Original Article

Evaluation of Two New Electronic Apex-Locator-Controlled Handpieces Using a NiTi Rotary File: An *In Vitro* Study

Kiumarz Nazarimoghadam[1]✉, Hossein Labaf[2]

[1]Associate Professor, Department of Endodontics, Dental School, Shahed University of Medical Sciences, Tehran, Iran
[2]Assistant Professor, Department of Endodontics, Dental School, Shahed University of Medical Sciences, Tehran, Iran

Abstract

Objectives: The aim of this *in-vitro* study was to compare the accuracy of two new electronic apex-locator controlled handpieces ($EALH_s$) using the first rotary M_{two} file while rotating in the canal.

Materials and Methods: A total of 36 extracted mandibular molar teeth were selected. The lengths of the mesio-buccal canals to the major foramina were measured directly using a size 10 K-file introduced in the canal until the tip was visible under a loupe and then 0.5 mm was subtracted from the recorded lengths as the actual working lengths (AWL_s). Subsequently, the teeth were randomly assigned to two groups and embedded in an alginate model. Auto-stop function of the $EALH_s$ was preset at ''0.5'' mark and then electrical working lengths (EWL_s) in groups 1 and 2 were recorded by VDW GOLD and Dentaport ZX, respectively. Analysis of variance (ANOVA, 1-way) and Tukey pairwise multiple comparison intervals (0.05) were used to compare the accuracy of the two electronic devices.

Results: For VDW GOLD, 61.1% of the measurements were within ±0.5 mm and 88.9% were within ±1 mm of the AWL. For Dentaport ZX, 88.9% of the measurements were within ±0.5 mm and 94.4% were within ±1mm of the AWL. There was no significant difference between AWL_s and EWL_s (p=0.466 for Dentaport ZX and p=0.283 for VDW Gold) and between the accuracy of the two devices in determining the EWL (p=0.8).

Conclusion: Both Dentaport ZX and VDW Gold were suitable for determining working length using a rotary file. To avoid over instrumenting the canal, we recommend setting the devices to automatically stop or reverse the rotary file at 1 mm level.

Key Words: Accuracy; Apex-Locator-Controlled Handpiece; Dentaport Zx Device; Mtwo Rotary File System, VDW Gold Device

Journal of Dentistry, Tehran University of Medical Sciences, Tehran, Iran (2013; Vol. 10, No. 6)

✉ Corresponding author:
K. Nazarimoghadam, Department of Endodontics, Dental School, Shahed University of Medical Sciences, Tehran, Iran

kiumarz819@hotmail.com

Received: 5 July 2013
Accepted: 9 September 2013

INTRODUCTION

It is a generally accepted standard that root canal treatment procedures should be confined to within the root canal system. The cemento-dentinal junction (CDJ) is the ideal end point for a root canal preparation [1].

However, considering the CDJ as the canal terminus has its own limitations. Clinically, we cannot identify this histological structure and the extension of the cementum into the root canal is variable [2, 3]. Generally, the apical constriction (AC), which usually does not coincide with the CDJ, is a more clinically dependable and practical demarcation to use as a terminus for the canal preparation [4]. Nevertheless, a well-defined AC exists in less than half of the teeth [5]. Moreover, in those cases with an AC, the distance between the AC and anatomic apex varies [6]. As a consequence, detection of the canal terminus by traditional methods, such as radiography, still remains a challenge.

The use of new generations of electronic apex locators (EAL_s) has gained increasing acceptance in the recent years because of their high precision in determining the working length [7-10]. However, using these devices, the operator faces some limitations. As some teeth do not have a clear and reproducible reference point, alteration in the primary measured distance during instrumentation seems likely. Besides, because of parallax errors when placing the rubber stop on the crown, the accurate adjusting and repositioning of a series of files is very difficult if possible [11-13]. Using rotary nickel titanium instruments to determine the working length lead to more acute parallax errors due to a wider shaft than the primary hand file. In addition, accuracy of file positioning and the working length is affected by the changes in the insertion path as canal preparation progresses [14].

More recently, devices have been introduced that consist of an EAL combined with a rotary handpiece. These $EALH_s$ have the capability to stop or reverse the rotation of the nickel-titanium files as the estimated end point of the root canal is reached. Thus, they could eliminate the problem of maintaining working length with multiple files and the need for a clear reference point on the tooth.

Dental literature search showed a few studies assessing $EALH_s$. As sufficient evidence suggests that accurate working length determination can profoundly affect the success of root canal treatment [15], further studies to evaluate the reliability of these devices are worth pursuing. In the current study, we used an in vitro model to compare the motor-driven mode of two newly developed $EALH_s$.

MATERIALS AND METHODS

Thirty six human mandibular molar teeth were collected for this study. After cleaning, each tooth was carefully examined under a loupe (magnification ×3) to detect the presence of external cracks, apical resorption or wide-open apices that might alter the accuracy of the working length measurements. Endodontic access cavities were prepared by using high-speed diamond bur (Dentsply, Maillefer, Ballaigues, Switzerland). All present amalgam or metallic restorations were removed. The cusps were then flattened to provide reproducible reference points for working length measurements. Preflaring of the mesiobuccal (MB) canals was performed with #2 and #3 Gates-Glidden burs (Mani, Japan) [7]. Subsequently, apical patency was confirmed by inserting a size 10 K-file (Mani, Japan) until the tip was just visible at the apical foramen using ×3 magnifications. AWL was determined by subtracting 0.5 mm from the observed instrument length. The specimens were then randomly divided into two groups of 18 and were placed into individual alginate settings used to simulate the periodontium [7]. Using a blunt 27-gauge needle, the canals were irrigated with 1 ml of 1% NaOCl. The pulp chambers were dried with a cotton pellet. Then, EWL_s were determined by VDW GOLD (VDW, Munich, Germany) and Dentaport ZX (J. Morita Corp., Tokyo, Japan) in groups 1 and 2, respectively. A size 10 M_{two} .04 taper NiTi rotary file (VDW, Munich, Germany) was mounted in the handpieces. The automatic stop function of the devices was preset at line 0.5 on the panel.

After the rotary instrument was introduced into the canal and reached the predetermined level, it automatically stopped.

Subsequently, the rubber stop was adjusted to the coronal reference point and the distance from the base of the rubber stop to the file tip was measured with a digital caliper to the nearest 0.01 mm. Analysis of variance (ANOVA, 1-way) and Tukey pairwise multiple comparison intervals (0.05) were used to compare the accuracy of the two electronic devices.

RESULTS

For VDW GOLD, 61.1% of the measurements were within ± 0.5 mm and 88.9% were within ± 1 mm of the AWL. 88.9% of Dentaport ZX measurements were within ± 0.5 mm and 94.4% were within ± 1mm of the AWL. For both of the devices, there was no significant difference between AWL and EWL (p=0.466 for Dentaport ZX and p=0.283 for VDW Gold). No significant difference was found between the accuracy of the two devices in determining the WL (p=0.8).

DISCUSSION

The current *in-vitro* study was aimed to compare the accuracy of two $EALH_s$ (Dentaport ZX and VDW Gold) using a nickel-titanium rotary file. Unlike the similar previous studies in which single rooted teeth had been used, MB canals of the mandibular molars were selected for this study. Using the motor-controlled mode of the $EALH_s$, the operator may encounter some potential limitations.

If the rotating file reaches any obstruction such as packed debris, the ability of the apex locator to accurately function will be compromised [14]. Canal blockage is possible by packing of the dentin debris as the motor progressively stops. In addition, binding of the file in the irregularities of the canal will cause it to be automatically reversed or stopped. MB canal of the mandibular molars is greatly narrower, more irregular and complex compared with the single rooted teeth [16].

Under the conditions of the present study, although Dentaport ZX recorded more measurements in acceptable range compared with VDW Gold, there are no significant differences between the accuracy of the devices.

Although literature search failed to reveal any study that evaluated the accuracy of the VDW GOLD regarding Dentaport ZX, the results of the current study were in agreement with previous studies showing that Dentaport ZX and Tri-Auto-ZX (a previous version of Dentaport ZX) are safe and reliable [17,18].

Nonetheless, Sue et al. [19] reported different results in their study. They compared motor-operated Root ZX II, Apex NRG XFR, and Mini Apex Locator using 0.04 tapered NiTi rotary Profiles sized 40–20 in a crown-down manner. Once the first rotary file reached the AC, the rotary motor was automatically stopped. They showed that the devices were able to locate the AC within ±0.5mm only 50% or less of the times. This discrepancy might be attributed to the following reasons. The most important factor could be the different condition of their study as it was clinical.

Table 1. Frequency of Electronic Working Length Measurements for the Two Devices

Distance from Actual Length	Dentaport ZX		VDW Gold	
(mm)[a]	N	%	N	%
01.0 to 0.5	3	16.67	2	11.12
0.0 to 0.5	2	11.12	4	22.21
0.0	6	33.33	4	22.21
-0.0 to -0.5	6	33.33	3	16.67
-1 to - 0.5	0	0	3	16.67

a Negative value indicates measurements shorter than the AWL

Another possible explanation might be the technique of filling. Using a series of NiTi files driven by $EALH_s$, the canal may be partially plugged by debris, leading to modification of the electrical conductivity of the root canal and cross-section of the file [20, 21]. For this reason, some authors recommend recapitulation with a small diameter hand file (14). Under conditions of the current study, as the strictest clinical tolerance (± 0.5 mm) was applied, the accuracy of the motor-driven mode of Dentaport ZX (88.9%) was in the range of reported accuracy for its manual mode in previous studies [22, 23]. Therefore, in comparison to the results of previous studies, it might be inferred that even if we consider the narrowest acceptable range, the rotational mode of Dentaport ZX is reliable similar to the manual mode. On the other hand, although the accuracy of VDW Gold in ± 0.5 mm (61.1%) was less than the reported average for manual mode of new generated EAL_s, considering the clinical range of ± 1.0 mm to the foramen, the results of this study were in agreement with those obtained by other investigators for the newest EAL_s (12, 24). In an *ex vivo* study conducted by Alves et al. [25], it was mentioned that if the motor-driven mode of Tri Auto ZX was set at 1, differences in working length measurements of manual and rotational mode were not significant. As cited in previous studies, because of the lack of a well-delineated limit for canal terminus, an error tolerance of ± 1.0 mm is deemed clinically acceptable [18]. Although in this study both of the devices detected the apical end point within an acceptable range, it should be noted that many practitioners believe that a distance from the file tip to the major foramen of 0.5 mm results in over instrumentation and incorrect working length [14, 18, 24]. For this reason, some authors suggest subtracting 0.5 mm from the estimated length by the electronic device [24]. Contrary to the study performed by Gimberg et al. [20] that concluded if the apical line of the Tri Auto ZX was preset at 0.5, it would prevent over preparation of the canal, Carneiro et al. [26] found Tri-Auto-ZX to be more accurate at measuring root canal length when it is preset at 1 rather than the 0.5 value. This finding was also supported by other similar studies [27, 28]. It has been reported that a slight screwing effect of the rotary file might be a cause for longer measurements as observed with $EALH_s$ [26, 29]. This factor could be an explanation for the relatively deep penetration of a number of files inside the root canals reported in the present study. We concluded that the motor-driven mode of these devices appeared to be clinically safe, as previous studies have shown [14].

CONCLUSION

Under the condition of the current study, it may be concluded that using motor-driven mode of apex-locator- controlled handpieces such as VDW Gold and Dentaport ZX offered an accurate method for endodontic working length determination. Further studies under clinical conditions are needed to confirm these results.

REFERENCES

1- Ricucci D, Langeland K. Apical limit of root canal instrumentation and obturation, part A histological study. Int Endod J. 1998 Nov;31(6):394-409.

2- Katz A, Tamse A, Kaufman AY. Tooth length determination: a review. Oral Surg Oral Med Oral Pathol. 1991 Aug;72(2):238-42.

3- Ponce EH, Vilar Fernandez JA. The cemento-dentino-canal junction, the apical foramen, and the apical constriction: evaluation by optical microscopy. J Endod. 2003 Mar;29(3):214-9.

4- Kuttler Y. Microscopic investigation of root apexes. J Am Dent Assoc. 1955 May;50(5):544-52.

5- Dummer PM, McGinn JH, Rees DG. The position and topography of the apical canal constriction and apical foramen. Int Endod J. 1984 Oct;17(4):192-8.

6- Stein T, Corcoran JF. Anatomy of the root apex and its histologic changes with age. Oral

Surg Oral Med Oral Pathol.1990 Feb;69(2):238-42.
7- Kaufman AY, Keila S, Yoshpe M. Accuracy of a new apex locator: an in-vitro study. Int Endod J. 2002 Feb;39(2):186-92.
8- Fouad AF, Rivera EM, Krell KV. Accuracy of the Endex with variations in canal irrigants and foramen size. J Endod. 1993 Feb;19(2):63-7.
9- Frank AL, Torbinejad M. An in vivo evaluation of Endex electronic apex locator. J Endod. 1993 Apr;19(4):177-9.
10- Mayeda DL, Simon JH, Aimar DF, Finley K. In vivo measurement accuracy in vital and necrotic canals with the Endex apex locator. J Endod. 1993 Nov;19(11):545-8.
11- Plotino G, Grande NM, Brigante L, Lesti B, Somma F. Ex vivo accuracy of the three electronic apex locators: Root ZX, Elements Diagnostic Unit and Apex locator and ProPex. Int Endod J. 2006 May;39(5):408-14.
12- Fouad AF, Krell KV, McKendry DJ, Koorbusch GF, Olson RA. A clinical evaluation of five electronic root-canal length measuring instruments. J Endod. 1990 Sep;16(9):446-9.
13- Czerw RJ, Fulkerson MS, Donnelly JC. An *In-vitro* test of a simplified model to demonstrate the operation of electronic root-canal measuring devices. J Endod. 1994 Dec;20(12):605-6.
14- Barthelemy M, Gregor J, Wataha J, Bouillaguet S. Accuracy of electronic apex locater-controlled handpieces Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2009 Mar;107(3):437-44.
15- Sjogren U, Hagglund B, Sundqvist G, Wing K. Factors affecting the long-term results of endodontic treatment. J Endod. 1990 Oct;16(10):498-504.
16- Vertucci FJ. Root canal anatomy of human permanent teeth. Oral Surg Oral Med Oral Pathol. 1984 Nov;58(5):589-99.
17- Kim E, Lee SJ, Electronic apex locator. Dent Clin North Am. 2004 Jan;48(1):35-54.
18- Peters OA. Current challenges and concepts in the preparation of root canal systems: a review. J Endod. 2004 Aug;30(8):559-67.
19- 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 Jul;35(7):962-65.
20- Grimberg F, Banegas G, Chiacchio L, Zmener O. In vivo determination of root canal length: A Preliminary report a preliminary report using the Tri Auto ZX apex-locating handpiece. Int Endod J. 2002 Jul;35(7):590-3.
21- Krizaj D, Jan J, Valencic V. Modeling AC current conduction through a human tooth. Bioelectromagnetics. 2004 Apr;25(3):185-95.
22- Pagavino G, Pace R, Baccetti T. A SEM study of *in vivo* accuracy of the Root ZX electronic apex locator. J Endod. 1998 Jun;24(6):438-41.
23- Shabahang S, Goon WW, Gluskin AH. An *in vivo* evaluation of Root ZX electronic apex locator. 1996 Nov;22(11):616-8.
24- Nekoofar MH, Ghandi MM, Hayes SJ, Dummer PM. The fundamental operating principles of electronic root canal length measurement devices. Int Endod J. 2006 Aug;39(8):595-609.
25- Alves AM, Felippe MC, Felippe WT, Rocha MJ. *Ex vivo* evaluation of the capacity of the Tri Auto ZX to locate the apical foramen during root canal retreatment. Int Endo J. 2005 Oct;38(10):718-24.
26- Carneiro E, Bramante CM, Picoli F, Letra A, da Silva Neto UX, Menezes R. Accuracy of root length determination using Tri Auto ZX and ProTaper instruments: an in vitro study. J Endod. 2006 Feb;32(2):142-4.
27- Felippe WT, Felippe MC, Reyes Carmona J, Crozoé FC, Alvisi BB. *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 Jun;41(6):502-7.
28- Topuz O, Ozun O, Tinaz AC, Bodrumlu E, Gorgul G. Accuracy of of two apex-locating handpieces in detecting simulated vertical and horizontal root fractures. J Endod. 2008 Mar;34(3):310-13.
29- Uzun O, Topuz O, Tinaz AC, Alaçam T. Apical accuracy of two apex-locating handpieces in root canal retreatments of root-end resected teeth. J Endod. 2007 Dec;33(12):1444-6.