört elektronik apeks bulucunun (EAB) çalışma boyu ölçüm kesinliği üzerindeki etkisini incelemeyi amaçladı.

**Gereç ve Yöntemler:** Bu çalışma toplam 160 üst orta kesici dişi içermektedir. Kök kanal preparasyonundan sonra, bir 25 numara boyutunda K-tipi eğe kök kanalına yerleştirilerek apeksten algılanıncaya kadar dikkatli bir şekilde ilerletildi ve ardından bu değerden 0,5 mm çıkarılarak gerçek uzunluk belirlendi. Örnekler kalsiyum hidroksit, ikili antibiyotik patı, üçlü antibiyotik patı ve kontrol grubu olmak üzere dört gruba ayrıldı. Kanal içi ilaçlar 10 gün sonra EDTA ile çıkarıldı ve elektronik ölçümler yapıldı. EAB'lerin doğruluklarını ±0,5 ve ±1 mm ($\alpha$=0.05) hata payı içinde değerlendirmek için ki-kare ($\chi^2$) testi kullanıldı.

**Bulgular:** Farklı kanal içi ilaç grupları için dört EAB'nin doğruluklarında ±0,5 ve ±1 mm tolerans sınırları içerisinde önemli ölçüde değişiklik tespit edilmedi ($\chi^2$ testleri, p>0,05).

**Sonuç:** Bu çalışmada kullanılan EAB'ler, farklı kanal içi ilaçların varlığında güvenilir çalışma uzunluğu ölçümleri sağlamıştır.

**Anahtar Kelimeler:** Kalsiyum hidroksit, antibiyotikler, kök kanal medikamanları, elektronik apeks bulucu

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## Introduction

Achieving the proper working length which is an important stage of the procedure (1), is vital for a successful root canal treatment (RCT). Since there are concerns that many factors may affect this measurement, the influence of numerous clinical factors on the precision of electronic apex locators (EALs), such as coronal enlargement (2), diameter of the apical foramen (3), irrigation solutions (4), and intracanal medicaments (5,6), have been investigated by many researchers.

Complex root canal anatomy and the bacteria behind persistent periapical lesions can be especially difficult to clean and disinfect from the root canal system; such conditions may require using medications between RCT sessions (7). The high pH of $Ca(OH)_2$ makes it the optimal intracanal medicament for RCT (8). As alternative intracanal drugs; triple antibiotic paste (TAP) is prepared by mixing ciprofloxacin, metronidazole, and minocycline antibiotics in equal proportions (1:1:1) (8), and double antibiotic paste (DAP) is obtained by mixing ciprofloxacin and metronidazole in equal proportions (1:1) (9).

In RCT, one of the biggest issues is the full eradication of intracanal medicaments that have stayed in root canals between treatment sessions (7). Prior research has revealed that it is impossible to completely flush or agitate away intracanal dressings from root canals (6,10). The influence of $Ca(OH)_2$ as an intracanal dressing on the accuracy of EALs has been explored in previous literature (5,6,11). Nevertheless, no research has assessed the impact of intracanal applications of DAP and TAP on the precision of EALs.

This study aimed to analyze the effect of various intracanal medicaments on the accuracy of four EALs. This study hypothesized that the accuracy of EALs would not vary significantly when exposed to various medication residues.

## Materials and Methods

This laboratory study has been composed in accordance with the Preferred Reporting Items for Laboratory studies in Endodontology 2021 guidelines (12). The Erciyes University Clinical Research Ethics Committee gave their consent to conduct this study (decision no: 2020/110, date: 12.02.2020). The G*Power v.3.1.9.2 (Heinrich Heine, Düsseldorf University, Düsseldorf, Germany) program was employed to ascertain the necessary minimum sample size. An alpha-type error of 0.05, an effect size of 0.26 and a beta power of 0.80 were set, thus determining the minimal estimated sample size to be 160.

### Selection and Preparation of Samples

This study used 160 extracted human maxillary central incisors. Radiographs were taken of the specimens in mesiodistal and buccolingual directions to verify the presence of straight single canals. Teeth with root canal obliteration, excessive coronal tissue loss, and internal or external resorption were excluded and replaced by two examiners (T.A., H.C.).

Testing was conducted after the teeth were submerged in a 0.1% thymol solution. Teeth were decoronated at the cementoenamel junction with a Minitome precision cutting device (Struers ApS, Ballerup, Denmark) to establish a fixed reference point. After locating the root canal orifices, canal patency was checked using a 10 K-type hand file (EndoArt, Incidental, İstanbul, Turkey). The root canals were enlarged using a 25 Wave One Gold rotary file system (Dentsply). During root canal preparation, the canals were irrigated with 2.5 mL of 2.5% NaOCl, followed by 2.5 mL of distilled water. Paper cones were utilized to dehydrate the canals, and appropriate root canal conditions were obtained prior to the application of intracanal medicaments.

### Actual Working Length (AL) Determination

An experienced clinician (T.A.) ascertained actual working length using an operating microscope (OPMI Pico, Carl Zeiss Gmbh., Jena, Germany) at 10× magnification. A 25 K-type hand file was advanced until it could be seen apically. The rubber stopper of the file was fixed and a digital calliper was employed to measure the space between the file tip and the stopper. This measurement minus 0.5 mm yielded the actual working lengths.

### Applying Medicaments to Canals

The samples were distributed into four groups (n=40) randomly with regard to the type of intracanal medication being used.

**Group 1 [$Ca(OH)_2$]:** $Ca(OH)_2$ powder (Kalsin; Spot Dis Deposu AS, İzmir, Turkey) and distilled water were mixed in a 1:1.5 proportion until a creamy consistency was obtained. The root canals were filled using a lentulo spiral until $Ca(OH)_2$ was visible at the apex.

**Group 2 (DAP):** DAP was obtained by mixing ciprofloxacin (Cipro, Biofarma, İstanbul, Turkey) and metronidazole (Nidazol, IE Ulagay, İstanbul, Turkey) in equal proportions (1:1). Sterile saline solution was used as a carrier to form a paste of the antibiotics and mixed until it reached a creamy consistency. The root canals were filled using a lentulo spiral until DAP was seen at the apex.

**Group 3 (TAP):** TAP was obtained by mixing ciprofloxacin, metronidazole, and minocycline (Skid, Zentiva, Frankfurt, Germany) in equal proportions (1:1:1). Sterile saline solution was used as a carrier to mix the antibiotic powder into a paste with a creamy consistency. The root canals were filled using a lentulo spiral until TAP was seen at the apex.

**Group 4 (Control):** In the control group, no intracanal medication was delivered into the root canals of the samples.

### Detection of Electronic Lengths (EL)

The medicaments were left in the root canals of the samples for one week, and then the temporary fillings were removed.

No additional preparation was performed, and the root canals were irrigated with 17% EDTA using a 30-G needle. The specimens were embedded in a plastic mould filled with alginate, keeping 2 mm of the teeth crowns visible.

After randomly allocating 40 teeth to four subgroups (n=10), each subgroup was assigned an EAL measurement. Prior to measurement, the lip clip was placed in the alginate, and all measurements were completed within 2 hours to ensure that the alginate remained moist. A 25 K-type hand file (EndoArt, Incidental, İstanbul, Turkey) was used during the measurement.

All measurements were performed by an experienced clinician (H.C.) and conducted for each device following the instructions provided by the manufacturers. In these instructions, the markings on the products and how to interpret the numerical values were specified to indicate the apical constriction point.

Representative samples from each group were divided into two halves. Stereomicroscope images were then obtained to determine if the intracanal medicament in the root canals could be completely removed (Figure 1).

### Statistical Analysis

All statistical analyses were carried out with SPSS 22.0 (SPSS Inc., IL, USA) employing an alpha value of 0.05. The normality of the data was examined with the Shapiro-Wilk test, which demonstrated that all data were normally distributed (p>0.05). The EL-AL scores for each medication group were categorized within the margin of ±0.5 and ± 1 mm, the chi-square ($\chi^2$) test was utilized to contrast the precision of the EALs, with a significance level of 0.05.

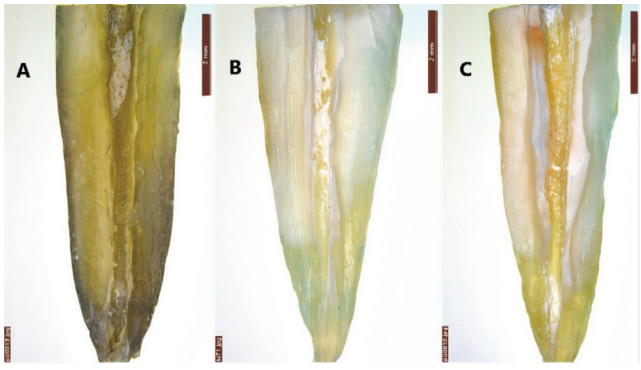


**Figure 1.** Representative stereomicroscope images of the root fragments (×10 magnification) showing the amount of residual medicament. (A) TAP, (B) DAP, (C) $Ca(OH_2)$

TAP: Triple antibiotic paste, DAP: Double antibiotic paste

## Results

The descriptive statistics of EL-AL values of EALs tested in different medicament groups are presented in Table 1. No statistical variation was found between the four EALs when evaluating measurements in the presence of different intracanal medicaments, given the tolerance of ±0.5 and ±1 mm ($\chi^2$ tests, p>0.05).

Figure 2 details the success levels of EALs based on intracanal medicaments staying within the ±0.5 mm tolerance limit.

In addition, no strong correlation was observed between the EL-AL differences and the type of residual medication [r=0.296 for $Ca(OH)_2$; r=0.025 for TAP; r=0.123 for DAP].

## Discussion

No residual intracanal medication should be left in the root canals; otherwise, these residues could impede the successful integration of root canal filling materials with the root canal walls (13). Therefore, various irrigation agents and techniques have been proposed to take out intracanal dressings from the root canal. According to previous studies, $Ca(OH)_2$, DAP, and TAP could not be completely removed from the root canal (6,14,15). In contrast, EDTA showed significantly greater success in eliminating $Ca(OH)_2$ than other irrigation solutions (16,17). In addition, EDTA can be effectively used to remove antibiotic pastes from root canals (14,18). In light of these findings, 17% EDTA was utilized in this study to dislodge intracanal medicaments from the root canal.

The impact of using $Ca(OH)_2$ as an intracanal drug on the precision of apex locator devices has been investigated in previous studies with conflicting results (5,6,11). In the $Ca(OH)_2$ group in this study, there was no notable discrepancy in the measurement accuracies of the four EALs at the ±0.5 and ±1 mm tolerance limits (p>0.05). Our results are consistent with those of Shojaee et al.'s (11).

**Table 1. Mean and standard deviation of EL-AL values of four EALs in the presence of different medicaments**

| | Raypex 6 (mean ± SD) (mm) | Ipex 2 (mean ± SD) (mm) | Apex ID (mean ± SD) (mm) | Propex Pixi (mean ± SD) (mm) |
|---|---|---|---|---|
| $Ca(OH)_2$ | 0.151±0.167 | 0.0450±0.134 | -0.260±0.337 | -0.276±0.187 |
| TAP | 0.120±0.120 | -0.0630±0.250 | -0.0130±0.283 | -0.192±0.204 |
| DAP | -0.0280±0.174 | -0.182±0.223 | 0.0660±0.284 | -0.167±0.190 |
| Control | 0.178±0.129 | -0.038±0.132 | -0.089±0.304 | -0.19±0.148 |

Negative values as the mean indicate shorter measurements than the actual length, while positive means indicate longer measurements than the actual length. EAL: Lectronic apex locators, SD: Standard deviation, TAP: Triple antibiotic paste, DAP: Double antibiotic paste

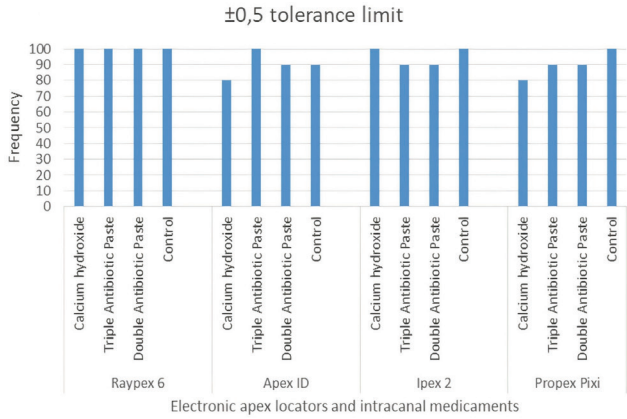


**Figure 2.** The percentage of measurement accuracy of EALs in the presence of intracanal medicaments within the tolerance limit of ±0.5 mm

EAL: Lectronic apex locators

This might be because the EALs used in both studies operated at nearly equal frequencies. Although there was no discernible statistical variation in the accuracy of EALs, Raypex 6 and Ipex 2 showed more consistent results than other EALs used in the $Ca(OH)_2$ group within the tolerance limit of ±0.5 mm. This might be due to variations in the apical anatomy of samples.

Analyses did not reveal any noteworthy variation in the precision of the four EALs when taking into account the ±0.5 and ±1 mm boundary conditions in the DAP and TAP groups ($p>0.05$). Considering the composition of DAP and TAP, only TAP contains minocycline. Minocycline is an antibiotic containing tetracycline, and it has a slight effect on removing the smear layer (19). Due to potential surface modifications caused by the smear layer's removal, such as the opening of tubules on the root dentin surface, dissolution of the inorganic structure, and movement of the dentin fluid (20) electronic measurement results may be affected. However, the lack of differences in the statistical results indicate that the antibiotic with the active ingredient minocycline did not significantly affect modern EALs. This might be because minocycline is a weak chelating agent at low doses and induces limited demineralization on the dentin surface (21).

Although no noteworthy distinction was observed between Raypex 6 and Apex ID in the TAP group, Raypex showed a higher accuracy in the DAP group, compared with other EALs, within the tolerance limit of ±0.5 mm. Due to the similar frequency ranges of EALs used in this study, no statistically significant difference may have occurred; however, small variations in frequencies may lead to small differences in the percentage of accuracy.

$Ca(OH)_2$, DAP and TAP groups showed less consistent results than the control group in measurements made with Propex Pixi. In the measurements made with Apex ID, the most consistent results were obtained in the TAP group, while the most inconsistent results were obtained from the $Ca(OH)_2$ group. However, these results as percentages are not statistically significant ($p>0.05$). These results may be due to the differences of apical anatomy in the samples.

The strengths of the present study are that the electronic measurement with EALs performed by another clinician who is unaware of the actual length measurements carried out under the operating microscope, and the differences between ELs and ALs were evaluated at a precision of 0.01 mm. All the EALs in this research showed optimum results with 100% accuracy in the four groups within the tolerance limit of ±1 mm. This was consistent with the findings of other studies in the literature (22). It is thought that the reason for the high accuracy rate within the 1 mm error range of the EALs tested in this study could be attributed to the remarkable technical characteristics of these contemporary EALs.

One of the shortcomings of this study was its *in vitro* nature hence the results of this study need to be verified *in vivo*. More research in a laboratory setting and in clinical trials is needed to back up the discoveries of this study.

## Conclusion

Within the confines of this study, contemporary EALs equipped with advanced technology were dependable in setting the working length despite the presence of DAP, TAP, and $Ca(OH)_2$ residue in the root canal.

### Ethics

**Ethics Committee Approval:** The Erciyes University Clinical Research Ethics Committee gave their consent to conduct this study (decision no: 2020/110, date: 12.02.2020).

**Informed Consent:** This study does not require informed consent.

**Peer-review:** Externally peer-reviewed.

### Authorship Contributions

Surgical and Medical Practices: H.C., Concept: H.C., T.A., B.K., Design: H.C., T.A., Data Collection or Processing: H.C., T.A., Analysis or Interpretation: T.A., Literature Search: H.C., T.A., B.K., Writing: H.C., B.K.

**Conflict of Interest:** No conflict of interest was declared by the authors.

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## References

1. Ricucci D, Langeland K. Apical limit of root canal instrumentation and obturation, part 2. A histological study. Int Endod J 1998; 31: 394-409.
2. de Camargo EJ, Zapata RO, Medeiros PL, Bramante CM, Bernardineli N, Garcia RB, et al. Influence of preflaring on the accuracy of length determination with four electronic apex locators. J Endod 2009; 35: 1300-2.

3. Herrera M, Abalos C, Planas AJ, Llamas R. Influence of apical constriction diameter on Root ZX apex locator precision. J Endod 2007; 33: 995-8.
4. Erdemir A, Eldeniz AU, Ari H, Belli S, Esener T. The influence of irrigating solutions on the accuracy of the electronic apex locator facility in the Tri Auto ZX handpiece. Int Endod J 2007; 40: 391-7.
5. Ustun Y, Uzun O, Er O, Canakcı BC, Topuz O. The effect of residual calcium hydroxide on the accuracy of a contemporary electronic apex locator. Acta Odontol Scand 2015; 73: 132-6.
6. Uzunoglu E, Eymirli A, Uyanik MÖ, Çalt S, Nagas E. Calcium hydroxide dressing residues after different removal techniques affect the accuracy of Root-ZX apex locator. Restor Dent Endod 2015; 40: 44-9.
7. Chou K, George R, Walsh LJ. Effectiveness of different intracanal irrigation techniques in removing intracanal paste medicaments. Aust Endod J 2014; 40: 21-5.
8. Faria G, Rodrigues EM, Coaguila-Llerena H, Gomes-Cornélio AL, Neto Angéloco RR, Swerts Pereira MS, et al. Influence of the vehicle and antibiotic formulation on cytotoxicity of triple antibiotic paste. J Endod 2018; 44: 1812-6.
9. Samir Abouelenien S, Mohamed Ibrahim S, Gameel Shaker O, Mohamed Ahmed G. Evaluation of postoperative pain in infected root canals after using double antibiotic paste versus calcium hydroxide as intra-canal medication: A randomized controlled trial. F1000Res 2018; 7: 1768.
10. Zhou J, Liu T, Guo L. Effectiveness of XP-Endo Finisher and passive ultrasonic irrigation on intracanal medicament removal from root canals: a systematic review and meta-analysis. BMC Oral Health 2021; 21: 294.
11. Shojaee NS, Zaeri Z, Shokouhi MM, Sobhnamayan F, Adl A. Influence of calcium hydroxide residues after using different irrigants on the accuracy of two electronic apex locators: An in vitro study. Dent Res J (Isfahan) 2020; 17:48-53.
12. Nagendrababu V, Murray PE, Ordinola-Zapata R, Peters OA, Rôças IN, Siqueira JF Jr, et al. PRILE 2021 guidelines for reporting laboratory studies in Endodontology: A consensus-based development. Int Endod J 2021; 54: 1482-90.
13. Kim SK, Kim YO. Influence of calcium hydroxide intracanal medication on apical seal. Int Endod J 2002; 35: 623-8.
14. Ustun Y, Düzgün S, Aslan T, Aktı A. The efficiency of different irrigation solutions and techniques for the removal of triple antibiotic paste from simulated immature root canals. Niger J Clin Pract 2018; 21: 287-92.
15. Dias-Junior LCL, Castro RF, Fernandes AD, Guerreiro MYR, Silva EJNL, Brandão JMDS. Final Endodontic Irrigation with 70% Ethanol Enhanced Calcium Hydroxide Removal from the Apical Third. J Endod 2021; 47: 105-11.
16. Nandini S, Velmurugan N, Kandaswamy D. Removal efficiency of calcium hydroxide intracanal medicament with two calcium chelators: volumetric analysis using spiral CT, an in vitro study. J Endod 2006; 32: 1097-101.
17. Rödig T, Vogel S, Zapf A, Hülsmann M. Efficacy of different irrigants in the removal of calcium hydroxide from root canals. Int Endod J 2010; 43: 519-27.
18. Eymirli A, Nagas E, Uyanik MO, Cehreli ZC. Effect of Laser-Activated Irrigation with Ethylene Diaminetetraacetic Acid and Phytic Acid on the Removal of Calcium Hydroxide and Triple Antibiotic Paste from Root Dentin. Photomed Laser Surg 2017; 35: 43-8.
19. Mohammadi Z, Shalavi S, Yaripour S, Kinoshita JI, Manabe A, Kobayashi M, et al. Smear layer removing ability of root canal irrigation solutions: A review. J Contemp Dent Pract 2019; 20: 395-402.
20. Silva AC, Moura CC, Ferreira JA, Magalhães Dd, Dechichi P, Soares PB. Biological Effects of a Root Conditioning Treatment on Periodontally Affected Teeth--An In Vitro Analysis. Braz Dent J 2016; 27: 160-8.
21. Parhizkar A, Nojehdehian H, Asgary S. Triple antibiotic paste: momentous roles and applications in endodontics: A review. Restor Dent Endod 2018; 43: e28.
22. Stöber EK, de Ribot J, Mercadé M, Vera J, Bueno R, Roig M, et al. Evaluation of the raypex 5 and the mini apex locator: An in vivo study. J Endod 2011; 37: 1349-52.