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A COMPARATIVE ASSESSMENT OF THE ACCURACIES OF RAYPEX 5, RAYPEX 6, IPEX AND IPEX II ELECTRONIC APEX LOCATORS: AN IN VITRO STUDY *

Raypex 5, Raypex 6, Ipex ve Ipex II Elektronik Apeks Bulucularının Doğruluğunun Karşılaştırmalı Olarak Değerlendirilmesi: In Vitro Çalışma

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ABSTRACT

Purpose: The aims of this study were to examine the accuracy of iPex II and to compare it with those of Raypex 5, Raypex 6 and iPex electronic apex locators (EALs).
Materials and Methods: Thirty fresh human mandibular premolar teeth were used in this study. Crown segments were cut and root canals were coronally flared. A #10 K-file was inserted until its tip can be seen within apical foramen to determine actual working length (AWL). Teeth were embedded in alginate and each multi-frequency EALs were randomly tested to determine the electronic working length (EWL). Differences between AWLs and EWLs were statistically compared.
Results: No significant differences were found between four EALs. EWL measurements by Raypex 5 were accurate in 64.29%, Raypex 6 in 53.58%, iPex in 64.29% and iPex II in 50% of the specimens, within the range of ±0.5 mm from the AWL.
Conclusion: Within the limitations of this in vitro experiment, our findings indicate that the accuracy of working length measurements calculated with iPex II was similar to those of other multi-frequency EALs used in this study.

Keywords: Electronic apex locator; iPex II; Raypex 6; root canal treatment; working length

ÖZ

Amaç: Bu çalışmanın amacı iPex II cihazı ile elde edilen ölçümlerin doğruluğunu değerlendirmek ve bunları Raypex 5, Raypex 6 ve iPex multi-frekans elektronik apeks bulucuları (EAB) ile elde edilen ölçümlerle karşılaştırmaktır.
Gereç ve Yöntem: 30 adet yeni çekilmiş insan alt küçük azı dişi kronlarından ayrıldı ve kök kanalları koronale açılı olarak genişletildi. 10 numara K tipi eğenin ucu apikal foramende görülene kadar ilerletilerek gerçek çalışma boyu (GÇB) belirlendi. Dişler aljinata gömüldü ve elektronik çalışma boyunu (EÇB) ölçmek için her bir apeks bulucu rastgele test edildi. GÇB ve EÇB arasındaki farklar istatistiksel olarak karşılaştırıldı.
Bulgular: Apeks bulucudan elde edilen ölçümler arasında istatistiksel olarak anlamlı bir fark saptanmadı. Bu çalışmanın verileri ±0.5 mm aralığında EÇB ölçümünün Raypex 5 kullanılan örneklerde %64.29, Raypex 6 kullanılanlarda %53.58, iPex kullanılanlarda %64.29 ve iPex II kullanılanlarda %50 oranında doğru olduğunu gösterdi.
Sonuç: Bu in vitro çalışmanın sınırları dahilinde, iPex II cihazı kullanılarak yapılan ölçümlerin doğruluğunun, bu çalışmada kullanılan diğer çok frekanslı EABlardan elde edilenlerin doğruluğu ile benzer olduğu sonucuna varılmıştır.

Anahtar kelimeler: Elektronik apeks bulucu; iPex II; Raypex 6; kök kanal tedavisi; çalışma boyu

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Introduction

Correctly determining the working length (WL) is one of the main factors that lead to successful endodontic therapy (1). The distance between the coronal access point and the apical end of root canal at which the obturation should be terminated, is defined as WL(2). Incorrectly measured root canal WL may leave undebrided bacteria in the apical area. Such miscalculation could also cause significant damage in the root end anatomy which, in turn, makes it difficult to obtain proper apical seal. Subsequently, this may lead to the failure of endodontic treatment (3). Periapical radiographs of the tooth with an instrument placed in the canal have long been used to determine the WLs of root canals. However, well-known limitations of this approach do exist, such as inadequate sensitivity, subjectivity, image magnification and distortion errors, as well as superpositioning of neighboring anatomical structures (4). Other shortcoming of radiography is exposing the patient to ionizing radiation (5).

To overcome these disadvantages, electronic apex locators (EALs) have been developed (6) to determine the WL more accurately (7-9) than radiographs (7, 10-13). First studies on EALs have begun as early as 1942 with Suzuki (14) who discovered the presence of constant electrical resistance that exist between the periodontium and oral mucous membrane. Sunada (15) found that electrical resistance between the periodontal ligament and the oral mucosa could be represented by numerical values. More advanced devices were then developed in successive generations, such as electrical resistance–based EALs (16), impedance-based EALs and frequency-based EALs (9, 17). Recently developed EALs measure the resistance and capacitance simultaneously by using different frequencies (18, 19). iPex II (NSK Inc., Kanuma, Japan) is a multi-frequency EAL which has been recently introduced to the market, however, no data is available in the literature regarding its accuracy. The aims of this study were therefore to examine the accuracy of iPex II in determining the WL and to compare it with those of Raypex 5, Raypex 6 and iPex EALs.

Materials and Methods

Specimen selection and preparation

The study protocol has been evaluated and approved by the Local Ethics Committee of Ankara University Faculty of Dentistry in Turkey (Project number: 36290600/24). Thirty freshly extracted human mandibular premolars with a straight, single root canal were used in this study (N=30). Teeth were stored in 1% thymol solution until used. Calculus and soft tissue remnants were cleared with ultrasonic devices. Root surfaces and apical regions were examined with a dental loupe (Carl Zeiss Gmbh., Jena, Germany) at 4x magnification to detect possible fractures and to determine the apex maturity. Digital periapical radiographs of with mesiodistal and buccolingual inclinations were taken (Trophy RadioVisio Graphy, Trophy Radiologie, Croissy-Beaubourg France) to justify that each specimen only had one straight, non-calcified root canal. The crown of each tooth was cut at the cemento-enamel junction with a diamond disk in order to provide a standard reference point for all measurements. The canal orifices were preflared with a rotary file Protaper SX (Dentsply Maillefer, Ballaigues, Switzerland). Patency was checked with a #08 K-file (Dentsply Maillefer, Ballaigues, Switzerland). Canals were irrigated with 5 ml 2.5% sodium hypochlorite (NaOCl, Werax, İzmir, Turkey).

Working length determination

Teeth were consecutively numbered up to 30 and specimens were randomly selected for measurement using a #10 K-file with double stoppers to decrease the chance of stopper movement during measurements. The file was progressed in the root canal until it became visible at the apical foramen under a dental loupe at 4x magnification. The file was then withdrawn 0.5 mm and the length between file tip and reference point was measured with a digital caliper till tenth of millimeter. Each measurement was repeated 3 times and the mean of these calculations was considered as the representative measurement of that sample. This distance was recorded as actual working length (AWL). Then, an adequate amount of alginate Cavex Color Change (Cavex Holland BV, Haarlem, The Netherlands) was condensed within the teflon molds in which the roots were embedded, leaving approximately 5 mm of the root surface exposed. The root was kept in that position until the setting process is complete.

Electronic working length (EWL) determination

All the electronic measurements were made within an interval of 2 h, with alginate maintained in sufficiently humid conditions. During electronic measurement, the labial clip of was inserted into

the alginate. Raypex 5 (VDW, Munich, Germany), Raypex 6 (VDW, Munich, Germany), iPex (NSK Inc., Kanuma, Japan) and iPex II (NSK Inc., Kanuma, Japan) EALs were used in accordance with their manufacturers' instructions. In order to obtain electronic measurements, #10 K-file with double stoppers that was connected to the each EALs were used to determine the EWL in each canal. The canals were irrigated with 2.5% NaOCl. Cotton pellets were used to dry the tooth surface and to eliminate the excess irrigating solution. When using Raypex 5 and Raypex 6, the file was advanced just beyond the foramen until the first red bar is seen on the screen and it was then withdrawn until all flashing green bars had been reached. When using the iPex and iPexII, the file was advanced within the root canal just beyond the foramen which is indicated by the flashing apex bar and the continuous sound tone. The file was then withdrawn until an audible signal and a flashing bar indicated that the 0.5 mm mark short of the apical foramen is reached. When the EAL exhibited the specified reading, the stoppers were adjusted to coronal surface of the roots, the file was removed and the distance was measured with a digital caliper. The mean of three consecutive measurements was recorded as the representative EWL of each canal for the corresponding device. Differences between EWL and AWL were calculated. Positive values indicated measurements that were long of the AWL, negative values indicated measurements that were short of the AWL, and ±0.5 values were considered coinciding measurements.

Statistical analysis

The collected data from all groups were imported to Statistical Package for Social Sciences (SPSS) for Windows software, version 16.0 (SPSS Inc., Chicago, IL, USA). Since the distribution met the assumptions of normality, One-way analysis of variance followed by the t-test were used to analyze the data and the significance level was set to $p<0.05$.

Results

2 specimens had to be discarded during EWL measurements because of the instrument failure; therefore, 28 teeth were included in the final analysis. There were no significant differences between four EALs. The mean differences between AWLs and EWLs are shown in Table 1. The data of this study showed that the EWL measurement with Raypex 5 was accurate in 64.29%, Raypex 6 in 53.58%, iPex in 64.29% and finally, iPex II in 50% of the specimens, within the range of ±0.5 mm from the WL (Table 2).

Table 1. *Mean differences and standard deviations (SD) between the electronic working lengths and actual working lengths measurements obtained from each electronic apex locator.*

Devices	n	mean difference (mm)	SD (mm)
Raypex 5	28	0.2039	0.4442
Raypex 6	28	0.3718	0.4008
iPex	28	0.2628	0.4163
iPex II	28	0.3618	0.4147

No statistically significant difference was found (p=0.4007).

Table 2. *Numbers and frequencies of the measurements falling short, long or within ±0.5 mm from the actual working length obtained from each electronic apex locator.*

Devices	<0.5 mm n (%)	±0.5 mm n (%)	>0.5 mm n (%)
Raypex 5	1 (3.47%)	18 (64.29%)	9 (32.14%)
Raypex 6	1 (3.47%)	15 (53.58%)	12(42.86%)
iPex	1 (3.47%)	18 (64.29%)	9 (32.14%)
iPex II	1 (3.47%)	14 (50%)	13(46.53%)

Discussion

Accurate measurement and maintenance of WL are critical steps in endodontic therapy (20). The aims of this in vitro study were to evaluate and to compare the accuracies of iPex II, Raypex 5, Raypex 6 and iPex devices. In general, in vitro test methods which include alginate models and extracted human teeth have been used to examine the accuracy of EALs (21, 22). This experimental set-up is non-expensive, easy to reproduce and teeth can remain stable for hours. Moreover, hiding the root apices by embedding the teeth into the alginate may mimic *in vivo* conditions to some extent. Blocks made of alginate are relatively stiff and this can prevent fluid movement inside the

canal. Therefore, premature electronic readings recorded with previous models could be avoided (22, 23). Commonly used irrigation solutions such as chlorhexidine, ethylene diamintetraacetic acid (EDTA), saline and NaOCl do not affect the accuracy of EALs (24, 25). In the present study, NaOCl was used as the irrigation solution during EWL measurements. Performing the measurements by using the same teeth with each device is an important detail in order to precisely compare the accuracies and possible differences between EALs in determining the WL (26). Based on this previous knowledge, same teeth were used to measure WL in the present study.

Although some authors prefer ±1 mm range from AWL (27, 28), ±0.5 mm range we used in this study is the strictest acceptable range (29-31) which was used to determine the accuracy of EALs. The reported accuracies of EALs vary from 35% (32) to %100 (21). The EWL measurements were mostly within the ±0.5 mm range for all tested EALs; Raypex 5 was accurate in 64.28%, Raypex 6 in 53.58%, iPex in 64.29% and iPex II in 50% of the cases. On the other hand, all EALs also produced measurements which fall short or long of this range. The number of longer measurements (+0.5) was higher than that of shorter measurements (-0.5 mm). The results of this study showed no statistically significant difference between the EALs.

There are conflicting arguments regarding the accuracies of EALs. Swapna *et al*. (33), Singh *et al*. (34) and Altunbas *et al*. (35) have reported that Raypex 5 was accurate in 93.2%, 91% and 91.7% of the cases, respectively. Somma *et al*. (36), who had compared the accuracies of Raypex 5, Propex II and Dentaport ZX in an *in vivo* study, have found that the percentage of EWL accuracy within ± 0.5 mm range was 20% for Raypex 5. They used a microscope at 20x magnification and a computer based measuring system to evaluate the accuracy of Raypex 5. Aydın *et al*. (37) evaluated the accuracies of Raypex 6 and Root ZX in teeth having different apical diameters. They reported that accuracy of Raypex 6 decreased with increasing apical diameter and athe ccuracy of Raypex 6 was 85% in mature apex. Moscoso *et al*. (38) found the accuracy of Raypex 6 as 88.22% by advancing the file within the root canal until the red bar began to flash. Vasconcelos *et al*. (39) showed that accuracy of iPex was 61.7% within the range of ±0.5 mm which is consistent with the findings of the present study. On the other hand, according to Duran-Sindreu *et al*. (40) the accuracy of iPex was 42.8%. Puri *et al*. (18) who have compared the accuracies of iPex and DentaPort ZX, showed that the accuracy of iPex was 90%. Since there was no data available on the accuracy of iPex II at the time of the present study, one of its aims was to determine the accuracy of this EAL. Within the limitations of this in vitro study, when compared to other multi-frequency EALs, iPex II was found to be accurate in 50% of the specimens which is numerically inferior to other EALs, however, this difference was not statistically significant. The accuracies of EALs depend largely on the anatomy of minor and major foramens as well as the location of the major foramen (41). Therefore, above mentioned inconsistencies among the findings of previously published articles could be partially explained by the anatomical characteristics of the teeth used in the experiments (40).

Conclusion

Within the limitations of this in vitro experiment, our findings indicate that the accuracy of working length measurements calculated with iPex II device is similar to those of other multi-frequency EALs used in this study.

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Conflict of interest
None declared.

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