Journal of Advanced Medical and Dental Sciences Research
@Society of Scientific Research and Studies ***NLM ID:*** *101716117*

Journal home page: www.jamdsr.com doi: 10.21276/jamdsr Indian Citation Index (ICI) Index Copernicus value = 100

(e) ISSN Online: 2321-9599; (p) ISSN Print: 2348-6805

Original Research

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

[1]Nikhil Soni, [2]Uzma Talath, [3]Aftab Nawab, [4]M Vivek Bhargava, [5]S. Narendra Prassath, [6]D. Narmadha

[1]Senior Lecturer, Department of Conservative Dentistry and Endodontics, V.Y.W.S Dental College and Hospital, Amravati, India;
[2]MD Biochemistry, Davangere, India;
[3]Reader, Department of Periodontics & Implantology, College of Dental Sciences, Davangere, India;
[4]Consulting Paediatric and Preventive Dentist Hyderabad, Telangana, India;
[5]Senior Lecturer, Department of Pedodontics, Karpaga Vinayaga Institute of Dental Sciences, Chengalpattu, Chennai, India;
[6]Assistant Professor, Department of Prosthodontics and Crown & Bridge, Meenakshi Ammal Dental College and Hospital, Chennai, India

ABSTRACT:
Aim- This study aimed to assess the effects of thermal processes on NiTi instruments and apical preparation diameter on the accuracy of integrated EALs.**Materials and methods-** 30 human mandibular incisors were selected based on specific criteria. These criteria included fully developed apex, a single canal as confirmed by periapical radiograph, and a curvature angle ranging between 15° and 35°. **Results-** Heat treatment of NiTi rotary instruments has no significant impact on the EAL's accuracy.**Conclusion-**The heat treatment of NiTi alloy in mechanized instruments and the tip diameter did not impact the accuracy of electronic apex locators (EALs).
Keywords- working length, apical, constriction

Received date: 23 February, 2024 Acceptance date: 07 March, 2024

Corresponding author: Nikhil Soni, Senior Lecturer, Department of Conservative Dentistry and Endodontics, V.Y.W.S Dental College and Hospital, Amravati, India

This article may be cited as: Soni N, Talath U, Nawab A, Bhargava M V, Prassath SN, Narmadha D. Influence of heat treatment of nickel–titanium instruments on the accuracy of an electronic apex locator integrated with endodontic motor. J Adv Med Dent Scie Res 2024;12(4):1-4.

INTRODUCTION

Accurately determining the working length (WL) in endodontic procedures is crucial for successful outcomes, ensuring proper instrumentation and obturation of the root canal system[1]. While the cement-dentinal junction is considered the ideal endpoint, locating it in clinical practice can be challenging, making the apical constriction a practical reference point for WL determination. Radiographic techniques and electronic apex locators (EALs) are commonly used for WL determination, but the accuracy of radiographs is questioned due to reliance on two-dimensional imaging and subjective interpretation. Additionally, lateral root surface foramens can complicate radiographic WL determination[2]. EALs, introduced by Suzuki[3] and clinically used by Sunada[4] in 1965, have become valuable tools for measuring root canal lengths. However, concerns exist regarding potential interference factors such as the anatomical diameter of the apical foramen, instrument tip diameter, and NiTi alloy type used. Manufacturers have developed various NiTi alloys with heat and surface treatments to improve mechanical properties, but the effects of these treatments on electrical circuit impedance are uncertain[5,6,7]. Integration of EALs into endodontic motors enables simultaneous WL determination during biomechanical preparation (BMP), particularly beneficial in curved root canals where WL may change during shaping[8]. This study aimed to assess the effects of thermal processes on NiTi instruments

and apical preparation diameter on the accuracy of integrated EALs.

MATERIALS AND METHODS

In this study, 30 human mandibular incisors were selected based on specific criteria. These criteria included fully developed apex, a single canal as confirmed by periapical radiograph, and a curvature angle ranging between 15° and 35°. To ensure standardization, the root length of each incisor was adjusted to 17 mm by removing the dental crowns with a diamond disc. Subsequently, these standardized specimens were preserved in distilled water at a constant temperature of 37℃ to maintain their integrity. In the determination of the working length (WL), a clinical microscope and a manual stainless steel K-file #10 were employed. The process involved carefully inserting the K-file into the root canal until it was observed to be flush with the major foramen. This visual confirmation allowed for the precise determination of the control WL.The DENTSPLY X-SMART IQ motor, equipped with an integrated electronic apex locator (EAL), was used to electronically measure working length (WL). Various NiTi systems of different diameters were evaluated after root canal rinsing with sodium hypochlorite. Electronic WL was determined by the appearance of an orange LED light on the motor display. Measurements were taken with an endodontic ruler and conducted in triplicate. Discrepancies between electronic and control WL were assessed based on a ≤0.5 mm accuracy threshold.Various NiTi systems with #25 tip diameter and subjected to different heat treatments were employed in the study. These included files in sizes 25.04, 25.06, and 25.08. Additionally, instruments with larger diameters were also evaluated in sizes 35.06, 40.06, 45.05, and 50.05.Following the rinsing of the root canals with 15 mL of 2.5% sodium hypochlorite, electronic working length (WL) was determined by aligning the file with the position indicated by an orange LED light on the endodontic motor display. Subsequently, the WL was measured using an endodontic ruler. Each measurement was carried out three times to ensure accuracy and reliability.Comparisons between electronic measurements and control WL were made, following criteria established in a prior study. A difference of ≤0.5 mm between the values was considered accurate (score 0), while differences exceeding 0.5 mm were deemed inaccurate (score 1).The study evaluated the electrical resistivity of instruments used for electronic working length measurement. Probes were placed on instrument tips and intermediate rods, and resistivity was measured using a 4263B LCR Meter.

RESULTS

There was no significant difference in EAL accuracy using instruments with different heat treatments and the same tip diameter of 0.25 mm and with different tip diameter. When comparing all heat treatments, results show a statistical difference between the CM group and the others ($P < 0.05$).

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

Difference ➔	Difference ≦ 0.5 mm	Difference > 0.5 mm
TF 25	**17***	**1**
Mtow 25	**18***	**0**
R25	**17***	**1**
wave one gold primary	**18***	**1**
R25 blue	**17***	**0**

***: Intergroup difference p-value < 0.05**

Table 2: Accurate and inaccurate results obtained using instruments of the same system with different diameter

	Wave One gold			Reciprocblbue		
	25.04	**35.06**	**45.05**	**25.08**	**40.06**	**50.05**
Difference ≦ 0.5 mm	17	15	16	17	16	16
Difference > 0.5 mm	1	2	2	1	2	1
p-value	0.12			0.28		

DISCUSSION

It is accepted that root canal instrumentation should be limited to the minor apical foramen. The minor apical foramen represents the junction of the pulpal space and the periodontal tissues. Working short of the canal terminus may result in insufficient debridement, whereas extending beyond may irritate the periapical tissues. The position of the minor foramen generally varies 0.5– 1.0 mm from the major foramen. Sometimes the apical foramen is located laterally on the root, up to a distance of 3 mm from the radiographic apex. To help clinicians, electronic root canal length measurement devices (ERCLMDs), or electronic apex locators, were introduced as an adjunct to radiographic techniques.[9- 11] There was no significant difference in EAL accuracy using instruments with different heat treatments and the same tip diameter of 0.25 mm and with different tip

diameter. When comparing all heat treatments, results show a statistical difference between the CM group and the others ($P < 0.05$).Aggarwal V, et al evaluated the influence of instrument size and the effect of the electrical resistance of endodontic instruments on the accuracy of three electronic root canal length measurement devices (ERCLMDs).Thirty single-rooted extracted human teeth were divided into three groups (n = 10) on the basis of the ERCLMD used: Root ZX II (J. Morita, Kyoto, Japan); ProPex (Dentsply Maillefer, Ballaigues, Switzerland); and iPex II (NSK, Tochigi, Japan). The electronic working length measurements (EWL) were made with K-files in the sequence sizes 08, 10, 15, 20, 25 and 30. The actual working length (AWL) was calculated by fixing a size 30 K-file in the canal and exposing the apical 5 mm of the root. The minor foramen was identified under an optical microscope, and its distance from the file tip was calculated. The accuracy of the ERCLMDs was evaluated in terms of percentages of accurate measurements (0.0 mm tolerance) and measurements with tolerance limits of ±0.5 mm and ±1.0 mm. The findings were analysed with the McNemar test, Pearson's chi-square tests and two-way analysis of variance. The multiple comparison procedures were carried out using Holm-Sidak method. The maximum electrical resistance tolerated by ERCLMDs was evaluated by connecting commercially available resistors between the file clip and the root canal instrument. The resistance was gradually increased until it started to affect the ERCLMD readings.The ERCLMDs were able to actually locate the minor foramen in 7% of samples. File size did not affect the accuracy of ERCLMDs ($P > 0.05$). Overall, the ERCLMDs gave 65% readings within a tolerance limit of ±0.5 mm and 90% within a tolerance of ±1.0 mm. The electrical resistance of endodontic files was less than the maximum electrical resistance tolerated by ERCLMDs (0.6-1 Ω vs. 2500-4000 Ω).The size of the root canal instrument did not affect the accuracy of ERCLMDs in this laboratory study.[12] Duran-Sindreu F et al 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. Teeth with metallic restorations, fractures, root resorption, pulp necrosis or open apices were not included 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. In each case, the RWL was subtracted from the electronic measurements. Positive values indicated electronic measurements that exceeded the RWL (long measurements), whereas negative values indicated measurements that were short of the RWL. The values obtained with the different irrigants and EALs were compared using the paired t-test. Significance was set at $P < 0.05$.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 accuracy of neither the iPex nor Root ZX EAL was affected by the irrigant used. However, the iPex was less accurate than the Root ZX in determining the RWL both for 2.5% NaOCl and for 2% CHX.[13]

CONCLUSION

The heat treatment of NiTi alloy in mechanized instruments and the tip diameter did not impact the accuracy of electronic apex locators (EALs).

REFERENCES

1. D Ricucci K Langeland Apical limit of root canal instrumentation and obturation, part 2. A histological studyIntEndod J199831639440910.1046/j.1365-2591.1998.00183.
2. MJ Altenburger Y Cenik JF Schirrmeister KT Wrbas E Hellwig Combination of apex locator and endodontic motor for continuous length control during root canal treatmentIntEndod J20094243687410.1111/j.1365-2591.2008.01535.
3. Suzuki K. Experimental study on iontophoresis. *Japan J Stomatol.* 1942;16:411–29.
4. Sunada I. New method for measuring the length of the root canal. *J Dent Res.* 1962;41:357–87.
5. Gehlot PM, Manjunath V, Manjunath MK. An *in vitro* evaluation of the accuracy of four electronic apex locators using stainless-steel and nickel-titanium hand files. *Restor Dent Endod*. 2016;41:6–11.
6. Gavini G, Santos MD, Caldeira CL, Machado ME, Freire LG, Iglecias EF, et al. Nickel-titanium instruments in endodontics: A concise review of the state of the art. *Braz Oral Res.* 2018;32:e67.
7. Aydin U, Karataslioglu E, Aksoy F, Yildirim C. *In vitro* evaluation of Root ZX and Raypex 6 in teeth with different apical diameters. *J Conserv Dent*. 2015;18:66–9.
8. Vasconcelos BC, Bastos LM, Oliveira AS, Bernardes RA, Duarte MA, Vivacqua-Gomes N, et al. Changes in root canal length determined during mechanical preparation stages and their relationship with the accuracy of root ZX II. J Endod. 2016;42:1683–6.
9. Ali MM, Wigler R, Lin S, Kaufman AY. An ex vivo comparison of working length determination by three electronic root canal length measurement devices integrated into endodontic rotary motors. Clin Oral Investig. 2016;20:2303–8.
10. Somma F, Castagnola R, Lajolo C, Paterno Holtzman L, Mar- igo L (2012) In vivo accuracy of three electronic root canal length measurement devices: Dentaport ZX, Raypex 5 and ProPex II. International Endodontic Journal 45, 552– 6.
11. Stein TJ, Corcoran JF, Zillich RM (1990) Influence of the major and minor foramen diameters on apical

electronic probe measurements. Journal of Endodontics 16, 520–2.
12. Aggarwal V, Singla M, Bhasin SS. Influence of instrument size and varying electrical resistance of root canal instruments on accuracy of three electronic root canal length measurement devices. Int Endod J. 2017;50:506–11.
13. Duran-Sindreu F, Gomes S, Stöber E, Mercadé M, Jané L, Roig M. In vivo evaluation of the iPex and Root ZX electronic apex locators using various irrigants. Int Endod J. 2013;46:769–74.