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The Effect of Long Service Life on the Accuracy of Dentaport ZX Electronic Apex Locator

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Introduction: Electronic apex locators are among the most acceptable instruments for determining root canal length**.** The present study aimed to evaluate the effect of long service life on the accuracy of the Dentaport Root ZX (DP ZX) electronic apex locator (EAL). **Materials and Methods:** In this study, fifty single-rooted freshly extracted human teeth were used. After determining the root canal length with a K-file and a dental operative microscope, the canals were measured with four separate DP ZX apex locators (two with more than 6 years of life service while two others had less than 6 years of life service). Data were analyzed by repeated ANOVA measurement. **Results:** No significant difference was found between the EALs with different years of life services (*P*=0.62). All EALs could determine root canal length with high accuracy of more than 94%. **Conclusion:** Based on the results of this *in vitro* study, the long service life had no significant impact on the accuracy of DP ZX EALs in terms of root canal length determination.

Keywords: Apex Locator; Apical Foramen; Endodontics; Root Canal Preparation; Root Canal Therapy

Introduction

For successful root canal treatment, it is essential to remove pulp remnants and necrotic tissues as well as bacteria and their by-products from the root canal space [1]. One of the important steps in endodontic practice is working length determination in order to keep root canal instrumentation inside the root canal to prevent post-operative pain and keeping irrigants and root canal obturating materials inside the root canal [2] . Several methods have been introduced for working length determination including: tactile sensation [3, 4], employing paper points [5, 6], radiography, electronic apex locators (EAL), cone-beam computed tomography (CBCT), and apical sensitivity during file penetration [7-9].

Currently, EAL and periapical radiography are two important tools for determining working length during routine root canal treatment. An important advantage of using EAL is the fact that it would decrease radiation dose during endodontic treatment by helping accurate measurement of tooth working length. Moreover, EALs are more predictable than the radiographs in determining the apical constriction since they are indicating location of the apical foramen; however, a periapical radiograph represents radiographic (anatomic) apex [10].

Root ZX EAL (J. Morita Corporation, Kyoto, Japan) is an apex locator that had been known as one of the most reliable EALs [11]. The manufacturer has declared that the service life time may affect accuracy of the device [12]. Therefore, one of the variables that may affect reliability of previous investigations might be the service life of an EAL.

Most investigations on determining working length using EALs had been focused on comparing accuracy of various brands of the device [13-16], working length determination in presence of different solutions inside the root canal space [17-20], the accuracy of the device on detecting root perforations [19, 21],

the accuracy of EAL in straight and curved root canals [22], the effect of the type and the size of root canal instruments on the accuracy of EAL [23, 24], the effect of root length [25], and the effect of root canal anatomy on EAL accuracy [26] in both primary and permanent dentition [19] and impact of apical patency on accuracy of EAL [27] and the impact of electronic devices on the accuracy of the EAL [28]. However, none of previous investigations considered the impact of long-time service as a confounding factor that may affect EAL accuracy.

The present study aims to evaluate the effect of the working life of Dentaport ZX (DP ZX; J. Morita USA, Inc., Irvine, CA, USA), as the latest version of the Root ZX EAL, on the root canal working length determination. The hypothesis was as follows: the device service life had no significant impact on the accuracy of working length estimation.

Materials and Methods

This study was performed at the Kerman Dental School. Fifty single-rooted freshly extracted human teeth with one canal were used. All teeth were examined under a dental operating microscope (Carl Zeiss Surgical GmbH, Oberkochen, Germany) and any teeth with cracks, root tip fracture, apical or lateral resorption, a curved root, or open apical foramina were excluded.

The teeth were decoronated at the cemento-enamel junction in order to have standard access and stable reference points for working length determination. The actual tooth length of each root was determined by inserting a size #10 K-file (Mani, Tochigi, Japan) into the root canal and observing it under the microscope under 25× magnification. The working length determined when the file tip reached the apical foramen. The silicon rubber stopper was positioned at the level of the reference point and the file was removed from the canal and then measured. The working length was set at 0.5 mm less than the length observed.

Each root was then fixed into a plastic bottle. The DP ZX lip clip was also fixed in the bottle so that a complete electronic circuit was established. Each bottle was filled with 0.9% normal saline as a conducting medium. Before starting the electronic root canal measurements, the cervical part of the root canals was enlarged with Gates Glidden drills #2 and #3 (Mani, Tochigi, Japan).

All measurements with the DP ZX apex locators were performed in a place free of any electronic device that generated radio waves [28]. The irrigant used was 2.5% NaOCl [17]. A #10 K-file was inserted into the root canal to determine the working length with the DP ZX apex locator. The root canal length was then determined by an experienced operator with four DP ZX devices, two older than six years (11 years) working service (serial numbers: ZJ3290, ZJ3288) while two others had lower than six years (5 years) working service (serial numbers: RK3041, WJ3174). Therefore, for each tooth, four measurements were obtained with different EALs. The practitioners who perform measurements with the devices were not aware of the device working service time.

The DP ZX was used in accordance with the manufacturer's instructions. The electrode was connected to a #10 K-type file which was then inserted into the root canal to reach just beyond the major foramen as indicated by the flashing red sign of APEX bar on the monitor of the DP ZX. The instrument was then slowly withdrawn until the monitor showed a flashing bar between "APEX" and 1 to indicate a 0.5 reading. Measurements were recorded when the instrument remained stable for at least 5 sec [29].

In order to analyze the data obtained from four apex locators, estimated length obtained from all EALs were compared to the length obtained by direct visual observation (the "gold standard").

A measurement was considered satisfactory if its difference with the AL was within ±0.05 mm from the AL. Data were analyzed by repeated ANOVA measurement. In all analyses, $P<0.05$ was considered as significant level.

Table 1. The frequency of accurate length estimation with different Dentaport ZX EAL N (%)

Device / DAL*	ZJ3290	ZJ 3288	RK3041	WJ3174
0.5 mm	47 (94)	49 (98)	48 (96)	47 (94)
1 mm	3 (6)	1 (2)	2 (4)	3 (6)

** Distance from the actual length; ZJ3290, ZJ 3288(older than 6 years electronic apex locators); RK3041, WJ3174 (lower than six years electronic apex locators*

Results

The results of the present study showed that the accuracy of working length determination among DP ZX EALs were between 94 to 98% (Table 1). Table 2 shows the mean distance between the actual length and the mean distance obtained with different devices. There was no significant difference on working length accuracy determination among the devices with more than six years life time service compared to the devices with shorter working life time ($P>0.05$).

Intra-class Correlation Coefficient (ICC) for brand newer devices were 98.5% and 97.8%, respectively. To compare the agreement between the apex locators with the dental operating microscope (DOM) which considered as the gold standard, the Bland-Altman plots have been prepared (Figure 1).

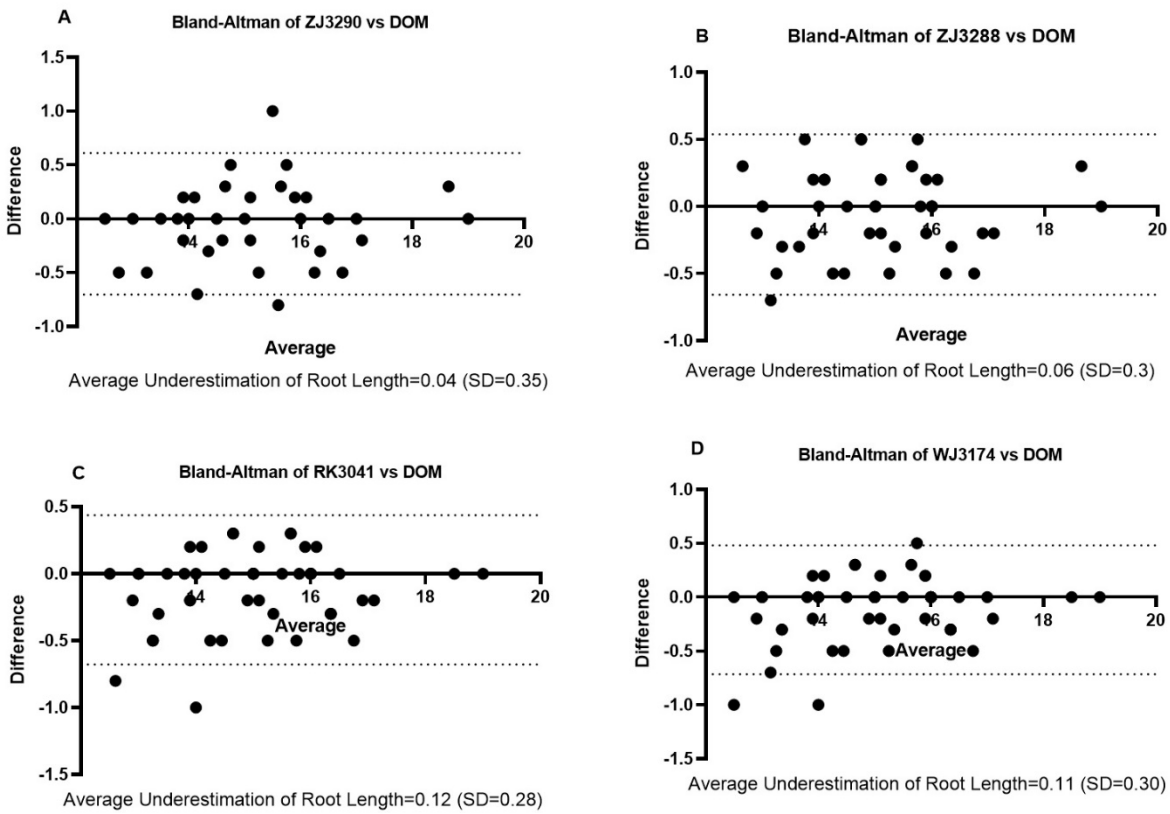

Figure 1. A-D; Bland-Altman Plot for ZJ3290T, ZJ3288T, RK3041T, WJ3174 *versus* DOM

Discussion

The results of the present study confirm our hypothesis that the service life of a DP ZX had no significant impact on the accuracy of working length determination of the device.

The Bland-Altman Plot that compared the apex locators to the microscope showed that overall the apex locators provided underestimate root length compared to the DOM (Figure 1). Comparing to the DOM, the underestimated root length measured by the newer apex locators was more frequent compared to the older apex locators; however, it was not statistically significant.

During *in vitro* evaluation of EALs, actual tooth length has been using as a gold standard [30-32]. Actual tooth length is defined by the visual observation of a file tip at the apical foramen under magnification and measurement of the distance between the reference point and the file tip.

Most studies considered measurement between ±0.5 mm precise and ±1 mm acceptable [30-32]. Results of the present study showed that a majority of measurements were precise and none of them was unacceptable. Therefore, the service life had no influence on the accuracy of DP ZX measurements.

In the present study, apical foramen has been considered as the anatomic land mark because it could be consistently located in all teeth [13, 33, 34]. Apical constriction could also be used as an anatomic landmark [35]. The apical constriction is defined as the narrowest region of the apical portion of the root canal system [36]; however, due to inflammatory resorption in necrotic teeth, it might be altered or even not found in some occasions [37, 38].

For root canal measurement using EAL, it has been suggested to use the largest file that registers a working length reading. Greater instrument size may influence EAL accuracy on determining root canal length [24, 39]. However, it has been shown that there was no significant difference among #8, #10, and #15 K-files on the accuracy of working length reading [40]. Therefore, in the present study, #10 K-file was used for actual tooth length measurement.

Table 2. Mean difference between actual length and the length obtain with different DP EALs

Device \ DAL[1]	Mean (SD)
ZJ 3290 [2]	0.233 (0.035)
ZJ 3288 [2]	0.244 (0.027)
RK 3041 [3]	0.208 (0.032)
WJ 3174 [3]	0.212 (0.035)

[1]DAL: Distance from actual length; [2] ZJ3290, ZJ 3288(older than 6 years electronic apex locators); [3] RK3041, WJ3174 (lower than six years electronic apex locators)

In the present study 2.5% NaOCl was used as an irrigant because previous investigations reported that the solution did not affect accuracy of the EAL working length estimation [17, 20, 41, 42].

During recent past decades, technologic improvements have influenced endodontic practice in terms of diagnosis, root canal preparation as well as magnification. Using EALs is a progress to decrease the number of radiographic images during endodontic treatment and to obtain more reliable working length compared to the radiography [10, 35]. From the economic standpoint, it is very important for a dental practitioner to know if the purchased device has had reliable working consistency even years after working service.

It has been shown that the number of practitioners using modern technology such as EAL has been significantly growing [43]. The results of the present study showed that EAL would be a reliable device even years following purchase.

In the present study, DP ZX with more than 6 years in service was selected as the long term working device because in the catalogue of the device, the manufacturer declared this period as the maximum service life of the device.

Conclusion

In conclusion, the result of the present *in vitro* study could not show any significant difference in working length determination when long term service DP ZX EAL compared to the recently employed devices.

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Conflict of Interest: 'None declared'.

References

1. Ng YL, Mann V, Rahbaran S, Lewsey J, Gulabivala K. Outcome of primary root canal treatment: systematic review of the literature–Part 2. Influence of clinical factors. Int Endod J. 2008;41(1):6-31.
2. 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.
3. ElAyouti A, Dima E, Löst C. A tactile method for canal length determination in teeth with open apices. Int Endod J. 2009;42(12):1090-5.
4. Subramaniam P, Konde S, Mandanna D. An in vitro comparison of root canal measurement in primary teeth. J Indian Soc Pedod Prev Dent. 2005;23(3):124.
5. Baggett F, Mackie I, Worthington H. An investigation into the measurement of the working length of immature incisor teeth requiring endodontic treatment in children. Br Dent J. 1996;181(3):96-8.
6. Marcos-Arenal JL, Rivera EM, Caplan DJ, Trope M. Evaluating the paper point technique for locating the apical foramen after canal preparation. Oral Surg Oral Med Oral Pathol Radiol. 2009;108(5):e101-e5.
7. Kim YJ, Chandler N. Determination of working length for teeth with wide or immature apices: a review. Int Endod J. 2013;46(6):483-91.
8. de Morais ALG, de Alencar AHG, de Araújo Estrela CR, Decurcio DA, Estrela C. Working length determination using cone-beam computed tomography, periapical radiography and electronic apex locator in teeth with apical periodontitis: a clinical study. Iran Endod J. 2016;11(3):164.
9. Segato AVK, Piasecki L, Nuñovero MFI, da Silva Neto UX, Westphalen VPD, Gambarini G, Carneiro E. The accuracy of a new cone-beam computed tomographic software in the preoperative working length determination *ex vivo*. J Endod. 2018;44(6):1024-9.
10. Martins JN, Marques D, Mata A, Caramês J. Clinical efficacy of electronic apex locators: systematic review. J Endod. 2014;40(6):759-77.
11. Tsesis I, Blazer T, Ben-Izhack G, Taschieri S, Del Fabbro M, Corbella S, Rosen E. The precision of electronic apex locators in working length determination: a systematic review and meta-analysis of the literature. J Endod. 2015;41(11):1818-23.
12. Gupta A, Sahai A, Aggarwal V, Mehta N, Abraham D, Jala S, Singh A. Anesthetic efficacy of primary and supplemental buccal/lingual infiltration in patients with irreversible pulpitis in human mandibular molars: a systematic review and meta-analysis. J Dent Anesth Pain Med. 2021;21(4):283.
13. Khandewal D, Ballal NV, Saraswathi MV. Comparative evaluation of accuracy of 2 electronic apex locators with conventional radiography: an *ex vivo* study. J Endod. 2015;41(2):201-4.
14. Connert T, Judenhofer M, Hülber-J M, Schell S, Mannheim J, Pichler B, Löst C, ElAyouti A. Evaluation of the accuracy of nine electronic apex locators by using Micro-CT. Int Endod J. 2018;51(2):223-32.
15. Tufenkci P, Kalaycı A. Evaluation of the accuracy of different apex locators in determining the working length during root canal retreatment. Journal of dental research, dental clinics, dental prospects. 2020;14(2):125-9.
16. Yolagiden M, Ersahan S, Suyun G, Bilgec E, Aydin C. Comparison of four electronic apex locators in detecting working length: An *ex vivo* study. The journal of contemporary dental practice. 2018;19(12):1427-33.
17. 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(8):769-74.
18. Çınar F, Üstün Y. *Ex Vivo* evaluation of the accuracy of 3 electronic apex locators in different environments: a micro-computed

tomography study. European endodontic journal. 2020;5(3):226-30.
19. Chukka RR, Bellam MD, Marukala NR, Dinapadu S, Konda NK, Nagilla J. Efficiency of an integrated apex locator in determining working length in various irrigating solutions: an *in vivo* study. Journal of pharmacy & bioallied sciences. 2020;12(Suppl 1):S410-s4.
20. Marek E, Łagocka R, Kot K, Woźniak K, Lipski M. The influence of two forms of chlorhexidine on the accuracy of contemporary electronic apex locators. BMC oral health. 2019;20(1):3.
21. Altunbaş D, Kuştarcı A, Toyoğlu M. The influence of various irrigants on the accuracy of 2 electronic apex locators in locating simulated root perforations. J Endod. 2017;43(3):439-42.
22. Saatchi M, Iravani S, Khaleghi MA, Mortaheb A. Influence of root canal curvature on the accuracy of root ZX electronic foramen locator: An *in vitro* study. Iran Endod J. 2017;12(2):173.
23. Chaudhary S, Gharti A, Adhikari B. An *in vivo* comparison of accuracy of two electronic apex locators in determining working length using stainless steel and nickel titanium files. Clin Cosmet Investig Dent. 2018;10:75.
24. Orosco FA, da Silva GF, Weckwerth PH, Lopes MTM, Garcia AM, Duarte MAH, de Moraes IG. Influence of different sized files on the accuracy of two electronic apex locators. Aust Endod J. 2018;44(3):251-4.
25. Saatchi M, Rahimi I, Khademi A, Farhad AR, Nekoofar MH, Dummer PM. Influence of tooth length on the accuracy of the Root ZX electronic apical foramen locator: an *ex vivo* study. Acta Odontol Scand. 2015;73(2):101-6.
26. Jafarzadeh H, Beyrami M, Forghani M. Evaluation of conventional radiography and an electronic apex locator in determining the working length in C-shaped canals. Iran Endod J. 2017;12(1):60.
27. Abdelsalam N, Hashem N. Impact of apical patency on accuracy of electronic apex locators: *in vitro* study. J Endod. 2020;46(4):509-14.
28. Parirokh M, Manochehrifar H, Abbott PV, Borna R, Haghdoost AA. Effect of various electronic devices on the performance of electronic apex locator. Iran Endod J. 2019;14(4):278-82.
29. Duran-Sindreu F, Stöber E, Mercadé M, Vera J, Garcia M, Bueno R, Roig M. Comparison of *in vivo* and *in vitro* readings when testing the accuracy of the Root ZX apex locator. J Endod. 2012;38(2):236-9.
30. Piasecki L, dos Reis PJ, Jussiani EI, Andrello AC. A micro–computed tomographic evaluation of the accuracy of 3 electronic ppex locators in curved canals of mandibular molars. J Endod. 2018;44(12):1872-7.
31. Cianconi L, Angotti V, Felici R, Conte G, Mancini M. Accuracy of three electronic apex locators compared with digital radiography: an *ex vivo* study. J Endod. 2010;36(12):2003-7.
32. Piasecki L, Carneiro E, da Silva Neto UX, Westphalen VPD, Brandão CG, Gambarini G, Azim AA. 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.
33. Stöber EK, de Ribot J, Mercadé M, Vera J, Bueno R, Roig M, Duran-Sindreu F. Evaluation of the raypex 5 and the mini apex locator: an *in vivo* study. J Endod. 2011;37(10):1349-52.
34. Yılmaz F, Kamburoğlu K, Şenel B. Endodontic working length measurement using cone-beam computed tomographic images obtained at different voxel sizes and field of views, periapical radiography, and apex locator: a comparative ex vivo study. J Endod. 2017;43(1):152-6.
35. Wrbas K, Ziegler A, Altenburger M, Schirrmeister J. In vivo comparison of working length determination with two electronic apex locators. Int Endod J. 2007;40(2):133-8.
36. Dummer PM, Mcginn JH, Rees DG. The position and topography of the apical canal constriction and apical foramen. Int Endod J. 1984;17(4):192-8.
37. Pommer O, Stamm O, Attin T. Influence of the canal contents on the electrical assisted determination of the length of root canals. J Endod. 2002;28(2):83-5.
38. Bilaiya S, Patni PM, Jain P, Pandey SH, Raghuwanshi S, Bagulkar B. Comparative evaluation of accuracy of Ipex, Root Zx Mini, and epex Pro Apex Locators in teeth with artificially created root perforations in presence of various intracanal irrigants. European endodontic journal. 2020;5(1):6-9.
39. Jadhav GR, Mittal P, Patil V, Kandekar P, Kulkarni A, Shinde S, Syed S, Elahi S. Accuracy of different apex locators in teeth with simulated apical root resorption: an *in vitro* study. Folia medica. 2018;60(4):624-31.
40. Briseño-Marroquín B, Frajlich S, Goldberg F, Willershausen B. Influence of instrument size on the accuracy of different apex locators: an in vitro study. J Endod. 2008;34(6):698-702.
41. Dinapadu S, Pasari S, Admala SR, Marukala NR, Gurram S, Peddi R. Accuracy of electronic apex locator in enlarged root canals with different root canal irrigants: an in vitro study. The journal of contemporary dental practice. 2013;14(4):649.
42. Bolbolian M, Golchin S, Faegh S. *In vitro* evaluation of the accuracy of the Root Zx in the presence of Naocl 2.5% and Chlorhexidine 0.2. J Clin Exp Dent. 2018;10(11):e1054-e7.
43. Markvart M, Fransson H, EndoReCo, Bjørndal L. Ten-year follow-up on adoption of endodontic technology and clinical guidelines amongst Danish general dental practitioners. Acta Odontol Scand. 2018;76(7):515-9.

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