ISSNe 2178-1990

10.35699/2178-1990.2023.45739

ARQUIVOS EM ODONTOLOGIA

Accuracy of an Endodontic Rotary Motor with Integrated Apex Locator to Determine the Root Canal Length

João Henrique Sousa Melo Borges[1] | Fabíola Bastos de Carvalho[1] | Maria Cristina Teixeira Cangussu[1] | Ove Andreas Peters[2] | Maria Guiomar de Azevedo Bahia[3] | Érika Sales Joviano Pereira[1]

[1]Faculdade de Odontologia, Universidade Federal da Bahia, Salvador, Bahia, Brasil
[2]School of Dentistry, The University of Queensland, Brisbane, Queensland, Australia
[3]Faculdade de Odontologia, Universidade Federal de Minas Gerais, Belo Horizonte, Minas Gerais, Brasil

Aim: The purpose of this study was to evaluate the efficacy to determine the root canal length, *in vitro,* of both the electronic apex locator (M2) and the autostop (AS - M3) functions of the Endus Duo Gnatus endodontic motor (Gnatus, São Paulo, SP, Brazil).

Methods: Thirty extracted human single-rooted premolars had their root canal lengths (TLs) up to the apical foramen determined using the Endus Duo Gnatus in two ways: (1) In the stainless steel (SS) control group, the measurement was obtained using a stainless steel hand instrument with the electronic locator mode (M2 function) connected to a stainless-steel hand instrument (K-file #15). In the NiTi rotary instrument (NiTi RI) intervention group, the measurement was obtained during the instrumentation (M3 function) of the root canals with a nickel-titanium rotary instrument (Hyflex CM: Coltene Whaledent, Cuyahoga Falls, OH, USA), size 25/.06. The NiTi manually used instrument (NiTi MUI) Intervention group performed the measurement in locator mode using a Hyflex instrument, placed to true length manually. Statistical analysis was performed using ANOVA followed by the Tukey post-hoc test with a significance level of $p < 0.05$.

Results: The true mean length and standard deviation (SD) of the standardized root canals were 18.40 ± 2.14mm, while the mean lengths and standard deviations (SD) were 18.29 ± 1.89mm, 18.22 ± 1.85mm, and 17.24 ± 2.09mm for the SS, NiTi RI, and NiTi MUI groups, respectively. However, data from the NiTi MUI Intervention group indicated shorter root canal lengths when compared to the SS control group and the NiTi RI Intervention group values, and were significantly shorter than the true canal length ($p < 0.001$).

Conclusions: The use of the motor in NiTi RI Intervention group showed acceptable results. However, the NiTi MUI Intervention group resulted in unacceptable short measurements.

Uniterms: Endodontics; Dental pulp cavity; Weights and measures.

Data de submissão: 10/04/2023
Data de aceite: 04/07/2023

INTRODUCTION

The determination of working length (WL) and its maintenance during cleaning and shaping procedures is a key factor for successful endodontic treatment[1,2,3]. This length is referred to as the distance from a coronal reference point to the apical end point of shaping and obturation procedures, which, ideally, should relate to the apical constriction (AC)[4-6]. An adequate WL enables the disinfection of the entire root canal length, the maintenance of the preparation, and filling within the confines of the root canal, thus preventing damage to the periapical tissues[5,6].

Autor para Correspondência:
Érika Sales Joviano Pereira
Avenida Araújo Pinho, 62 – Campus Canela, Salvador, Bahia. CEP: 40.110-150. Telefone: +55 71 3283-8964.
E-mail: erikajoviano@gmail.com

The AC has high variability in its presence, location, and topography, and can be altered by pathological conditions[4,7,8]; therefore, it cannot be detected clinically or radiographically[5,8]. Electronic root canal length measurement devices, known as ‘‘electronic apex locators’’ (EALs), have proven to be clinically effective instruments for the identification of the apical foramen (AF)[3,8-10]. Moreover, clinical and laboratory studies have shown that the definition of WL using EALs presents more accurate and reliable results than the traditional radiographic method[11,12]. Finally, the electronic definition of the WL is a quick procedure, and since it does not require ionizing radiation, it can be used to confirm the apical limit during or after endodontic procedures[13].

Endodontic motors with integrated EALs have been developed with the intention of making root canal treatment simpler and faster[14,15]. Apart from torque and speed control, these hybrid devices also aim to monitor and maintain the apical limit throughout the mechanical preparation of the root canals[15]. Endus Duo Gnatus (Gnatus, São Paulo, SP, Brazil) is a 2-frequency-based EAL that presents an optional module for rotary instrumentation, enabling the device to function as a low-speed handpiece, apex locator, or a combination of both. The apical autostop function (AS - M3) stops when the file tip reaches the specified apical limit. According to the manufacturer, the bar labeled ‘‘APEX’’ represents the file tip positioned at the AF while the bar labeled ‘‘OVER’’ the instrument is beyond the foramen. To date, no data is available regarding the performance of this new endodontic motor.

Therefore, this study aimed to evaluate the *in vitro* the efficacy of both the EAL and the apical autostop functions of the Endus Duo Gnatus device, considering as a null hypothesis that there are no differences between the measures of the functions.

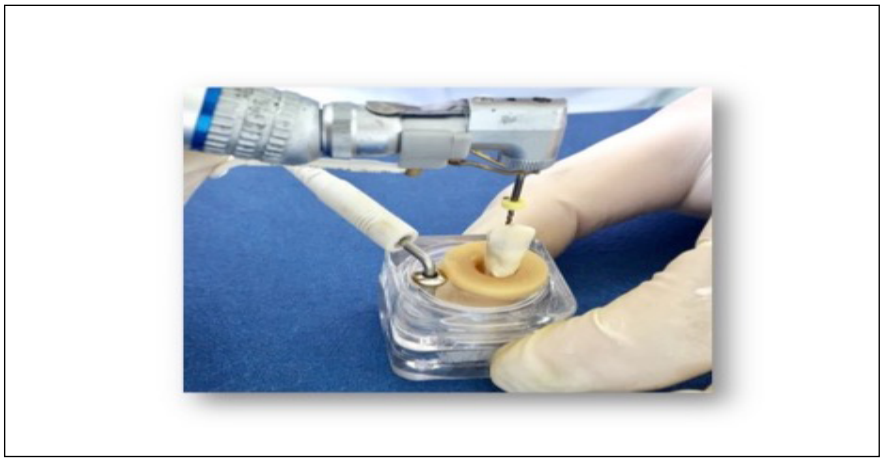
MATERIALS AND METHODS

After approval by the Research Ethics Committee of the Dental School of the Federal University of Bahia (UFBA), CAAE 60325416.6.0000.5024, thirty human premolars extracted due to dental needs at the Surgery I Outpatient Clinic of the UFBA Dental School were selected fr this study. The sample size was convenience based on previous studies[15,16]. Inclusion criteria considered upper and lower premolars, single-rooted with no or minimal coronary destruction; Weine class I root canals selected based on the study radiograph; and teeth with fully formed apices as confirmed with initial periapical radiographs. However, teeth with extensive carious lesions weakening the tooth structure were excluded from the study.

Specimens were stored in a 0.1% thymol solution; teeth with cracks, immature apices, resorptive defects, or root fillings, as well as teeth with a diameter of the apical foramen larger than a size #25 K-file were further excluded from this study. Selected teeth had a root length of approximately 18mm, and were radiographed in orthoradial direction. A size #15 K-file (Dentsply Sirona, York, PA) was used to confirm patency length and the presence of a single canal. Root canals were pre-flared using #35/.06 and #30/.06 Hyflex CM rotary instruments (Coltene Whaledent, Cuyahoga Falls, OH, USA) with 2.5% sodium hypochlorite (NaOCl) as the irrigating solution. The root canal length determination was performed through AF standardization and visual measurements at 8x magnification until the tip of the #25 K-file became visible at the most coronal border of the AF opening. The rubber stop was then carefully adjusted to the reference point. The distance between the file tip and the rubber stop was measured and recorded as the true root canal length (TL). These values were considered the gold standard for comparison with the other measurements.

When using the device, the teeth were fixed to an acrylic dental support (Fig.1) for apex locator testing (IM do Brasil® Ltda, São Paulo, Brazil), embedded in fresh physiological solution (NaCl 0.7%), and the two-locator electrodes (lip clip and file holder) were connected to the motor. The lip clip touched the metal of the contra-angle to close the electrical circuit, and the locator function (M2 on the device) was activated on the main screen. Subsequently, the lip clip was inserted in the reservoir of physiological solution present in the dental support, with the apical third of the tooth inserted in the same medium. Ttwo experimental interventions and one control intervention were performed in all 30 teeth (n = 30).

Figure 1. Measurement with the Hyflex CM instrument driven by the motor (M3 function) and tooth inserted in the simulator support for apical locator.



In the SS control group, the file holder was positioned and inserted into the root canal, while the instrument performed the measurement in the Locator mode - M2 function. The apical foramen was reached when the word “Apex” blinked intermittently. At this point, the operator confirmed the correct position of the instrument cursor at the external reference point. With motor and instrument disconnected, an orthoradial radiograph was taken. and the instrument was removed manually from the root canal. A length measurement was then taken using an endodontic ruler (Dentsply Maillefer; Ballaigues, Vaud, SWI) under a stereomicroscope, together with a KL200 digital camera (Carl Zeiss; Göttingen, Germany) at 10x magnification, and the value found was recorded in a database with double readings.

In the NiTi Ri intervention group, with the measurement taken during instrumentation, the Locator and Motor modes (apical autostop function - M3) were selected. The instrument was inserted deep into the canal, and the motor stopped moving when the file tip reached the apical foramen. At this point, the operator confirmed the correct position of the instrument with the rubber stop at the external reference point; motor and instrument were disconnected following the same steps described for the previous group.

In the NiTi MUI intervention group, the root canals had their lengths up to the apical foramen determined using the locator function - M2 using Hyflex CM #25/.06 instruments, but manually without connected to the handpiece for comparison purposes. After insertion of the instrument into the apical foramen, indicated by the word “Apex” as in the previous groups, the same procedures mentioned above were performed.

The measurements were recorded after double readings if the mark at display remained stable for at least 5 seconds, and a single operator performed all electronic measurements. Radiographs were obtained from all teeth to confirm the measurement obtained electronically. The accuracy of the measurements of each group was compared using the ANOVA followed by Tukey post-hoc test, with the significance set at 0.05.

RESULTS

The mean true canal length and standard deviation (SD) measured to 18.40 ± 2.14 mm with a range of 14.5 - 24mm. The mean lengths and SDs at the apical foramen level were 18.29 ± 1.89mm for the SS control group, 18.22 ± 1.85mm for the NiTi RI Intervention group, and 17.24 ± 2.09mm for the NiTi MUI Intervention group. The SS and NiTi RI Interventions groups did not differ statistically from TL, while the NiTi MUI Intervention group resulted in significantly shorter lengths ($p < 0.001$). Similarly, the mean differences from the true length were 0.07, 0.14, and 1.12mm, for the three intervention groups, respectively. Post-hoc comparisons between the NiTi MUI group and the two other groups indicated significant ($p < 0.001$) differences. Figure 2 shows the distribution of the measurements, and Figure 3 includes the scatter data showing the two outliers in the better groups (SS Control Group and NiTi RI Intervention Group), and the consistent short measurements in the NiTi MUI group.

Figure 2. Mean length and standard deviation (SD) at the apical foramen level at 95% confidence intervals for the three intervention groups. The True length (TL) was considered as the gold standard for comparison purposes.

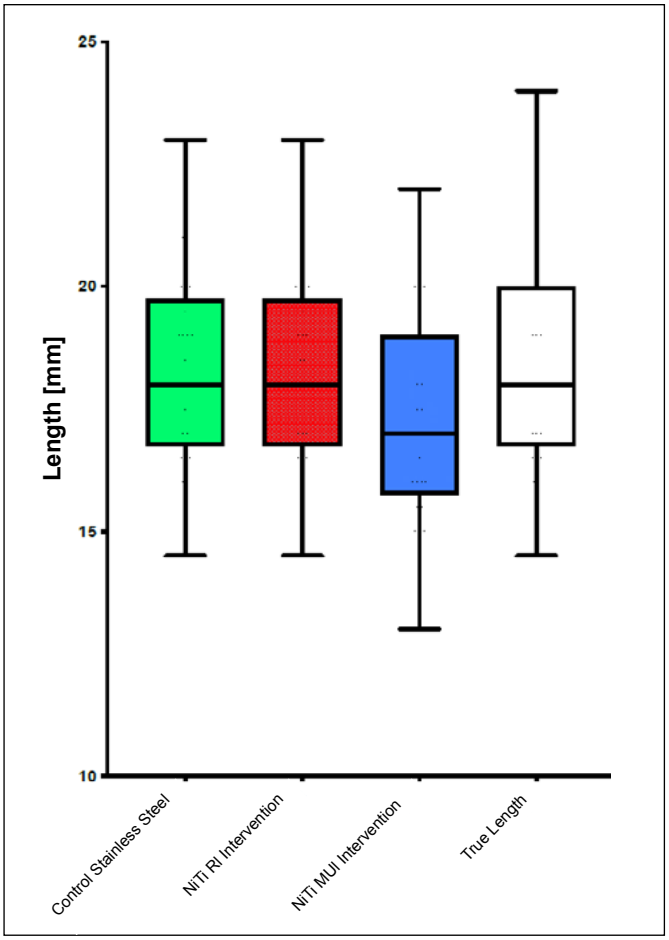
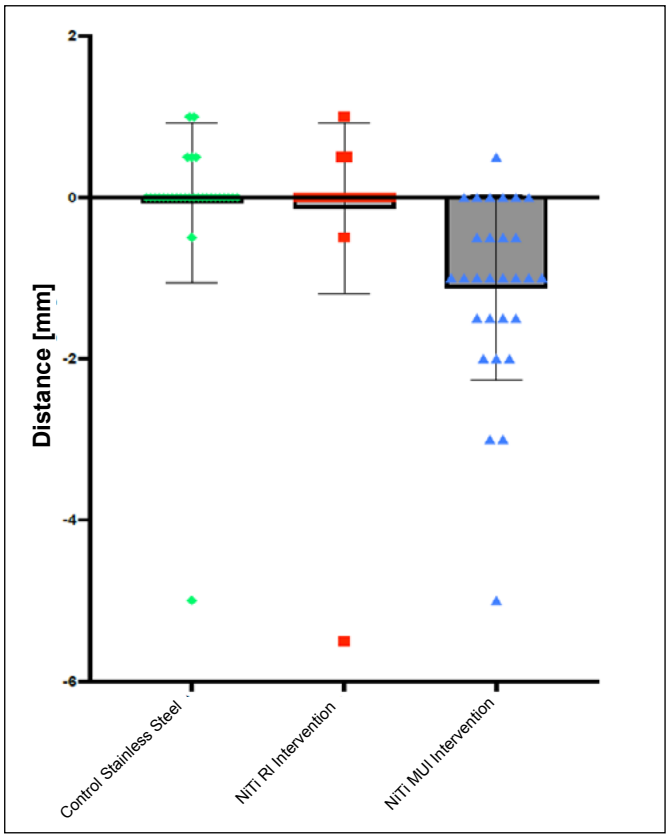


Figure 3. Comparison of the groups in relation to the distance to true length. Scatter data show the two outliers in the SS Control Group and the NiTi RI Intervention Group, as well as the consistent short measurements in the NiTi MUI Intervention Group.



DISCUSSION

During shaping procedures, establishment of working length is one of the first steps that mark the extension of the instrumentation of the chemical-mechanical preparation. With the precise determination of this data point, the likelihood of possible detrimental consequences is greatly reduced, including: ledge formation in the root canal wall, over instrumentation, inadequate fillings, root perforation, and postoperative symptoms[3,16].

To the best of our knowledge, to date, no study has evaluated the precision of the Endus Duo Gnatus device. There is similar equipment on the market, such as the Root ZX II (J Morita, Tokyo, Japan). Although the Root ZX II may be considered a highly reliable device to define the WL, there are controversial reports regarding the accuracy of the AAR function[17-19].

When using the electronic method to determine the actual working length, the exposure of the patient to the radiation can be reduced due to the smaller number of radiographs required. Another advantage is the reduction in treatment time as well as a lower endodontic treatment cost for the patient due to the optimization of the professional's working time[5].

As in the study by Siu, Marshall, Baumgartner[16] (2009), it was showed that apical locators used with manual files are reasonably accurate in determining the location of the apical foramen. In Intervention I, in which the apical locator was used with a stainless-steel instrument, it showed high precision in the location of the apical foramen.

Other studies have demonstrated that electronic apical locators with rotational NiTi files were not as reliable as compared to the use of manual files to locate the apical constriction within the apical extension of 0.5mm[3,16]. Similarly, in the present study, shorter lengths (1.5 to 3mm) were obtained with a rotating NiTi file than with manual files in nine of the thirty samples. One explanation for this observation is that locators need time to process the position of the file within the root canal. NiTi files are usually used with a repetitive movement, in-and-out of the canal, while the apical extension of the manual files can be better controlled due to a smoother movement.

In the study by Akisue, et al.[20] (2014), a file that best fit the root canal would be selected to be used with the apical locator. This is in accordance with previous recommendations that suggest higher accuracy of the locators with the use of files adjusted for the apical third when working on teeth with extended foramina. In the present study, the selected teeth had an apical size of a K-file #25. In the literature, there is no agreement regarding the diameter of the endodontic instrument that should be used in the electronic measurements. Teeth with large apical sizes showed greater difficulty in obtaining the true working length with the electronic method, demonstrating a shorter length than the true root canal length[20-22]. Therefore, instruments with a diameter as close as possible to the diameter of the anatomical foramen are required.

Researchers should be aware that results obtained from laboratory studies are not to be directly extrapolated to a clinical situation; however, the use of *in vitro* models is useful to control variables and overcome some of the limitations of clinical studies[3,18]. In the present study, the use of the same extracted teeth enabled a direct comparison of both the EAL (M2) and the AS (M3) functions of the tested device.

In the present study, the true length was the gold standard. The three interventions do not measure the true length, only approximate it. Thus, the statistics can use multiple comparisons towards a gold standard. It is important to note that the NiTi MUI Intervention group resulted in overall shorter lengths. In the NiTi RI Intervention group, the AS (M3) provided a mean distance of slightly shorter than the AF (0.5 and 1.0 mm) when compared to the SS control group, the EAL (M2) function (in 3 of the 30 analyzed teeth) but with no statistically significant difference. Considering that the WL is subjected to changes because of the shaping procedures, the apical limit after preparation should be considered adequate when placed near the terminus of the root canal, but within the dentinal walls, at distances varying from 0 mm to 1 mm short of the AF[14,15], which is in agreement with the differences of the results of the SS control group when compared to the NiTi RI Intervention group. Moreover, when comparing the NiTi MUI Intervention group with the SS and NiTi RI Intervention groups, nine teeth showed lower values. Clinically, this finding may contribute to undesirable outcomes for successful endodontic treatments[2,5,18,20]. The incidence of underinstrumentation in the NiTi MUI Intervention group may compromise the disinfection of the root canal, as it will not allow for the removal of all pulp tissue, necrotic material, and microorganisms[2,12,16]. Overinstrumentation was not observed in any of the intervention groups. Conflicting results are found in the literature regarding overextension provided by

the 0.5 automatic apical reverse function (AAR) of Root ZX II. One laboratory study[18] showed 18.46%, whereas clinical evaluations have reported 28.6% (SIU et al., 2009) and 70%[14]. According to the authors, this may be due to the fact that the device works better with passively inserted files and not in motor-coupled mode because the electronic measurement needs time to process the position of the instrument inside the root canal.

Because the *Autostop* function is an optional feature, more studies are required to elucidate which is the most reliable function to control the apical limit when using integrated motors clinically. However, based on the data presented and within the limitations of an *in vitro* study, it can be concluded that the use of the Endus Duo Gnatus motor with rotating instruments provides accurate measurements of the true root canal length.

CRediT – CONTRIBUIÇÕES AUTORES

João Henrique Sousa Melo Borges: Methodology
Fabíola Bastos de Carvalho: Methodology

Maria Cristina Teixeira Cangussu: Formal analysis, Validation

Ove Andreas Peters: Writing – review & editing, Validation, Visualization

Maria Guiomar de Azevedo Bahia: Writing – review & editing

Érika Sales Joviano Pereira: Conceptualization, Writing – review & editing

ORCID

João Henrique Sousa Melo Borges https://orcid.org/0000-00016420-9864
Fabíola Bastos de Carvalho https://orcid.org/0000-00015326-9562
Maria Cristina Teixeira Cangussu https://orcid.org/0000-0001-5946-9178
Ove Andreas Peters https://orcid.org/0000-0001-5222-8718
Maria Guiomar de Azevedo Bahia https://orcid.org/0000-0003-1565-1888
Érika Sales Joviano Pereira https://orcid.org/0000-0001-5504-6055

REFERENCES

1. Ricucci D, Langeland K. Apical limit of root canal instrumentation and obturation, part 2. A histological study. Int Endod J. 1998;31(6):394–409.
2. Sjögren U, Hägglund B, Sundqvist G, Wing K. Factors affecting the long-term results of endodontic treatment. J Endod. 1990;16(10):498–504.
3. Cruz ATG, Wichnieski C, Carneiro E, Neto UXS, Gambarini G, Piasecki L. Accuracy of 2 endodontic rotary motors with integrated apex locator. J Endod. 2017;43(10):1716-9.
4. Kuttler Y. Microscopic investigation of root apexes. J Indiana Dent Assoc. 1955;89(1):20-8.
5. Wu MK, Wesselink PR, Walton RE. Apical terminus location of root canal treatment procedures. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2000;89(1):99–103.
6. Gordon M, Chandler N. Electronic apex locators. Int Endod J. 2004;37(7):425–37.
7. Dummer PM, McGinn J, Rees DG. The position and topography of the apical canal constriction and apical foramen. Int Endod J. 1984;17(4):192–8.
8. Elayouti A, Hülber-J M, Judenhofer MS, et al. Apical constriction: location and dimensions in molars - a micro–computed tomography study. J Endod. 2014;40(8):1095–9.
9. Nekoofar M, Ghandi M, Hayes S, Dummer P. The fundamental operating principles of electronic root canal length measurement devices. Int Endod J. 2006;39(8):595–609.
10. Plotino G, Grande N, Brigante L, et al. Ex vivo accuracy of three electronic apex locators: Root ZX, Elements Diagnostic Unit and Apex Locator and ProPex. Int Endod J. 2006;39(12):408–14.
11. Piasecki L, Carneiro E, Silva Neto UX, et al. The use of micro–computed tomography to determine the accuracy of 2 electronic apex locators and anatomic variations affecting their precision. J Endod. 2016;42(8):1263–7.
12. Martins JN, Marques D, Mata A, Caramês J. Clinical efficacy of electronic apex locators: systematic review. J Endod. 2014;40(6):759–77.
13. Vasconcelos BC, Bastos LM, Oliveira AS, 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(11):1683–6.
14. Fadel G, Piasecki L, Westphalen V, et al. An in vivo evaluation of the auto apical reverse

function of the Root ZX II. Int Endod J. 2012;45(10):950–4.
15. Vasconcelos BC, Frota LM, Abreu Souza T, et al. Evaluation of the maintenance of the apical limit during instrumentation with hybrid equipment in rotary and reciprocating modes. J Endod. 2015;41(5):682–5.
16. Siu C, Marshall JG, Baumgartner JC. An in vivo comparison of the Root ZX II, the Apex NRG XFR, and Mini Apex Locator by using rotary nickel-titanium files. J Endod. 2009;35(7):962–5.
17. Carneiro E, Bramante CM, Picoli F, et al. Accuracy of root length determination using Tri Auto ZX and ProTaper instruments: an in vitro study. J Endod. 2006;32(2):142–4.
18. Felippe W, Felippe M, Reyes Carmona J, et al. Ex vivo evaluation of the ability of the Root ZX II to locate the apical foramen and to control the apical extent of rotary canal instrumentation. Int Endod J. 2008;41(6):502–7.
19. Jakobson SJ, Westphalen VP, Silva Neto UX, et al. The accuracy in the control of the apical extent of rotary canal instrumentation using Root ZX II and ProTaper in- struments: an in vivo study. J Endod. 2008;34(11):1342–5.
20. Akisue E, Gratieri SD, Barletta FB, Caldeira CL, Grazziotin-Soares R, Gavini G. Not all electronic foramen locators are accurate in teeth with enlarged apical foramina: an in vitro comparison of 5 brands. J Endod. 2014;40(1):109-12.
21. Goldberg F, Silvio AC, Manfre S, Nastri N. In vitro measurement accuracy of an electronic apex locator in teeth with simulated apical root resorption. J Endod. 2002;28(6):461-3.
22. ElAyouti A, Dima E, Ohmer J, et al. Consistency of apex locator function: a clinical study. J Endod. 2009;35(2):179–81.

Precisão de um motor rotatório endodôntico com localizador apical integrado para determinação do comprimento radicular

Objetivo: O objetivo deste estudo foi avaliar a eficácia na determinação do comprimento do canal radicular, *in vitro*, das funções localizador eletrônico foraminal (M2) e auto-parada durante a instrumentação (M3) do motor endodôntico Endus Duo Gnatus (Gnatus, São Paulo, SP, Brasil).

Métodos: Trinta pré-molares humanos uniradiculares extraídos tiveram seus comprimentos de canais radiculares (CRTs) até o forame apical determinados usando o Endus Duo Gnatus de duas maneiras: (1) No grupo controle de aço inoxidável (SS), a medida foi obtida usando um instrumento manual de aço inoxidável com modo de localização eletrônica foraminal (função M2) conectado a um instrumento manual de aço inoxidável (lima tipo K #15). No grupo intervenção instrumento rotatório NiTi (NiTi RI), a medida foi obtida durante a instrumentação (função M3) dos canais radiculares com instrumento rotatório de níquel-titânio (Hyflex CM: Coltene Whaledent, Cuyahoga Falls, OH, EUA), tamanho 25/.06. O grupo de intervenção NiTi instrumento usado manualmente (NiTi MUI) realizou a medição no modo localizador foraminal usando um instrumento Hyflex, colocado manualmente no comprimento real do dente. A análise estatística foi realizada por meio de ANOVA seguida do teste post-hoc de Tukey com nível de significância de $p < 0,05$.

Resultados: Os comprimentos reais médios dos dentes e desvios-padrão (DP) dos canais radiculares padronizados foram 18,40 ± 2,14 mm, enquanto os comprimentos médios e desvios- padrão (DP) foram 18,29 ± 1,89 mm, 18,22 ± 1,85 mm e 17,24 ± 2,09 mm para os grupos SS, NiTi RI e NiTi MUI, respectivamente. No entanto, os dados do grupo de intervenção NiTi MUI indicaram comprimentos de canais radiculares mais curtos quando comparados aos valores do grupo controle SS e do grupo de intervenção NiTi RI, e foram significativamente mais curtos que o comprimento real do canal ($p < 0,001$).

Conclusões: A utilização do motor no grupo Intervenção NiTi RI apresentou resultados aceitáveis. No entanto, o grupo de intervenção NiTi MUI resultou em medições curtas inaceitáveis.

Palavras-chave: Endodontia; Cavidade pulpar dentária; Pesos e medidas.