Effectiveness of Two Apex Locators to Determine Simulated Horizontal Root Fractures

Farklı Seviyelerde Yapay Olarak Oluşturulmuş Horizontal Kök Kırıklarının Tespitinde İki Apeks Bulucunun Doğruluğunun Karşılaştırmılması

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SUMMARY
Aim: The aim of this study was to evaluate in vitro the effectiveness of the two different electronic apex locators (Dentaport ZX and Rootor-EALs) in locating simulated horizontal root fractures.

Materials and Methods: Forty extracted human single-rooted teeth with mature apices were randomly divided into two groups of 20 teeth each. An incomplete horizontal fracture was simulated by preparing a with a 0.25 mm thick disk in the middle and apical portion of the root and the teeth were mounted in an alginate mold. The electronic measurements (ELs) of the simulated root fractures were established with a size 10 K-file by each EAL in both fracture levels. The actual canal lengths (ALs) were measured under a stereomicroscope. The ALs were subtracted from the ELs of the fractures. The data were analyzed using the Mann-Whitney U and the Wilcoxon signed-rank tests at a significance level of P < .05.

Results: The mean differences between the ELs and ALs were -0.12 ± 0.27; 0.09 ± 0.38; -0.10 ± 0.25; 0.18 ± 0.53 mm in the Dentaport ZX and Rootor groups and middle and apical horizontal fracture levels, respectively. The Dentaport ZX performed measurements within ±0.5 mm in 18 and in 19 samples while the Rootor performed in 12 and in 11 samples, middle and apical horizontal fracture levels respectively. Statistically, significant differences were found among the EALs at both horizontal fracture levels (P < .05). However; no statistically significant differences were found between the fracture levels in each of the EALs (P > .05).

Conclusions: The Dentaport ZX measurements were shorter than ALs whereas the Rootor measurements were longer than ALs. Furthermore, the number of measurements obtained within ± 0.5 mm in Dentaport ZX is more than that of Rootor. Under the conditions of this study, the Dentaport ZX group showed an acceptable determination of the horizontal root fracture.

Key words: Apex locator, Dentaport ZX, horizontal root fractures, Rootor

ÖZET
Amaç: Bu çalışmanın amacı yapay olarak oluşturulan horizontal kök kırıklarının teşhisinde iki farklı elektronik apex bulucu cihazın (Dentaport ZX and Rootor) etkinliğinin karşılaştırmasıdır.

Gereç ve Yöntem: 40 adet tek köklü çekilmiş daimi diş her bir grupta 20 adet olmak üzere 2 guruba ayrıldı. 0.25 mm kalınlığında elmas separe kullanılarak köklerin orta ve apikal uçlular hizasında horizontal kırık hatları oluşturuldu. Alınan model içinde yerleştirilen kökler üzerinde her iki elektronik apex bulucu ile horizontal kırık hatlarının tespiti 10 K eğesi kullanılarak yapıldı. Gerçek ölçüler aynı ege kullanılarak stereomikroskop (SMZ 800, Nikon, Tokyo, Japan) kullanılarak tespit edildi. Gerçek ve elektronik ölçüler arasındaki fark hesaplanmıştır. İstatistiksel incelemelerde Mann-Whitney U ve Wilcoxon Eşleştirilmiş İki
INTRODUCTION

Root fractures, which may be oblique, vertical and horizontal, are among the most difficult cases in clinical endodontic practice, especially when they are not completed. Because of the restrictions of the clinical and radiological examination accurate diagnosis of these fractures is still a challenge. Often, the coronal segment of the pulp of teeth with fractured roots will become non vital over time; thus it is recommended to implement root canal treatment for a tooth with a root fracture, the first simple EAL device to measure the canal length. Suzuki recorded steady measure of 0.25 mm. Dentaport ZX (Morita, Tokyo, Japan) is an EAL that measures the impedance at two frequencies (0.4 and 8 kHz), requires no calibration, and accurately measures the moisture conditions inside canal. It is composed of two modules: the Root ZX and the Tri Auto ZX. The Rootor (Meta Biomed Cheongwon-gun, Korea) is a multiple-frequency EAL that uses two frequencies (0.5 and 5 kHz).

No comparative analysis has been performed regarding the use of these EALs for locating horizontal fractures. Thus, the aim of this investigation was to evaluate the ability of the Dentaport ZX and the Rootor EALs to determine simulated horizontal root fractures in vitro using an alginate model.

MATERIALS AND METHODS

Selection and Preparation of Teeth

Forty freshly extracted human maxillary anterior teeth with mature apices and straight root canals without any crack or perforations were selected. The reasons for the extraction were not related to this study. The external surfaces of the teeth were cleaned with an ultrasonic scaler (EMS Pieazon Master 400, CH-1260 Nyon, Switzerland). The teeth were viewed radiographically in a buccolingual and mesiodistal plane, and teeth with calcification, more than one canal and apical foramen or endodontic treatment were excluded from the study. The 40 teeth selected with these criteria were immersed in 4 °C distilled water until use.

The teeth were decoronated at the cementoenamel junction using a high-speed diamond disk with a cooling system to achieve a flat surface and standardize the root length of 16 mm. The contents of the canals were removed with a proper barbed broach. The patency of the apical foramen was controlled with a size 10 K-file (Dentsply Maillefer, Ballaigues, Switzerland). Subsequently, the canals were irrigated with 2.5 mL 2.5% sodium hypochlorite followed by 2.5 mL distilled water.

The forty roots were randomly divided into two experimental groups (n = 20) for simulation of horizontal fractures in two different regions. An incomplete horizontal root fracture was simulated by preparing a horizontal incision in the middle of the canal. The contents of the canals were removed with a proper barbed broach. The patency of the apical foramen was controlled with a size 10 K-file (Dentsply Maillefer, Ballaigues, Switzerland). Subsequently, the canals were irrigated with 2.5 mL 2.5% sodium hypochlorite followed by 2.5 mL distilled water.

The forty roots were selected with these criteria were immersed in 4 °C distilled water until use.

Electrical measurements

The specimens were placed into freshly mixed alginate, which was poured into a plastic mold, leaving a coronal 2 mm of the root. The Dentaport ZX and the Rootor EALs...
were used in accordance with the manufacturer’s instructions for locating simulated horizontal fractures. The root canals were irrigated with a 0.9% saline solution with a 27-gauge needle, and the coronal plane surfaces were gently dried with a cotton pellet. The labial clip of the EALs was also inserted into the alginate, and the instrument clip was attached using a size 15 K-file. For the Dentaport ZX device, the measurements of the canal length was recorded when the file was withdrawn until the last green bar had been reached on the display after going through the ‘APEX’ (red bar lit). For the Rootor, the file was advanced until the last red led ‘00’.

Then, both EALs, a rubber stop on the file was carefully adjusted to the reference level. The distance between the rubber stop and the file tip was measured with a caliper to the nearest 0.05 mm and the readings were recorded (ELs).

All measurements were made in an interval of 2h, with the alginate gel kept sufficiently humid for this time.

**Actual length measurements**

The roots were removed from the alginate; the fracture was completed with the same disc, and the actual canal lengths (ALs) were measured with a size 15 K-file under a stereomicroscope (SMZ 800, Nikon, Tokyo, Japan). The electronic and actual lengths were all measured by a single endodontist. All measurements were performed 3 times and the averages of the measurements were taken.

**Statistical Analysis**

For each EAL, the ALs were subtracted from the electronic lengths (ELs) of the fractures and the differences were noted. Negative and positive values indicated measurements that were shorter and longer than the AL, respectively, whereas 0.0 indicated coinciding measurements. IBM SPSS 20 Software (IBM SPSS Inc., Armonk, NY, USA) was used for all statistical analyses. A significance level of 0.05 was used for all statistical tests. The results were statistically analyzed using the Mann-Whitney U and the Wilcoxon signed-rank tests at a significance level of p<.05.

**RESULTS**

Table 1 shows the mean difference between the EL and the actual length of the horizontal fracture at different levels of the root with the standard deviation (SD) for each EAL. The distribution of frequency (%) of the distance between the EL and the AL according to the horizontal fracture level for each device is shown in Table 2. Statistically significant differences were found among the EALs at both horizontal fracture levels, (p<0.05). However; no statistically significant difference was found between the fracture levels in each EAL group (p>0.05).

| Group | Distance from the actual length (mm) | Dentaport ZX | Rootor |
|-------|-------------------------------------|--------------|--------|
|        |                                    | Mean ± SD    | Mean ± SD |
| Middle | 1.0 to 0.5                          | -0.12 ± 0.27 | 0.09 ± 0.18 |
|        | 0.01 to 0.5                         | 5 ± 20       | 11 ± 55  |
|        | 0.0 to 0.5                          | 4 ± 20       | 0 ± 0    |
|        | -0.01 to -0.5                       | 9 ± 45       | 1 ± 5    |
|        | -1 to -0.51                         | 2 ± 10       | 6 ± 30   |
| Apical | 1.0 to 0.5                          | 0 ± 0        | 0 ± 0    |
|        | 0.01 to 0.5                         | 6 ± 30       | 6 ± 30   |
|        | 0.0 to 0.5                          | 5 ± 1        | 5 ± 1    |
|        | -0.01 to -0.5                       | 12 ± 40      | 4 ± 20   |
|        | -1 to -0.51                         | 1 ± 5        | 2 ± 10   |

*Negative values indicate measurements short of the actual canal length*

**DISCUSSION**

Root fractures constitute nearly 7% of endodontic trauma cases. Although three different radiograph angulations have been recommended for the detecting the fracture line, the location of the fracture plane is also still difficult to detect.2 Within the first hour after the dental trauma, we were not able to mark fractures by means of radiographs. In such cases, it is possible for the coronal root segment to lose vitality while the apical segment remains vital. In such cases it may be necessary to apply canal treatment to the coronal portion of the fracture line.6 EALs are capable of recording the point at which the tissues of the periodontal ligament begin outside the canal by measuring electrical properties so that they mark the first point that has periodontal communication as the apex.1,17 In many in vitro studies evaluating the accuracy of EALs, different electroconductive materials, such as agar, alginate, saline gelatin, flower sponge have been used to simulate the clinical situation.18,19 Baldi et al.17 carried out a study to compare these media, and the results showed that alginate provided the most coherent results with the actual working length. Therefore, in the current study, alginate was selected as a medium to simulate the normal periodontium.

Several in vitro researches have assessed the accuracy of various EALs such as Justy II, ProPex, NovApex, Elements Apex Locator, Root ZX, Foramatron D10, Apex NRG TCM Endo V, Tri Auto ZX, and Raypex-4 in locating the horizontal fractures. All of these studies showed that EALs detected the root fractures within a clinically acceptable range.1,3,9,20,21 To the best our knowledge, no published studies have evaluated the Rootor or Dentaport ZX for detecting horizontal fracture. In the present study, horizontal fractures were simulated at the 4 and 8 mm from the apex of the roots. According to the results of this study, which examined these devices for this purpose, the Dentaport ZX and Rootor, were acceptable. However, the Dentaport
ZX was more successful in the detection of horizontal fractures than the Rootor at both levels. It was not possible to compare the Rootor with other existent studies because of the lack of research on this device's location of horizontal fractures. Altunbaş et al. reported that the Dentaport ZX and Rootor detected the root canal perforations within a clinically acceptable range. These results are in agreement with the above-mentioned studies. Many studies have used a ± 0.5 mm error range to assess the accuracy of the EALs, and others have relied on a range of ±1.0 mm. Measurements within these tolerances were considered accurate and clinically acceptable in the present study because the relation between the rubber stop and the reference point, the rubber stop and the caliper, or the file tip and the caliper was difficult to control visually. The present results indicate that both devices were acceptable because all difference values were within the range of ±1.0 mm. The Dentaport ZX detected the middle horizontal root fracture within ±0.5 mm in 18 samples (90%) and the apical horizontal fracture in 19 cases (95%). The Rootor detected the middle and apical horizontal fracture within ± 0.5 mm in 12 cases (60%) and in 11 cases (55%), respectively (Table 2). There was no measurement showing error of 1 mm or more. In root fractures, the accuracy of the EAL is important to prevent under or over instrumentation. Because the Dentaport ZX measurements were shorter than actual measurements in general, we are of the opinion that the Dentaport ZX is more acceptable than the Rootor in the present study. A comparison of the SD is also helpful for assessing the reliability of the measurements. According to Lee et al., the reproducibility of the measurements in a consistent manner, as measured by the SD, is more important than knowing the mean distance from the measurements to the AL. If the reading of the device is consistent, a low SD is obtained. In the present study, the findings obtained with the Dentaport ZX device were more consistent than those for the Rootor device, especially in the apical horizontal fractures.

CONCLUSION
The Dentaport ZX measured (on average) shorter than the real measurements, while the Rootor measured longer than the real measurements. Under the conditions of this study, the two tested EALs were accurate and acceptable clinical device for detecting the position of horizontal fractures when ± 1.0 mm of error is considered. However, the Dentaport ZX was more successful in the detection of horizontal fractures than the Rootor, at both levels. It should be emphasized that the results obtained from in vitro studies cannot be directly extrapolated to the clinical situation, and further clinical examinations of the use of EALs are needed.

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The authors deny any conflicts of interest related to this study.

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