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Assessment of effect of heat treatment of nickel–titanium instruments on the accuracy of an electronic apex locator integrated with endodontic motor

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ABSTRACT

Background: Determining the working length (WL) is crucial for the effectiveness of endodontic therapy, as the best results are achieved when the apical limit is correctly determined and established in close proximity to the apical constriction. The present study was conducted to assess effect of heat treatment of nickel–titanium instruments on the accuracy of an electronic apex locator integrated with endodontic motor.

Materials & Methods: The study consisted of 25 extracted human mandibular incisors with fully developed apex of both genders. WL was determined visually using a clinical microscope and a manual stainless steel K-file #10. Instruments of Mtwo, Reciproc, Reciproc Blue, WaveOne Gold, Twisted File Adaptive, and Hyflex CM systems with diameters from 0.25 mm to 0.50 mm, were used to measure WL during root canal preparation. The electrical resistivity of instruments with a diameter of 0.25 mm from each system was assessed.

Results: There was non- statistical difference in EAL accuracy was observed using instruments with different heat treatments and the same tip diameter of 0.25 mm ($P > 0.05$). There was no statistical difference in EAL accuracy was found when comparing instruments of the same system but with different tip diameters ($P > 0.05$).

Conclusion: The EAL accuracy is independent of the tip diameter and the type of heat treatment applied to the NiTi alloy used in mechanized instruments.

Keywords: Electronic apex locators, Twisted File Adaptive, Hyflex CM systems

Introduction

Electronic apex locators (EALs) are devices used in endodontics, the branch of dentistry concerned with the diagnosis and treatment of diseases and injuries of the dental pulp and surrounding tissues.[1] Specifically, EALs are used during root canal treatment procedures. The apex of a tooth's root is the tip or endpoint of the root canal system, where the nerves and blood vessels enter and exit the tooth.[2] During root canal therapy, the goal is to remove infected or damaged tissue from the root canal system and fill it with a biocompatible material to seal and protect the tooth. Determining the working length (WL) is crucial for the effectiveness of endodontic therapy, as the best results are achieved when the apical limit is correctly determined and established in close proximity to the apical constriction.[3]

Manufacturers of nickel-titanium (NiTi) instruments have created a wide range of NiTi alloys to enhance their mechanical qualities. Instruments made with heat and surface treatments are more flexible and resistant to fatigue from torsional and cyclic loads. These treatments are often measured using LCR meters to detect electrical resistivity; it is unknown if they could interfere with the electrical circuit's impedance.[4]

Presently, several endodontic motors feature an integrated EAL that enables the WL and root canal preparation to be monitored simultaneously. The concurrent use of EAL is preferred because changes in work length may occur in root canals with significant curvatures during the shaping phase.[5] The present study was conducted to assess effect of heat treatment of nickel–titanium instruments on the accuracy of an electronic apex locator integrated with endodontic motor.

Materials & Methods

The present study consisted of 25 extracted human mandibular incisors with fully developed apex of both genders. WL was determined visually using a clinical microscope and a manual stainless steel K-file #10. The file was inserted into the root canal until it was visualized flush with the major foramen to determine the control WL. Instruments of Mtwo, Reciproc, Reciproc Blue, WaveOne Gold, Twisted File Adaptive, and Hyflex CM systems with diameters from 0.25 mm to 0.50 mm, were used to measure WL during root canal preparation. The electrical resistivity of instruments with a diameter of 0.25 mm from each system was assessed using an Inductance, Capacitance, and Resistance (LCR) meter. Data thus obtained were subjected to statistical analysis. P value < 0.05 was considered significant.

Results

Table I Accuracy of Electronic apex locators using instruments with different heat treatments and mean electrical resistivity values

Difference (mm)	Mtwo25	R25	R25 blue	TF 25	Primary	CM 25	P value
<0.5	25[a]	24[a]	24[a]	24[a]	24[a]	20[a]	0.21
>0.5	0	1	1	1	1	5	

Electrical resistivity	0.081	0.053	0.045	0.077	0.069	0.012	0.04

Table I shows that there was non- statistical difference in EAL accuracy was observed using instruments with different heat treatments and the same tip diameter of 0.25 mm ($P > 0.05$).

Table II Accurate and inaccurate results obtained using instruments of the same system with different diameters

Difference (mm)	**Gold wire–WaveOne Gold**			**P value**	**Blue wire–Reciproc blue**			**P value**
	25.07	35.06	45.05		25.08	40.06	50.05	
<0.5	24	22	23	0.04	24	23	23	0.72
>0.5	1	3	2		1	2	2	

Table II shows no statistical difference in EAL accuracy was found when comparing instruments of the same system but with different tip diameters ($P > 0.05$).

Discussion

Electronic apex locators work by measuring the electrical resistance or impedance between two electrodes placed in the tooth and the surrounding tissues.[6] As the tip of the file approaches the apex of the tooth, the electrical resistance changes, and the device calculates the point at which the resistance reaches a certain threshold, indicating the location of the apex.[7] Electronic apex locators can provide precise measurements of the length of the root canal, reducing the risk of over- or under-instrumentation.[8] Electronic apex locators can save time during root canal procedures by quickly and accurately determining the working length. By avoiding over-instrumentation, EALs help minimize the risk of damaging the surrounding tissues or pushing debris beyond the apex of the tooth.[9] The present study was conducted to assess effect of heat treatment of nickel–titanium instruments on the accuracy of an electronic apex locator integrated with endodontic motor.

We found that there was non- statistical difference in EAL accuracy was observed using instruments with different heat treatments and the same tip diameter of 0.25 mm ($P > 0.05$). Bukhari et al[10] assessed ex vivo the effects of different thermal processes on NiTi instruments. This study used 20 extracted human maxillary incisors. The visual approach was used to establish the working length (WL) control. WL was measured during cleaning and shaping using rotary files consisting of the Reciproc, Reciproc Blue, Wave One Gold, Twisted File Adaptive, and Hyflex CM systems using 0.25 diameter instrument size. Heat treatment of NiTi rotary instruments has no significant impact on the EAL's accuracy ($P > 0.051$). The precision of WL estimation using an EAL incorporated with the endomotor was unaffected by the use of thermal processes.

We found that there was no statistical difference in EAL accuracy was found when comparing instruments of the same system but with different tip diameters ($P > 0.05$). Paiva et al[11] evaluated ex vivo, the influence of different heat treatments of NiTi instruments, and the diameter of the apical preparation on the accuracy of an EAL used during root canal preparation using an integrated EAL and motor unit. Nineteen extracted human mandibular incisors were

included in the study. The WL control was determined by the visual method. Instruments of Mtwo, Reciproc, Reciproc Blue, WaveOne Gold, Twisted File Adaptive, and Hyflex CM systems, with diameters from 0.25 mm to 0.50 mm, were used to measure WL during root canal preparation. The electrical resistivity of instruments with a diameter of 0.25 mm from each system was evaluated using an Inductance, Capacitance, and Resistance (LCR) meter. The different heat treatments and different diameters did not influence the precision of the EAL ($P > 0.05$). Duran-Sindreu F et al[12] evaluated in vivo the performance of the iPex and Root ZX electronic apex locators (EALs) in the presence of several irrigant solutions: 2.5% sodium hypochlorite (NaOCl) and 2% chlorhexidine (CHX). Thirty-two single-rooted human teeth that were scheduled for extraction were selected. The working length (WL) was determined electronically for the root canals with the iPex and Root ZX EALs in the presence of two different irrigant solutions, 2.5% NaOCl and 2% CHX. After the teeth had been extracted, a size 10 K-file was used to determine the reference working length (RWL), which was established at 0.5 mm short of the major foramen. The accuracy of the iPex nor Root ZX EAL was not affected by 2.5% NaOCl or 2% CHX ($P > 0.05$). However, significant differences were observed between the readings of the iPex and Root ZX, irrespective of whether 2.5% NaOCl or 2% CHX was used as the irrigant ($P < 0.05$). The iPex was less accurate than the Root ZX in determining the RWL.

The limitation of the study is the small sample size.

Conclusion

Authors found that the EAL accuracy is independent of the tip diameter and the type of heat treatment applied to the NiTi alloy used in mechanized instruments.

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