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**Araştırma/ Research Article**

# A COMPARISON OF THE ACCURACY OF TWO DIFFERENT APEX LOCATORS USING DIFFERENT ROOT CANAL SOLUTIONS

# FARKLI KANAL YIKAMA SOLÜSYONLARI KULLANILARAK İKİ FARKLI APEKS BULUCUNUN DOĞRULUĞUNUN KARŞILAŞTIRILMASI

**Doç. Dr. M.Sinan EVCİL*** **Arş. Gör. Dt. İbrahim ERSOY****
**Arş. Gör. Dt. Kübra YEŞİLDAL YETER**** **Doç. Dr. K. Meltem COLAK TOPCU***

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## ÖZET

**Aim:** The aim of this study was to investigate whether the Apex Pointer EAL (Electronic Apex Locator) or the Propex EAL can give actual working length measurements in dry canals or canal irrigated with NaOCl, EDTA, or saline.

**Material and Methods:** Thirty-one human premolar and incisor teeth with single roots were used in this study. To determine the actual working length, a number 10 K-file was progressed as far as the major foramen under a stereomicroscope. When the tip of the K-file was visible in the major apical foramen, a silicon stopper was immediately adjusted to the canal surface. The K-file was removed from the root canal and the distance between an endodontic ruler and the silicon stopper was measured. These measurements were selected as the control group. Then, measurements were performed with both the Propex EAL and Apex Pointer EAL under different conditions (dry, NaOCl, EDTA, and saline). A measurement was deemed unstable when the reading of the EAL did not remain stable for at least 5 seconds. The stable measurements were selected as the study group.

**Results:** The rate of the accurate measurements with the Propex were 35% at ± 0.5 mm and 70% at ±1 mm in dry canals; 26% at ±0.5 mm and 58% at ±1 mm in canals with NaOCl; 58% at ± 0.5 mm and 90% at ±1 mm in canals with saline; and 26% at ±0.5 mm and 71% at ±1 mm in canals with EDTA. The rate of the with the actual measurements with the Apex Pointer were 35% at ±0.5 mm and 61% at ±1 mm in dry canals; 26% at ±0.5 mm and 45% at ±1 mm in canals with NaOCl; 45% at ±0.5 mm and 70% at ±1 mm in canals with saline; and 54% at ±0.5 mm and 80% at ±1 mm in canals with EDTA. None of the tested devices delivered an actual measurement of 100%. However, the differences between control and study groups in all samples were not statistically significant.

**Conclusion:** Therefore, both the Propex EAL and Apex Pointer can be used safely to determine the actual working length.

**Keywords:** Working length, Propex EAL, Apex Pointer EAL

## ABSTRACT

**Amaç:** Bu çalışmanın amacı Apex Pointer EAL (Elektronik Apeks Bulucu) ve Propex EAL'nin kuru veya NaOCl, EDTA ve salin solüsyonu ile yıkanmış kanallarda gerçek çalışma uzunluğunu verip vermediğini incelemektir.

**Gereç ve Yöntem:** Bu çalışmada 31 tek köklü premolar ve kesici insan dişi kullanıldı. Gerçek çalışma boyutunu belirlemek için 10 numaralı K tipi kanal eğesi bir steromikroskop altında majör foramene kadar ilerletildi. Kanal eğesinin ucu majör apikal foramende görüldüğü zaman silikon bir stoper hemen kanal yüzeyine ayarlandı. Kanal eğesi kök kanalından çıkarıldı ve endodontik cetvel ile silikon stoper arasındaki mesafe ölçüldü. Bu ölçümler kontrol gurubu olarak kabul edildi. Sonraki ölçümler hem Propex EAL hem de Apex Pointer EAL ile farklı koşullar altında (kuru, NaOCl, EDTA ve saline) yapıldı. EAL'nin okuması en az 5 saniye stabil kalmadıkça o ölçüm "stabil değil" şeklinde kabul edildi. Stabil ölçümler çalışma gurubu olarak dahil edildi.

**Bilgular:** Propex ile yapılan değerlendirmeler; kuru kanallarda ±0.5 mm de %35 ve ±1 mm de %70, NaOCl'li kanallarda ±0.5 mm de %26 ve ±1 mm de %58, salin sulüsyonu ile yıkanan kanallarda ± 0.5 mm de %58 ve ±1 mm de %90 ve EDTA'lı kanallarda ±0.5 mm de %26 ve ±1 mm de %71 gerçek boyuta yakın değerler gösterdi. Apex Pointer ile yapılan değerlendirmeler; kuru kanallarda ±0.5 mm de %35 ve ±1 mm de %61, NaOCl'li kanallarda ±0.5 mm de %26 ve ±1 mm de %45, salin sulüsyonu ile yıkanan kanallarda ± 0.5 mm de %45 ve ±1 mm de %70 ve EDTA'lı kanallarda ±0.5 mm de %54 ve ±1 mm de %80 gerçek boyuta yakın değerler gösterdi. Test aletlerinin hiçbiri %100 gerçek boyut doğruluğu göstermedi. Bununla birlikte tüm örneklerde çalışma ve kontrol gurubu arasındaki farklılıklar istatistiksel olarak anlamlı değildi.

**Sonuç:** Bu nedenle hem Propex EAL hem de Apex Pointer gerçek çalışma boyutunu belirlemede güvenle kullanılabilir.

**Anahtar Kelimeler:** Çalışma boyutu, Propex EAL, Apex Pointer EAL

*Associated Professor, Department of Endodontic, Faculty of Dentistry, Ataturk University, Erzurum, Turkey
**Research Assistant, Department of Endodontic, Faculty of Dentistry, Ataturk University, Erzurum, Turkey

## INTRODUCTION

Although it is difficult to measure an exact working length under clinical conditions, there is a consensus on the importance of an actual working length determination.[1] The apical construction, where the pulp tissue is connected to the periodontal tissue, is accepted as the appropriate landmark. This construction, also referred as the foramen minor,[2] is the narrowest part of the root canal treatment in the apical area that treatment should be terminated. The apical construction is the end-point of the instrumentation and the obstruction. The tooth pulp is also the narrowest at that point and the healing of the pulp wound is more favourable.[3] The apical construction is thought to be located 0.5 or 1mm, on average, short of the anatomical apex. Damaging the apical construction is reported to cause tissue destruction, inflammation, and foreign body reaction in the apical tissue following the over-limitation of root filling.[4]

Generally, the working length is measured using periapical radiography. In this method, the tip of a file is inserted in the root canal and the distance between the tip of the file and tip of the radiographic apex is measured. However, determination of the working length with this method may be difficult because of the superimposition of anatomical structures (i.e., zygomatic arch, maxillary sinus, etc.). Because periapical radiography has two dimensions, it cannot show the bucco-lingual curvature. For these reasons, new devices, called the electronic apex locators (EALs),[5] have been developed to determine the actual working length.

One of the most important issues in endodontic studies is the determination of the actual working length before the treatment. With technological developments, apex locators are now being used to determine the actual working length in modern endodontics. This electronic method for the determination of working length was first investigated by Custer.[6] Suzuki[7] later carried out a study on dog teeth. About 20 years later, Sunada[8] developed this technique to allow the measurement of the root canal length in a clinical setting. Technological developments have since resulted in rapid improvements in the EALs. Today, the actual working length is routinely measured using EALs rather than radiographic methods.

A typical root canal irrigation solution is 5.25% sodium hypochlorite (NaOCl), which is preferred in endodontic clinics for dissolving necrotic pulp tissues and organic remnants.[5] Another type of canal irrigation is ethylene diaminotetraacetic acid (EDTA). EDTA is a chelation agent used to clean canals and it has been widely used in narrow canals since the 1970s. Chelation solutions are more toxic to the periapical tissues compared to acids and they soften the dentin.[9] The chelation agent inactivates calcium ions by combining with them in the dentin. Therefore, the canals are more easily instrumented due to the decreased dentin strength.[9] EDTA demineralizes the dentin by reaching to depths of 20-30 micron in 5 minutes in dentin. It is also antimicrobial.[10]

Many attempts have been made to validate EAL measurements, but there is a lack of reliability in the results.[11] The reliability of EALs can change in a range from 35% to 100%.[12] Although EALs are developing in parallel with advances in technology, it has always been a subject for debate whether these instruments measure the actual working length.

The objective of the present paper is to evaluate the reliability of two different apex locators: the Apex Pointer (Micromega, Bestnea, France) and the Propex (Dentsply, Maillefer, Switzerland) in the actual working length determination under different irrigation conditions.

## MATERIALS AND METHODS

31 human premolar and incisor teeth with single roots which had been extracted due to orthodontic or periodontal reasons were used in this study. Teeth showing resorption and fracture were excluded. Both bucco-lingual and mesio-distal digital radiographies were taken before operation and the teeth with a calcified root canal were also eliminated. The extracted teeth were kept for 2 h in distilled water. In order to create smooth surfaces against the roots vertical length, crown part is separated from cement-enamel junction. Standard entrance preparation is done by using fast speed diamond fissure frez (Hager and Meisinger, Germany) under water cooling. Then the teeth are numbered the middles of root canals and their coronels are shaped with 3 and 4 number Gates-glidden drills (Dentsply, Germany). Tissue remnants were removed with barbed broaches



(VDW-GmbH, Munich, Germany). The roots were washed with 1% sodium hypochlorite. The actual working length (AWL) was measured by inserting a # 10 k-file (Mani, INC, Tochigi, JAPAN) until the file tip was just visible using 3 x magnification. After adjusting a silicone stopper (Maillefer, Dentsply, GERMANY) to the coronal reference, the file was removed from the canal and its length was measured. According to Kuttler`s study, 0.5 mm was subtracted from this length and the new length was considered as the actual working length.[4]

All processes were carried out under the supervision of four dentists. The roots were embedded in alginate (Alginoplast, Heraus, Germany) so that about 1 or 2 mm of the coronal region protruded. A lip clip was immersed into the alginate for electronic measurements. All specimens' root canal lengths were measured with a spectromicroscobe because of determining the actual working length as control values. After than each tooth was irrigated 4 different methods and root canal lengths were measured with Apex Pointer AEL and Propex AEL respectively. According to the irrigations methods, this study comprises 5 groups and 2 AEL. The root canals were washed with 1% NaOCl with an endodontic injector (Ultradent, South, Jordan), which cleaned up to 1/3 of the coronal part of the root canals. The top and internal surfaces of the canals were dried with a cotton ball and a sterile paper point (Aceonedent, Geonggi, KOREA), respectively. After this preparation, the working length measurements were first taken from dry canals using the Apex Pointer EAL and Propex EAL and these measurements were recorded when the reading of the EAL remained stable for at least 5 seconds. The root canals were then washed with 5.25% NaOCl and the measurements were repeated. For other measurements, the root canals were washed with 0.9% physiological saline and 19% EDTA (MM-EDTA, Cream, Germany), and then the working lengths were measured and recorded. The root canals were washed with 0.9% physiological saline and dried thoroughly with a sterile paper point before each measurement.

For determining the statistically differences between the working groups, the root canal length values (mm) were analyzed by one-way analysis of variance (ANOVA) with a specific software (SPSS 16 for Windows) ($p<0.05$).

## RESULTS

The results are shown in Figure 1, 2 and Table I. The rate of the accurate measurements with the Propex were 35% at ±0.5 mm and 70% at ±1 mm in dry canals; 26% at ±0.5 mm and 58% at ±1 mm in canals with NaOCl; 58% at ± 0.5 mm and 90% at ±1 mm in canals with saline; and 26% at ±0.5 mm and71% at ±1 mm in canals with EDTA. The rate of the accurate measurements with the Apex pointer were 35% at ±0.5 mm and 61% at ±1 mm in dry canals;26% at ±0.5 mm and45 % at ±1 mm in canals with NaOCl; 45% at ±0.5 mm and70% at ±1 mm in canals with saline; and 54% at ±0.5 mm and 80% at ±1mm in canals with EDTA. None of the tested devices delivered an actual measurements of 100%. According to the statistically analyses, there were any differences between groups ($p>0.05$) (Table I).

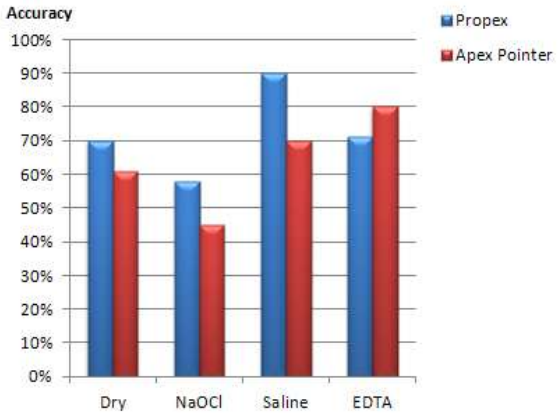


Figure 1. The frequency of the measurements (±1 mm) relative to the apical construction

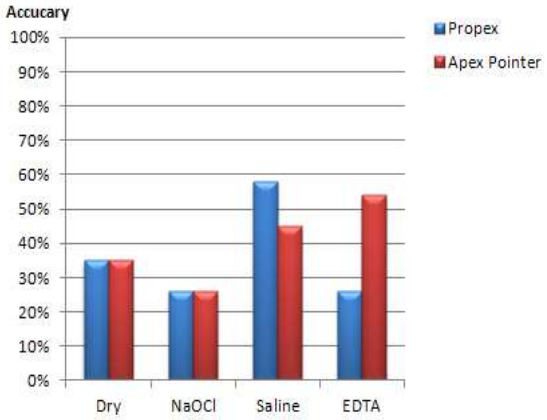


Figure 2. The frequency of the measurements (±0.5 mm) relative to the apical construction

Table I: The mean values and standard deviations of root canal lengths (mm) for each group.

| | Irrigation Methods | N | Mean Values | Std. Dev. | Sig. |
|---|---|---|---|---|---|
| **Apex Pointer EAL** | *Control* | 30 | 14.62 | 1.92 | .236 |
| | *Dry* | 31 | 15.35 | 1.72 | |
| | *NaOCl* | 31 | 14.56 | 1.72 | |
| | *Saline* | 31 | 14.77 | 1.70 | |
| | *EDTA* | 31 | 15.31 | 1.76 | |
| **Propex EAL** | *Control* | 30 | 14.62 | 1.92 | .093 |
| | *Dry* | 31 | 15.85 | 1.83 | |
| | *NaOCl* | 31 | 15.02 | 1.90 | |
| | *Saline* | 31 | 15.52 | 1.92 | |
| | *EDTA* | 31 | 15.25 | 1.79 | |

## DISCUSSION

Different studies have investigated the accuracy of EALs in determining the root canal length.[13] The aim of the present study was to assess the capability of EALs to go beyond the apical construction in mm while the file tip is advancing through the root canal.

Various media have been used in the laboratory studies of the EALs to mimic the clinical situation. The alginate model was selected for its good electroconductive features, easy preparation stability, and firm consistency.[14] The determination of the canal length before flaring with Gates glidden drills could change the actual root canal length. Measurements were done before and after flaring, but no difference was found because teeth with smooth roots were used.

The biggest difference was found when the distance between the file tip and apical construction was about 5mm. According to previous studies, the measurement's accuracy increases as the file tip gets nearer to the foramen.[15,16]

In the present study, the Propex apex locator measurements in the 0.0 point were 16% when the root canals were dry; 5.25% when they were washed with NaOCl; 13% when the root canals were washed with physiological saline; and 32% when the root canals were washed with EDTA.

All of the measurements were within the acceptable clinical range of AL±0.5 mm. Nearly the same reports were given by Venturi and Breschi.[17] If the considered working length is AL±0.5 mm, which is acceptable in clinics, then the measurements done with the two EALs at 0.5 foramen are agreeable. The results are in agreement with previous studies, which stated that EALs can actually determine the root canal length within 0.5mm from the apical construction.[18] When the position of the file tip was at the major apical foramen, some of the measurements by the three EALs were positive as the file tip was beyond the major foremen, according to Wrbas et al.[19] and D'Assuncao et al.[20] The apical construction, rather than the major apical foramen, should be used as a benchmark to determine the working length in order to eliminate over-preparation.

Some researchers have measured the minor apical foramen while others have measured the major apical foramen.[19-25] If we consider a working length of 0.5mm as acceptable, then we see that the accuracy of the Propex apex locator was 35% when the canals were dry; 5.25% when NaOCl was used; 26% when saline was used; and 58% when EDTA Cream 26% was used. Briseno-Marroquin et al.[12] found 38 %, 62-43, 45%, and 40, 63% in succession with a 08-10-15 numbered K-files for the Propex apex locator in their research.

For the Apex Pointer EAL, the correct point at 0.0 mm is found 22% of the time when the root canals are dry; 13% with NaOCl; 16% with physiological saline; and 32% with EDTA Cream. If we consider ±0.5mm as acceptable, then we can say that the Apex Pointer gave 35% correct measurements when the canals were dry; 26% when they were washed with NaOCl; 45% with saline; and 54% with EDTA Cream.

In the investigations where the function rate was 86.6 with the Apex Pointer, the rates of radiographically admitted measurements were 93.9%.[1] With an over-preparation, the wrong measurements resulted; namely, a longer working length than normal was determined when the canals were dry; 10% with NaOCl; 6% with saline irrigant; and 10% with EDTA Cream. Therefore, we determined that the working length values for the Propex apex locator in physiological saline gave more accurate measurements.

For over preparation, the Apex Pointer EAL gave 16% wrong measurements when the canals were dry; 13% when the root canals were irrigated with NaOCl; 0% with physiological saline; and 3% with EDTA Cream. As we have seen here, The Apex pointer EAL, like the Propex EAL, gives more correct (fewer wrong) results in physiological saline environment; in the present study it produced 0% wrong measurements.

These result prompt a question of whether the working length might be measured when the EAL shows the apical construction or at same coronal distance from that point.[21,26] To prevent over-preparation, some authors have suggested going 0.5 mm to 1.00 mm beyond the electronic measurements.[19,27,28]

If we accept the actual EAL working limit as ±1 mm and compare its accuracy, we find that 70% of the Propex apex locator measurements are correct when the canals are dry; 58% with NaOCl; 90% with saline; and 71% with EDTA Cream.

If we compare the working length of the Apex Pointer EAL at ±1mm, it is 61% accurate when the canals are dry; 45% with NaOCl; 90 % with saline; and 80% with EDTA Cream.

This technology that underlies these new types of EALs, which are not affected by the different discharges from the blood, electrolytes, saline, distilled water, or hydrogen peroxide, delivers extreme accuracy and reliability and eliminates overextended or under extended root filing.[29] Much research have shown that the usage of EALs does not give 100% precise placement of the apical construction or the major foramen.[19]

The use of NaOCl can result in a toxic effect that is ten times greater than the anti-microbial effect when tested in cell cultures. Even 5.25% NaOCl is much too toxic, as shown by results of the cytotoxicity investigations. Huffaker et al.[30] witnessed that rats developed skin ulcerations following intradermal injections of NaOCl diluted 1/1, 1/2, and 1/4 with water and NaOCl can affect living tissue in addition to necrotic tissue. Susin et al.[31] found that when 2.5% NaOCl drops were applied to dog teeth or mouth mucosa, ulcerations resulted and stressed that a very good rubber-dam should be applied when this solution is used. Despite these investigations, Cunningham says, "The results of laboratory studies cannot completely be applied to clinics, as clinic conditions are different; there is no toxic effect under these conditions.[32] Becker et al.[33] stated that when 0.5 mm of 5.25% NaOCl escapes to periapical tissues, it creates a temporary loss of feeling.

## CONCLUSION

None of the tested devices gave an actual measurement of 100%. However, the difference between control and study groups in all samples was not statistically significant. Therefore, both the Propex EAL and the Apex Pointer EAL can be used safely to determine the actual working length

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**Yazışma Adresi:**
Research Assistant Ibrahim ERSOY
Department of Endodontic,
Faculty of Dentistry, Ataturk University,
25240, Erzurum, TURKEY
Tlf: +90.442 2311746
Fax number: +90 442 2360945
E-mail address:dt_ibrahim_777@hotmail.com