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ARAŞTIRMA

Eğe iletkenliği ile Root ZX elektronik apeks bulucu doğruluğunun ilişkisi

The relationship between file conductivity and Root ZX electronic apex locator accuracy

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Abstract

Objective: The aim of this study was to determine the relationship between the accuracy of the Root ZX apex locator and conductivity of hand files.
Material–Method: In this study, 47 extracted maxillary anterior teeth were used. Each tooth was mounted in an alginate model so that an electronic apex locator could be used to measure canal length with four different hand ISO 15 K–file groups. Four groups were established which consist of a different type file. All file groups were tested for electrical conductivity using the four–point probe method. The relationship between the accuracy of Root ZX and electrical conductivity of the files was analysed with Kruskal Wallis at a significance level of 0.05. Duncan's Multiple Range Test was used to detect the differences between the groups.
Results: Whilst 34% of samples were short of the control working length, the highest conductivity values were obtained in Group 2 ($p < 0.05$).
Discussion: For the conductivity results, there was a correlation between accuracy of the Root ZX apex locator and the conductivity of hand files. However clinical trials that involve further apex locators and files of observations are needed.
Keywords: Electrical Conductivity, Nickel–Titanium Alloy, Stainless Steel.

Özet

Amaç: Bu çalışmanın amacı el eğelerinin iletkenliği ile Root ZX elektronik apeks bulucu doğruluğunun ilişkisini tespit etmektir.
Materyal–Metot: Bu çalışmada 47 adet çekilmiş insan üst çene ön dişleri kullanıldı. Her bir diş, bir aljinat modele gömülerek, elektronik apeks bulucu ile 4 farklı ISO 15 K tipi eğe kullanılarak dişlerin çalışma boyları ölçüldü. Her bir eğe bir grubu oluşturacak şekilde 4 grup oluşturuldu. Bütün eğe grupları elektrik iletkenlikleri açısından dört nokta tekniği ile test edildi. Eğe iletkenliği ile Root ZX elektronik apeks bulucu doğruluğunun ilişkisi 0.05 önem düzeyinde Kruskal Wallis testi ile analiz edildi. Gruplar arasındaki farklılık Duncan'ın Çoklu Dağılım Testi ile saptandı.
Bulgular: Grup 2 ye ait örneklerin %34'ünde kontrol grubuna göre daha kısa olarak çalışma boyu ölçümü yapılırken, en yüksek iletkenlik değeri elde edildi.
Tartışma: İletkenlik bulgularına göre, Root ZX apeks bulucunun doğruluğu ve el eğelerinin elektrik iletkenliği arasında bir korelasyon bulunmaktadır. Ancak daha farklı apeks bulucular ve eğeleri içeren klinik çalışmalara ihtiyaç vardır.

Anahtar Kelimeler: Elektrik iletkenliği, Nikel–Titanyum alaşım, Paslanmaz çelik.

Introduction

Today many clinicians use both stainless–steel/nickel–titanium files and apex locators during the root canal treatment. Generally, apex locator studies have used both nickel–titanium and stainless–steel hand files for testing purposes. However, just three published studies compared nickel–titanium and stainless–steel hand files for testing accuracy of the electronic apex locator (1–3). Although these studies resulted in statistically significant differences between the file types, researchers described the differences as "not clinically significant".

Root ZX (Morita, Kyoto, Japan) applies a 'ratio method' for measuring root canal length (4). It simultaneously measures the impedance of two different frequencies, calculates the quotient of the impedances, and expresses this quotient as a position of the electrode (file) inside the root canal. Nguyen *et al*. (5) declared that Root ZX was able to identify the apical constriction location even when this anatomic landmark had been eliminated. However, their accuracy within 0.5 mm of the apical constriction

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has been reported to be from 82% to 100% of the measurements with Root ZX (6, 7).
A literature search failed to reveal any published study that directly compares the accuracy of an apex locator and the conductivity of different hand–file types. The purpose of this study was to determine the relationship between the accuracy of the Root ZX apex locator and conductivity of hand files.

Material-Method

Forty seven freshly extracted human single–rooted maxillary anterior teeth with mature root apices and patent root canals were used. Roots with resorption, fractures, open apices or radiographically invisible canals were excluded. Tooth suitability was determined by visual inspection using radiographs, and finally, after decoronation, by placement of a file into the root canal to determine patency. Each tooth was decoronated at approximately the cementoenamel junction (CEJ) to provide a flat horizontal surface.

Control Setup: The control working length was determined by inserting a #10 stainless steel K–file into the canal and observing the tip of the file to reach the apical foramen under x10 magnification (Zeiss, Jena, Germany). The rubber stopper was then adjusted to be level with the reference surface. The distance between the stopper and the file tip was measured, and the control working length was determined to be 0.5 mm shorter, as described by Ebrahim et al. (8).

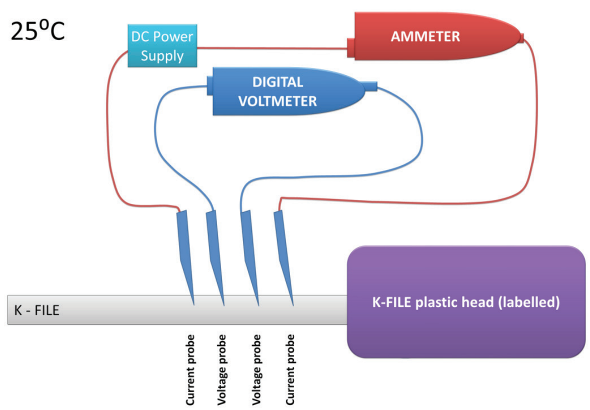
The stainless steel digital vernier caliper (Absolute Digimatic & Vernier Caliper Series 550, Mitutoyo Inc., Ontario, Canada) was used in a horizontal position during measurement. All experimental measurements were repeated three times. Each tooth's true length was taken to be the average of these measurements. Each tooth's control working length was noted.

Working Length Determination Using Apex Locator: Each tooth was mounted in an alginate model so that an electronic apex locator could be used to measure canal length (9, 10). The manufacturer's recommended operating procedures for the Root ZX apex locator were used. Before taking electronic apex measurements, all files were labelled from 1 to 47 on finger grips in every group and the root canals uninstrumented. Files that were labelled with the same number from each of the groups were operated upon with Root ZX in the same tooth. All measurements of canal length were to the apex location on the Root ZX.

The four file types tested were nickel–titanium 2% tapered hand files (Diadent, Seoul, Korea) files (Group 1), Sendoline 2% tapered (Sjöding Sendoline, Kista, Sweden) files (Group 2), stainless–steel 2% tapered hand files (VDW, Antaeos, Munich, Germany) (Group 3), and Mani 2% tapered (Mani, Tochigi, Japan) files (Group 4). To avoid bias, the measurements were taken by randomizing the order of the file types. Files with apical sizes of #15, were used for all file groups. Data for each tooth and file type were recorded along with the control working length and electronically measured length. One experienced operator performed all measurements. Accuracy was defined as the difference between the control working length and electronically measured length.

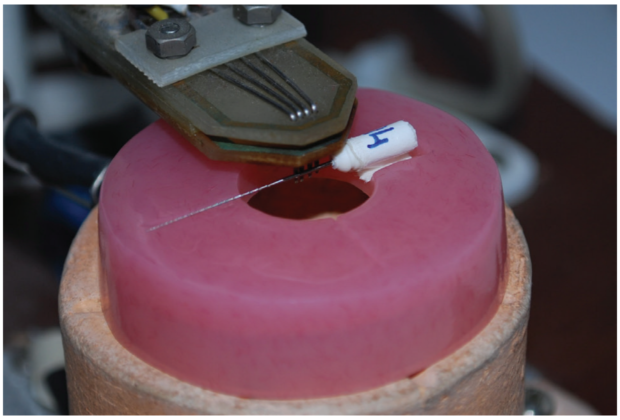
All files were tested for electrical resistivity using the four–point probe method of the Süleyman Demirel University, Physico–Chemistry Research Laboratory (Fig. 1 and Fig. 2).

Figure 1. The four-point probe method for testing electrical



conductivity on a hand ISO 15 K-file.

Figure 2. File's electrical resistivity using the four–point probe



test device.

The individual stand for ISO 15 K hand files was created with polymethyl–methacrylate for the four–point probe test machine (PCI–DAS6014 thermo–regulator, ammeter and voltameter card controlled computer, Süleyman Demirel University, Computer Research and Application Center (SDU–BAUM), Isparta, Turkey). All conductivity data was obtained under a 25^{0}C stabilized condition. Current value was 610 nA and potential input value was 5V. Electrical resistivity tests were performed 3 times and at 10s intervals for each measurement. The obtained data showed the resistance of the files. The formula used for calculating the electrical conductivity of files used the Van Der Pauw method (11). The electrical conductivity of files; σ $=^{-1}$ can be calculated by the relation:**.** According to the relation "t" was the size of the test structures (ISO 15 K–file = 0.065 cm), "V" was measured electric potential and "I" was measured current. The thickness of the hand ISO 15 K–file (t) was measured with a digital vernier caliper. Data for each file type and electrical conductivity were recorded.

Statistical Analysis: Data were analysed in the statistical package SPSS Version 15 (SPSS Inc., Chicago, IL, USA). Collected data regarding the accuracy of the Root ZX apex locator and conductivity of hand files was analysed using Kruskal Wallis at a significance level of 0.05 and their relation was tested by correlation regression. Duncan's multiple–range test was also performed to analyse the difference among the groups.

Results

The difference between control working length and electronically measured length was calculated for each canal. There was only a significant difference in Group 2 for the mean differences between control working length and the electronic measured length ($p<0.05$). The frequencies of canal measurements are presented in Table 1.

Table 1. Frequency of electronic working length measurements using different files according to the true length.

Groups	**N**	**<0.5mm %**	±0.5mm %	**>0.5mm %**
Group I	47	2	96	2
Group II	47	34[a]	64[a]	2
Group III	47	0	100	0
Group IV	47	2	96	2

a Statistically differences were significant ($p<0.05$)

Whilst 64% of the measurements were in the apex, 34% were shorter of the control working length in Group 2 ($p < 0.05$).The mean and standard error of the electrical conductivity values are shown in Table 2.

Table 2. Electrical conductivity means of groups.

Groups	**N**	**Mean**	**Standard error**
Group I	47	0,0001	0,00001
Group II	47	0,0007[a]	0,00032
Group III	47	0,0001	0,00002
Group IV	47	0,0001	0,00001

a Statistically differences were significant ($p<0.05$)

The equalisation of regression that revealed "y", added in all graphs, was used for explaining the relation between the differences of the lengths and electrical conductivity changes. "R" showed as the coefficient of determination. The results of the correlation–regression test were: R = 0.16 in Group 1, R = 0.15 in Group 2, R = 0.24 in Group 3, and R = 0.21 in Group 4. According to these results there was a weak correlation between the accuracy of Root ZX and file conductivity among the groups.

Discussion

Root ZX apex locator was used with dry canals in this study because this device has a high reliability index as reported in previous studies (7, 12, 13). Jenkins et al. (14) reported that the Root ZX could reliably measure canal lengths to within 0.31 mm and there was virtually no difference in the length determination as a function of the various irrigants used, such as 2% lidocaine, 5.25% NaOCl, RC Prep, Liquid EDTA and 3% hydrogen peroxide. Normal saline was used as the root canal irrigant and electrical conductive media because previous studies showed that in the presence of EDTA and saline, measurements were closer to the actual length (15). The number of unstable measurements reported in a previous study revealed different clinical behaviour in the apex locators. Venturi and Breschi (16) stated that Root ZX revealed several unstable measurements in different conductive situations. Group 2's poorer accuracy in measurements may be related to the high conductivity values of samples and would reflect agreement with Venturi and Breschi.

Hand ISO 15 K files were used for length determination. Kovacevic and Tamarut (17) have demonstrated that larger file sizes tend to increase error in measurement accuracy.

The four–point probe method is the most common way to measure a conductor material's resistivity. Two of the probes are used to source current and the other two probes are used to measure voltage. Using four probes eliminates measurement errors due to the probe resistance, the spreading resistance under each probe, and the contact resistance between each metal probe and the semiconductor material. This technique involves bringing four equally spaced probes into contact with the material of unknown resistance (18, 19). All electrical tests were performed at 25 ^{0}C. Thermal conditions as one property may have affected the electrical conductivity of alloys. In addition, alloying elements are often added to metals to improve certain characteristics of the metal. Alloying can increase or reduce the strength, hardness, electrical and thermal conductivity, corrosion resistance, or change the color of a metal (20).

Researchers have compared elemental composition, microstructure, and hardness of commercially available reamers, K files and H files from five different manufacturers. The elemental composition of the files tested was determined by energy dispersive X–ray microanalysis. It has been reported that endodontic files have differences in alloy type, hardness, microstructure and from the residual effects of manufacturing processes. Darabara et al. (21) reported that the differences can affect the performance of endodontic files found in laboratory and clinical studies.

In the present study, there was only a significant difference in the nickel–titanium hand K–file in Group 2 for the mean differences between control working length and the electronic measured length ($p < 0.05$). Although statistically significant differences occurred in Group 2 files, the largest of these differences (0.32 mm) was not clinically significant.

It is interesting to note that endodontic files manufactured with the same alloy and method showed significant differences in electrical conductivity (Group 1 and Group 2) ($p < 0.05$). The nickel–titanium alloys used in root canal treatment contain approximately 56% (wt) nickel and 44% (wt) titanium. In some nickel–titanium alloys, a small percentage (< 2% wt) of metals can be added (22). Furthermore only one manufacturer (Dentsply Maillefer, Ballaigues, Switzerland) has released the absolute composition and manufacturing details of the nickel–titanium used to construct their instruments, while other nickel–titanium alloy manufacturers do not provide the absolute alloy composition (22). It is possible to measure various conductivity results in order to determine the variance in the composition of nickel–titanium alloy.

More accurate results were found in both Group 3 and Group 4 where the conductivity values were similar among the group samples. The measurements with Root ZX were less accurate where file conductivity values were high. These seemly contradictory results could be explained by the differences in composition of the similar alloys, in agreement with Darabara et al. (21).

Conclusion

Within the limitations of this study there was correlation between file conductivity and the accuracy of Root ZX. Increasing file conductivity resulted in less accurate measurements with Root ZX or where clinically insignificant. Clinical trials that involve further apex locators and files of observations are needed.

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