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An *In-vitro* Evaluation of Auto Apical Reverse Motion of Tri Auto ZX at Working Length Determined by Dentaport Root ZX

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ABSTRACT

Objective: *To evaluate the auto apical reverse motion of Tri Auto ZX at working length determined by Dentaport Root ZX.* ***Study design:*** *Cross-sectional design.* ***Place and duration of study:*** *Department of Operative Dentistry, Islamic International Dental College, and the duration of study was 6 months.* ***Materials and methods:*** *Total 72 extracted teeth were used in the present study and standard access cavities were prepared in all the teeth. For in vitro working of Dentaport Root ZX and Tri Auto ZX an apparatus was designed which used normal saline as the conducting medium to ensure free movement of ions between electrodes of electronic apex locator (EAL). Working length was measured electronically using Dentaport Root ZX and noted as Electronic length (EL). The canals were then prepared using Protpaer files till F2 using Tri Auto ZX and the length at which it starts auto apical revere motion (AAR) was noted as AAR.* ***Results:*** *EL showed a mean of 14.69 ± 1.137 mm and SD of 1.137. Measurement at which Tri Auto ZX started its AAR motion showed that the minimum length of canal was 12.5 mm and maximum length was 17.5 mm with a mean of 14.687 ± 1.089 and SD of 1.087. The difference of root canal length measurements taken by EL and AAR motion of Tri Auto ZX showed a minimum difference of -1.5 mm and a maximum of 1 mm with mean difference of -0.014 ± 0.4819 mm. Out of 72 extracted teeth that were used in the present study the difference between EL and AAR was insignificant ($p<0.05$).* ***Conclusion:*** *In this study it was also established that not only Root ZX is capable of correct determination of the working length but its canal preparation module i.e. Tri Auto ZX is also capable of preparing the canal at the length determined by Root ZX.*

Keywords: Endodontics, Working length, Electronic apex locators, Auto apical reverse, Dentaport Root ZX, Tri Auto ZX

INTRODUCTION

Root canal treatment is considered to be an ideal option for treating the necrotized tooth, tooth with irreversible pulpitis and traumatized teeth with pulpal exposure. Irrespective of the reasons for undergoing it, endodontic therapy is regarded as a specialized procedure which not only requires complete knowledge of the subject but an appropriate armamentarium as well [1-3].

Determining the apical limit of canal preparation or determination of the working length, which is one of the important aspects of root canal treatment, has always been a challenge for all endodontist. Optimal rates of healing occur when instrumentation and filling are contained within the region of apical constriction.

Traditional methods for establishing working lengths such as radiographs, anatomical averages of canal length, tactile sensation in both open and closed apices and moisture on a paper point have their limitations. Radiographs have many disadvantages when it comes to working length determination.

The development of Electronic apex locators (EALs) has helped in making the assessment of working length more accurate and predictable [4,5]. EALs have proved their efficiency in primary molars with difficult canal anatomy [6,7],

in the presence of different irrigants within the canal [8-10], apical periodontitis [11], defibrillators [12], in root canals with large periapical lesion or intracanal exudate [13] , in root canals with large apical foramen and in the presence of different solvents [14,15].

This study will be testing the ability of Tri Auto ZX for auto-reversing at working length determined by Dentaport Root ZX. Many studies have been conducted in this part of the world to assess the ability of Dentaport Root ZX for correct working length determination however very few of them tested Dentaport Root ZX in combination with Tri Auto ZX for its ability to auto apical reverse at the canal terminus [16-18].

METHODOLOGY

Approval for this study from the ethical committee of Islamic International Dental Hospital was obtained. The study was conducted on 72 extracted maxillary and mandibular anterior teeth with single straight canal. Teeth with completely formed roots with no previous attempt for endodontic therapy were included in the present study. Teeth with curved, resorbed roots, roots with open apices and previous endodontic therapy, calcified canals having pulp stones were excluded.

After obtaining informed written consent from the patients, teeth that could not be saved due to periodontal, orthodontic and/or prosthetic reasons were extracted. Every tooth was labeled with a number from 1-72 and to eliminate operator bias. Only one length was taken at a time so that the previously noted length was not known. The selected teeth were stored in 10% formalin and rinsed in saline solution before use. Incisal edges of all the teeth were reduced to produce a regular, flat reference point in such a way that each tooth was measured in a range of 13 mm to 18 mm in length.

Data Collection

Standard access cavities were prepared. A special apparatus was designed for *in vitro* working of Dentaport Root ZX. A plastic container was filled with saline-soaked sponge. This sponge was used to support another perforated small plastic container and the tooth was mounted in the lid of this container at the CDJ so that its root was completely submerged in the solution.

The working length of the same tooth was then noted with the help of Dentaport Root ZX. Apical line indicator on the LED of the apex locator was adjusted at 0.5 positions. The stopper was adjusted against the crown of the tooth as reference point and the length was noted as Electronic length (EL) from tip of the file till the stopper with the help of millimeter-scale in millimeters. To test the auto apical reverse function of Dentaport Tri Auto ZX the root canals were instrumented with NiTi rotary files, Protaper (Dentsply Maillefer). The files were used in a sequence recommended by the manufacturer i.e. starting from S1 and ending at F2 file. The stopper of the F2 file was adjusted against the same reference point used for correct working determination at a point when F2 file started auto-reversing. This length of F2 file from the tip till the stopper was recorded with the help millimeter-scale as AAR. The difference between EL and AAR was also noted which received a negative sign when EL is more than AAR and vice versa.

All the data was entered and analyzed using the Statistical Package for Social Sciences (SPSS version 10). Descriptive statistics were used. Mean+standard deviation was calculated for root canal length measurement (in millimeters) by electronic apex locator and auto apical reverse at that length. Independent sample t-test was applied to compare means of different qualitative variables. The $p<0.05$ was taken as statistically significant.

RESULTS

The root canal length measured by Dentaport Root ZX i.e. EL showed the minimum length of 12 mm and maximum length of 18 mm with mean length of 14.69 mm and standard deviation of 1.137 mm (Table 1).

Table 1 Distribution of root canal length measured by EAL (EL)

Variables	n	Minimum	Maximum	Mean	Std. Deviation
EL (mm)	72	12	18	14.69	1.137

Similarly, the measurement at which Tri Auto ZX started its AAR motion showed that the minimum length is 12.5 mm and maximum length is 17.5 mm with a mean of 14.687 ± 1.089 (Table 2).

Table 2 Distribution of lengths at which AAR motion starts

Variables	n	Minimum	Maximum	Mean	Std. Deviation
AAR (mm)	72	12.5	17.5	14.687	1.0891

The difference of root canal length measurements taken by EL and AAR motion of Tri Auto ZX showed a minimum difference of -1.5 and a maximum of 1 mm with a mean difference of -0.014 ± 0.4819 mm. This small difference between the 2 measurements showed that the values of these 2 measurements were close to each other but a tendency towards higher values with AAR was observed as given in Table 3.

Table 3 Distribution of the difference between EL and AAR

Variables	n	Minimum	Maximum	Mean	Std. Deviation
EL-AAR	72	-1.5	1	-0.014	0.4819

The distribution of ability of Tri Auto ZX to start AAR motion at EL showed that in 61 (84.72%) teeth it was able to start AAR motion at the same level as of EL as shown in Figure 1.

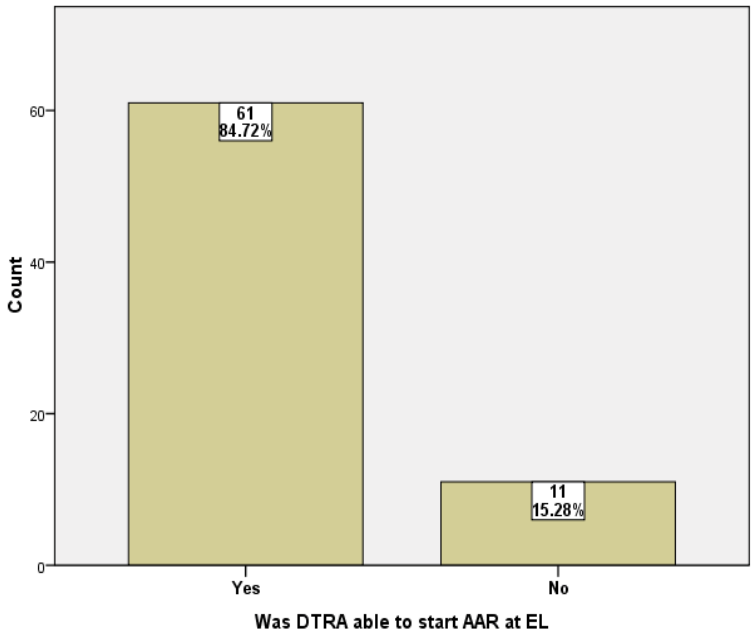

Figure 1 Distribution of ability of Dentaport Tri Auto ZX to start AAR at EL

Comparison of root canal length measured by EL and length at which AAR motion of Tri Auto ZX started revealed no statistically significant difference between the 2 (14.6875 ± 1.1366 vs. 14.6875 ± 1.0891, p>0.05) by EL and AAR methods as given in Table 4.

Table 4 Comparison of root canal length (mm) measured by EL and AAR

Variables	Method	n	Mean	Std. Deviation	p-value
Root Canal Length (mm)	EL	72	14.6875	1.1366	1
	AAR	72	14.6875	1.0891	

The difference of root canal length measurements taken by EL and AAR motion of Tri Auto ZX showed a minimum difference of -1.5 and a maximum of 1 mm with a mean difference of -0.014 ± 0.4819 mm. This small difference between the 2 measurements showed that the values of these two measurements were close to each other but a tendency towards higher values with AAR was observed (Table 5).

Table 5 Distribution of the difference between EL and AAR

V	n	Minimum	Maximum	Mean	Std. Deviation
EL-AAR	72	-1.5	1	-0.014	0.4819

DISCUSSION

The present study was conducted on 72 extracted maxillary and mandibular anterior teeth. Comparisons with other studies in terms of sample size revealed that in studies conducted by Barthelemy, et al., the sample size was 45, 24, 65 and 60 extracted teeth respectively with a mean sample size of 48.5 per study. EALs have proven accuracy in determining the working length under different clinical conditions and working environments [19-25].

In the present study for eliminating the variable of tooth length and to obtain a flat reference point, the incisal surfaces of all the teeth were prepared so that every tooth should measure between a range of 13-18 mm. The electronic length (EL) was measured with the apical line indicator on the LED of the EAL so adjusted to detect the major foramen.

The difference of ± 0.5 mm was considered as negligible to accommodate the following variations that can occur during the working length determination:

- Accurate adjustment of the rubber stop along with the reference point
- Accurate adjustment of the length determining file along the ruler
- Minor errors that may or may not be present in the ruler that is used for measuring the file length

Canals were prepared using ProTaper NiTi file system according to the manufactures instructions i.e. starting from the SX file and ending at F2 file. In this study, no significant difference was found when AAR motion of Root ZX was compared with DL and EL. Hence the null hypothesis for this study that Dentaport Tri Auto ZX starts AAR motion at the working length determined by Root ZX was proved to be right. However, the AAR motion of the EAL controlled handpieces is dependent on many factors. The setting on the LED of EAL is one of them. The apex line of LED of EAL can be adjusted at 0.5, 1 and 2 positions for the determination of apical foramen. According to manufacturer these measurements that are shown on the LED of the EAL do not represent correct distances from the apical foramen in millimeters. In an *in vitro* study conducted on distobuccal roots of the maxillary molars by Carneiro [25], he determined the accuracy of root canal length determination by Tri Auto ZX and ProTaper instruments. He divided the roots into 2 groups. In group 1 the AAR motion of Tri Auto ZX was set on position I of LED of EAL and for group II the AAR motion of Tri Auto ZX was set on position 2 of LED of EAL. Carneiro found that the mean difference between the distance obtained between the tip of the instrument and apical foramen and the present distances in Tri Auto ZX was 0.331 mm for group I and 0.616 for group II which proved the manufacturer's claim that the measurements on the LED of EAL are not true measurements in millimeters.

Another study conducted by Kobayashi in which he studied all the properties of Tri Auto ZX i.e. auto-start and stop mechanism, auto apical reverse mechanism and auto torque reverse mechanism [26]. He found that all the function of Tri Auto ZX functions normally but recommended an improvement in the properties of NiTi files so that their breakage can be avoided.

In this study, 5 teeth (6.944%) showed that the AAR motion of Tri Auto ZX started at a length that was short of the length determined by EAL (EL) by a mean distance of 1.1 mm. The greatest distance at which the AAR motion starts short of EL was 1.5 mm. However Felippe found it to be 24.615%. In the study conducted by Grimberg out of 25 teeth AAR motion started short of length that was determined by EAL in only one tooth by only 0.5 mm which was considered to be negligible for the study [27,28].

In 61 teeth (84.72%) the AAR motion of Tri Auto ZX started at the same length that was determined by EAL (EL). However, Felippe found it to be 64.615% and Jakobson found it to be 58.33%. Another study was conducted *in vivo* to evaluate auto apical reverse function of Root ZX II [29,30].

The results of this study differ from the one that was conducted by Grimberg. He conducted an *in vivo* study on 25 human maxillary incisor and canine teeth scheduled for extraction. Like this study, Grimberg also adjusted the apical line position on the LED of EAL at 0.5 both for the determination of the working length by Root ZX and AAR motion of Tri Auto ZX at this working length and showed 100% coincident with the length at which the AAR motion of Tri

Auto ZX started. After *in vivo* determination of these lengths he extracted the teeth and then took direct length by the same method used in this study. This study by Grimberg also proved another thing that the working of Tri Auto ZX *in vivo* conditions is better than *in vitro* conditions.

In 6 teeth (8.333%) the AAR motion of Tri Auto ZX started after the length that was determined by EAL (EL) by a mean distance of 1 mm. The greatest distance at which the AAR motion starts after EL was 1 mm. However, Felippe found it to be 9.230% with the greatest distance at which the AAR motion starts after EL as 2 mm. In the study conducted by Grimberg out of 25 teeth AAR motion started after the length that was determined by EAL in only 14 teeth by only 0.5 mm, which was considered to be negligible for the study.

In an *in vitro* study conducted on 45 single-rooted human teeth by Barthelemy, 3 EALs and their respective handpieces i.e. Dentaport Root ZX, Endomaster, and XSmart Dual were compared for their accuracy in root canal length determination and it's preparation by the respective handpiece at the same length [31]. He found that the average distance between the tip of the file and the major foramen was 0.52 mm for XSmart Dual, 0.24 mm for Endomaster and 0.18 mm for Dentaport Root ZX. Therefore Dentaport Root ZX was found to be better in functioning than the fourth-generation X-Smart dual. However, when endodontic handpieces were tested in combination with EAL the XSmart Dual reported the longest average working length i.e. 0.13 mm ahead of the major foramen. In case of Tri Auto ZX it was found to be 0.4 mm short of the major foramen and Endomaster proved to be the most accurate one with the distance of only 0.24 mm form the major foramen. Various studies have also been conducted to test different endodontic handpieces integrated with electronic apex locators [32,33].

CONCLUSION

In this study, it was also established that not only Root ZX is capable of correct determination of the working length but its canal preparation module i.e. Tri Auto ZX is also capable of preparing the canal at the length determined by Root ZX. However, the fact that in some cases the possibility of over and under preparation still exists which cannot be overlooked. Therefore, it is highly recommended to closely monitor and adjust the stoppers according to the pre-determined working length so that over and under preparation of the canal can be avoided.

DECLARATIONS

Conflict of Interest

The author declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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