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IP Indian Journal of Conservative and Endodontics

Journal homepage: https://www.ijce.in/

Original Research Article

Impact of nickel-titanium instrument heat treatment on the precision of an inbuilt electronic apex locator and endodontic motor

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ARTICLE INFO

Article history:
Received 24-06-2023
Accepted 26-08-2023
Available online 02-09-2023

Keywords:
RCT
NiTi alloy
Apex locator and apical foramen

ABSTRACT

Context: Numerous nickel-titanium alloys have been designed by manufacturers, however there is little information on the precision of integrated EAL when utilized with various NiTi thermal processes to determine working length.

Aim: An integrated EAL and endomotor assembly is utilized in this study to assess ex vivo the effects of different thermal processes on NiTi instruments.

Materials and Methods: 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.

Statistical analysis: Fisher's exact test and the Kruskal-Wallis statistic tests were used in the analysis of the information at hand.

Results: Heat treatment of NiTi rotary instruments has no significant impact on the EAL's accuracy ($P > 0.051$).

Conclusion: The precision of WL estimation using an EAL incorporated with the endomotor was unaffected by the use of thermal processes.

1. Introduction

Determining the working length (WL) is crucial for the outcome of the endodontic procedure since the greatest results are obtained when the apical limit is precisely determined and set up near where there is apical constriction. The process of root canal preparation and obturation necessitates strict confinement within the root canal system.[1] The cement dentinal junction is widely regarded as the optimal end point.[2] In practical clinical settings, however, pinpointing this histological feature is unfeasible. As a result, the apical constriction is deemed an acceptable reference for canal preparation. Determining the appropriate working length (WL) involves employing both radiographic techniques and electronic apex locator in daily practice.

Despite its common use, the radiographic approach's accuracy has been challenged by several studies.[3–5] This method relies on two-dimensional imagery and the subjective interpretation of the clinician, often leading to potential over- or under instrumentation.[5–9] Additionally, many root canals exhibit foramens located on the lateral root surfaces, limiting accurate radiographic WL determination.[3]

Suzuki originally briefed about EALs for measuring root canal lengths during 1942,[4] and Sunada reportedly employed them in clinical settings in 1965.[5] Although

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https://doi.org/10.18231/j.ijce.2023.029

some authors claim that the anatomical diameter of the apical foramen,[10] instrument's tip diameter, and type of alloy might result in interference in the precision of these instruments in estimating root canal length.[11–13]

Manufacturers have developed various nickel-titanium (NiTi) alloys with heat and surface treatments to enhance the mechanical properties of NiTi instruments, resulting in increased flexibility and resistance to torsional and cyclic fatigue.[13–15] However, the potential effects of these treatments on the electrical circuit impedance remain uncertain.

The WL and BMP can now be done simultaneously thanks to various endodontic motors that feature an integrated EAL. The concurrent use of EAL is preferred because root canals with significant curvatures may experience alterations in work length during the shaping phase.[16]

Since an integrated EAL and motor unit is employed during BMP, the current research sought to assess ex vivo the effects of various thermal processes on NiTi equipment as well as the diameter of the apical preparation on an EAL's accuracy.

2. Materials and Methods

2.1. Preparing the teeth

In the current research, 20 extracted human Maxillary incisor with completely formed apex in each group a single canal verified by periapical radiograph, and the curvature ranging from 10° to 30° were obtained using schneider's method. These teeth were formerly standardized at 17 mm root length by removing dental crowns with a diamond disc.

2.2. Establishment of the control working length

WL was assessed via a manual stainless steel K-file #15 (Dentsply Maillefer, Ballaigues, Switzerland) and a clinical microscope (Zeiss, Oberkochen, Germany). To identify the WL, the file was pushed into the root canal up until it could be seen flush with the main foramen.

2.3. Measurement of working length electronically

The roots were then secured within an acrylic container and covered with a conductive gel that contained 0.5 percent KCl, and a saltwater solution and 2.5 percent hydroxyethyl cellulose.[6]

WL was electronically measured using a J. Morita Endomotor TRI AUTO ZX2 (Frankfurt, Germany) that has an inbuilt EAL.

The study utilized NiTi systems of tip diameter of 0.25 and various heat treatments: HyFlex CM size 25.04 (Coltene, Altstätten, Switzerland), Twisted file Adaptive size 25.06 (Axis/SybronEndo, Orange, CA, USA), WaveOne Gold Primary size 25.,07 (DentsplyMaillefer, Ballaigues, Switzerland), Reciproc R25 size 25.08 (VDW, Munich, Germany), and Reciproc Blue R25 size 25.08 (VDW, Munich, Germany).

Root canals were flushed with 15 mL of 2.5% sodium hypochlorite, and electronic working length (WL) was ascertained when the file reached the point where the orange LED light became visible on the endodontic motor screen. Subsequently, the silicone stopper was adjusted at the occlusal reference, and the length was measured using an endodontic gauge (Dentsply Maillefer, Ballaigues, Switzerland). Three measurements were taken for each instrument.

If the readings were within 0.5 millimeters of each other, and the measuring was deemed to be accurate (scoring 0), although discrepancies more than 0.5 mm were deemed incorrect (score 1).

2.4. Statistical analysis

The significance level was set at (P<0.05) and IBM SPSS statistics software was used for the data analysis. To compare the results collected through comparing the various heat treatments or tip diameters, Fisher's exact test was employed to assess the variances between and between groups.

3. Results

There wasn't any significant variation in EAL accuracy in measuring working length amongst different groups (P > 0.05). Instruments with various thermal treatments and an identical 0.25 mm tip diameter did not result in any statistically significant differences in EAL accuracy (Table 1).

Table 1: Accurate and inaccurate results obtained using 0.25 mm diameter instruments with different heat treatments.

	Difference ≦ 0.5 mm	Difference > 0.5 mm
Mtow 25	20	0
TF 25	20	0
wave one gold primary	19	1
R25	19	1
R25 blue	19	1

*indicate statistical difference between group (P<0.05)

4. Discussion

The purpose of the research was to assess the impact of heat treatment and endodontic instrument tip width on the precision of an EAL integrated into an endodontic motor. According to the findings of this investigation, the thermal evaluation of treatments (M-wire, R-phase, Gold Wire, Blue Analysis of wire, CM wire, and tip diameters (0.25 mm,0.35", 0.45", 0.45" and 0.50") revealed no influences on the EAL's accuracy during BMP. The null hypothesis was accepted.

The accurate calculation of the WL is one of the parameters that determines whether endodontic therapy will be successful.[3] The WL, particularly in curved canal, may vary throughout the BMP.[16–18] It is advantageous to follow the WL during root canal preparation when endodontic motors and EAL are used paired together.[19–21] The precision of EALs is frequently evaluated in the scientific literature using ex vivo investigations.[1,10,11,21] To assess the correctness of EALs, Duran-Sindreu et al.[22] compared in vivo and ex vivo models and discovered no differences. Ex vivo studies can also more precisely control sample variability and conditions for experimentation because they are straightforward, reproducible, and standardized.[11,21] We used a conventional, easily produced 2.5% hydroxyethyl cellulose gel that conducts electricity.[11] Sodium hypochlorite, as in earlier studies,[1,11,21,23] was utilized as an irrigation solution to mimic clinical use.

In order to calculate WL utilizing the differential between resistance and capacitance (impedance) inside the root canal, EALs function as electricity conductors in the electrical circuit.[23] Whenever an endodontic equipment approaches the apical constriction, impedance values change and are converted into WL measurements in millimeters from the apical foramen.[12,23,24] The composition of NiTi alloys changes with different thermal treatments, affecting the percentage of different crystalline phases (martensite and austenite), which affects the mechanical characteristics of the equipment.[15]

The study's findings indicate that the precision of the EAL device was unaffected by the thermal processes of the NiTi alloy (P = 0.17). The crystalline structure of NiTi can also affect electrical resistivity values given that the martensite phase's resistivity is 14.7% more than the austenite phase's. Compared to other alloys, CM wire contains a higher proportion of martensite-phase crystals in its crystalline structure.[13] Although CM alloys had higher resistivity, there were no appreciable variations in the WL readings.

5. Conclusion

It was discerned that the variations induced by the diverse heat treatment approaches did not result in any statistically significant differences. It is important to acknowledge the inherent limitations of the study, which encompass factors such as sample size, experimental conditions, and the specific heat treatment protocols applied. However, within the confines of these limitations, the results consistently pointed towards a lack of substantial divergence in the material's properties and precision of apex locator.

6. Source of Funding

None.

7. Conflicts of Interest

There are no conflicts of interest.

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Cite this article: Bukhari SMUH, Bhat R, Rashid S. Impact of nickel-titanium instrument heat treatment on the precision of an inbuilt electronic apex locator and endodontic motor. *IP Indian J Conserv Endod* 2023;8(3):155-158.