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An In Vitro Evaluation of the Elements Apex Locator Using the Endo Q System

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AN IN VITRO EVALUATION OF THE ELEMENTS APEX LOCATOR USING THE ENDO Q SYSTEM

A Thesis submitted in partial fulfillment of the requirements for the degree of Master of Science at Virginia Commonwealth University.

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Abstract

AN IN VITRO EVALUATION OF THE ELEMENTS APEX LOCATOR

USING THE ENDO Q SYSTEM

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The objective of this study was two-fold: 1) to determine the accuracy of the Elements Apex Locator and 2) to compare the accuracy of the alginate and Endo Q models as in-vitro apex locator testing devices. Twenty teeth were decoronated at the CEJ and triplicate measurements were made using the Elements Apex Locator. All measurements were made to the apex reading of the apex locator. True length was established by visualizing the file tip at the apex with a dental operating microscope. Measurements were then taken with the teeth mounted in an alginate model and then in the Endo Q model. The two models were compared using a repeated-measure ANOVA. Statistically significant

differences occurred between the alginate and Endo Q models. The results showed that in 95% (n=19) of the cases, an accurate location to within ± 0.5 mm of the apical foramen was obtained with the Endo Q model and 55% (n=11) with the alginate model. With a ± 1.0 mm tolerance level, an accuracy of 95% (n=19) was found with the use of the alginate model. In conclusion, it seems that the Endo Q system was more suitable for testing the electronic apex locator than the alginate model. The Elements Apex Locator with the use of the Endo Q model was highly accurate in locating to within ± 0.5 mm of the apical foramen (Mean deviation = .17 mm).

Introduction

In 1942, Suzuki (1) determined the electrical resistance between an instrument in the root canal and an electrode applied to the oral mucous membrane to be constant. Twenty years later, Sunada (2) developed an electronic method that could measure the length of the canal according to this principle. First generation electronic apex locators (EAL) used direct current and the known constant resistance as a basis for working length determination. Second generation EALs used a single frequency alternating current (AC) and measured changes in impedance. Third generation EALs use multiple AC frequencies that monitors change in impedance. Recently, Sybron Endo has developed the Elements Apex Locator a fourth generation electronic apex locator. This unit uses multiple frequencies, but breaks impedance down into resistance and capacitance and measures those directly and independently during use.

There have been many in vitro models used to test the accuracy of electronic apex locators. Aurelio et al. (3) first suggested a model in 1983 that was found to accurately simulate the clinical setting. This model consisted of polystyrene culture tubes containing agar in phosphate-buffered saline. Donnelly (4) in 1993 substituted sugar-free Jell-O and saline for water, and plastic specimen cups. Others have used alginate as a method to test electronic apex locators (5-6).

An apex locator training device called the Endo Q (Acadental, Mission, KS) has been developed by Acadental. This device allows students to mount their extracted teeth

into a small box with materials developed to simulate the periodontal ligament of a tooth. To date there have been no studies published that test the accuracy of the Elements Apex Locator with the use of the Endo Q system. Therefore, the purpose of this study was two-fold: 1) to determine the accuracy of the Elements Apex Locator and 2) to compare the accuracy of the alginate and Endo Q models as in vitro apex locator testing devices.

Material and Methods

A group of twenty single rooted and single canal teeth with mature root apices and patent root canals were used. Extracted teeth were obtained and immediately placed into a solution of formalin. They were kept in this solution until needed. Each tooth was decoronated at the cemento-enamel junction to provide a flat horizontal surface for measurement purposes. The true length was determined by using a #15 stainless steel Flex-o-file (Dentsply/Mallefer, Tulsa, OK) placed into the root canal until the tip of the file reached the plane of the major diameter of the foramen as defined by Kuttler (7). A dental operating microscope (Global, St. Louis, MO) at the 1.0 step was used to view the file tip. The file length was determined by placing a silicone stopper flush to the flat horizontal coronal surface of the root when the file tip was placed to the level of the major foramen. The length of the file was then read using a millimeter digital caliper with a measurement accuracy of .01mm. Root canal measurements were made to the nearest .01mm. This measurement was repeated three times, the average of the three measurements was considered the true measurement to be used for statistical analysis and comparison purposes. Each tooth was then mounted in an alginate model as described by McDonald (8). The manufacturers recommended operating procedures for the Elements Apex Locator (Sybron Endo, Orange, Ca) were used. All measurements were to the "apex"

designation on the Elements unit or the apex location as visualized with the dental operating microscope.

After EAL measurements were recorded in triplicate, the teeth were removed from the alginate system with the use of a #557 fissure bur. After removal a ½ inch long piece of 3/8 inch tubing was placed over the apical portion of each root. The open portion of the tubing was then filled with the periodontal ligament simulating paste. The Endo Q-box was then placed into an oven preheated to 150° for 5 minutes. The Q-Box was then removed and the grounding plate or Q-link was inserted into the slot at the base of the Q-Box. A hole was then created with a mirror handle and the teeth were fit in the space. The fixing paste to be used to secure the teeth was then mixed and adapted around the teeth so that the level of material was flush with the top of the holder. The Endo Q with tooth was then allowed to cool for thirty minutes. Measurements were then taken in triplicate with the Elements Apex Locator to the "apex" designation.

Results

Twenty teeth were measured in triplicate using three measurement systems. The true root canal length was compared to the alginate and the Endo Q measurements. The three measurement systems were compared using a repeated-measure ANOVA. The results showed that the three measurement systems were significantly different ($F(2, 120) = 127$, p-value < .0001). The three group means were each significantly different from one another with the following ordering: Alginate > EndoQ > True. Note, however, that this result was not consistent from tooth to tooth ($F(38, 120) = 16$, $p > .0001$). In table 4 the means for each tooth and measurement system are shown. Next, comparisons between the measurement systems are shown separately for each of the 20 teeth. In the columns of p-values, the first value shows the overall test result for comparing the three measurements systems. If this p-value is significant (< 0.05), then the Bonferroni-adjusted p-value is shown for the three paired comparisons. The last column shows the means that are significantly different.

The most common result (six teeth out of 20) was that the three measurement systems were not significantly different. Next most common (five teeth out of 20) was the predominant ordering (Alginate>Endo Q>True). In three teeth (#4, #13, #15) the test indicated that

Alginate>Endo Q and Alginate>True but that Endo Q and True were not significantly different. There were other patterns as well.

Additionally, each of the two test-systems was compared to the true measurement to ascertain whether there was a trend between the amount of error and the true root length. In Figure 1, a reference line is shown at zero to indicate no measurement error and a trend line is shown to illustrate the relationship between the alginate error (the difference between the alginate measurement and the true measurement) and the true root length. As may be seen, the trend is not significant (p-value = .7). In figure 2, a comparable figure shows the relationship between Endo-Q error and true root length. Here, the relationship is only marginally significant (p-value = 0.0994).

The results showed that in 95% (n=19) of the cases, an accurate location to within $\pm$ 0.5 mm of the apical foramen was obtained with the Endo Q model and 55% (n=11) with the alginate model. With a $\pm$ 1.0 mm tolerance level, an accuracy of 95% (n=19) was found with both the Endo Q and the alginate model.

	Length			p-values				
Tooth	True	Alginate	Endo Q	difference	A = E?	A = T?	E = T?	Order
9	14.67	15.64	15.05	<.0001	<.0001	<.0001	0.0015	A>E>T
8	15.44	15.64	15.24	0.0011	0.0006	0.1638	0.2016	A>E
4	15.52	16.80	15.76	<.0001	<.0001	<.0001	0.0843	A>E, A>T
5	15.90	15.58	15.78	0.0099	0.1758	0.0081	0.7473	T>A
3	16.11	15.82	16.08	0.0140	0.0483	0.0243	1.0000	E>T>A
13	16.33	17.05	16.46	<.0001	<.0001	<.0001	0.7473	A>E, A>T
1	16.54	16.49	16.42	0.5482				
17	16.93	17.29	17.07	0.0043	0.1230	0.0033	0.6054	A>T
20	16.97	17.06	16.90	0.3377				
10	17.02	16.94	16.93	0.6683				
11	17.43	18.01	17.47	<.0001	<.0001	<.0001	<.0001	A>E>T
12	17.47	17.71	17.54	0.0840				
14	17.56	18.38	17.60	<.0001	<.0001	<.0001	<.0001	A>E>T
15	17.70	18.57	17.88	<.0001	<.0001	<.0001	0.2991	A>E, A>T
2	17.96	18.47	18.25	<.0001	0.1230	0.0000	0.0222	A>T, E>T
19	18.10	18.12	18.23	0.4046				
18	18.15	18.38	18.21	0.0921				
6	18.29	18.95	18.64	<.0001	0.0156	0.0000	0.0036	A>E>T
7	18.73	19.37	20.40	<.0001	<.0001	<.0001	<.0001	A>E>T
16	20.78	20.92	21.11	0.0106	0.2631	0.5427	0.0081	E>T>A
all	17.18	17.56	17.35	<.0001	<.0001	<.0001	<.0001	A>E>T

Table 1. Comparisons Between the Three Measurement Systems

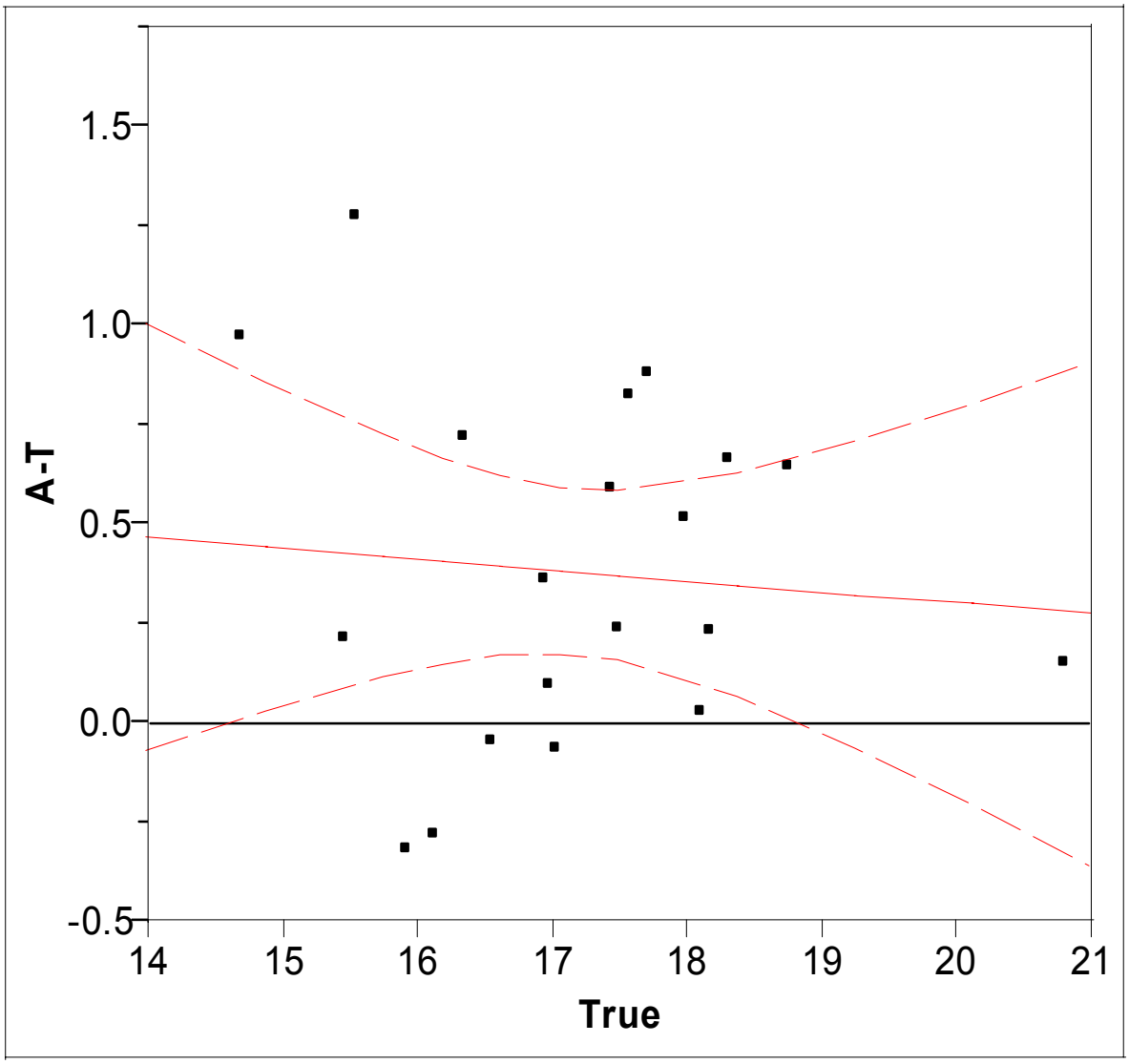

FIG 1. Relationship between the Alginate Error and True Root Length

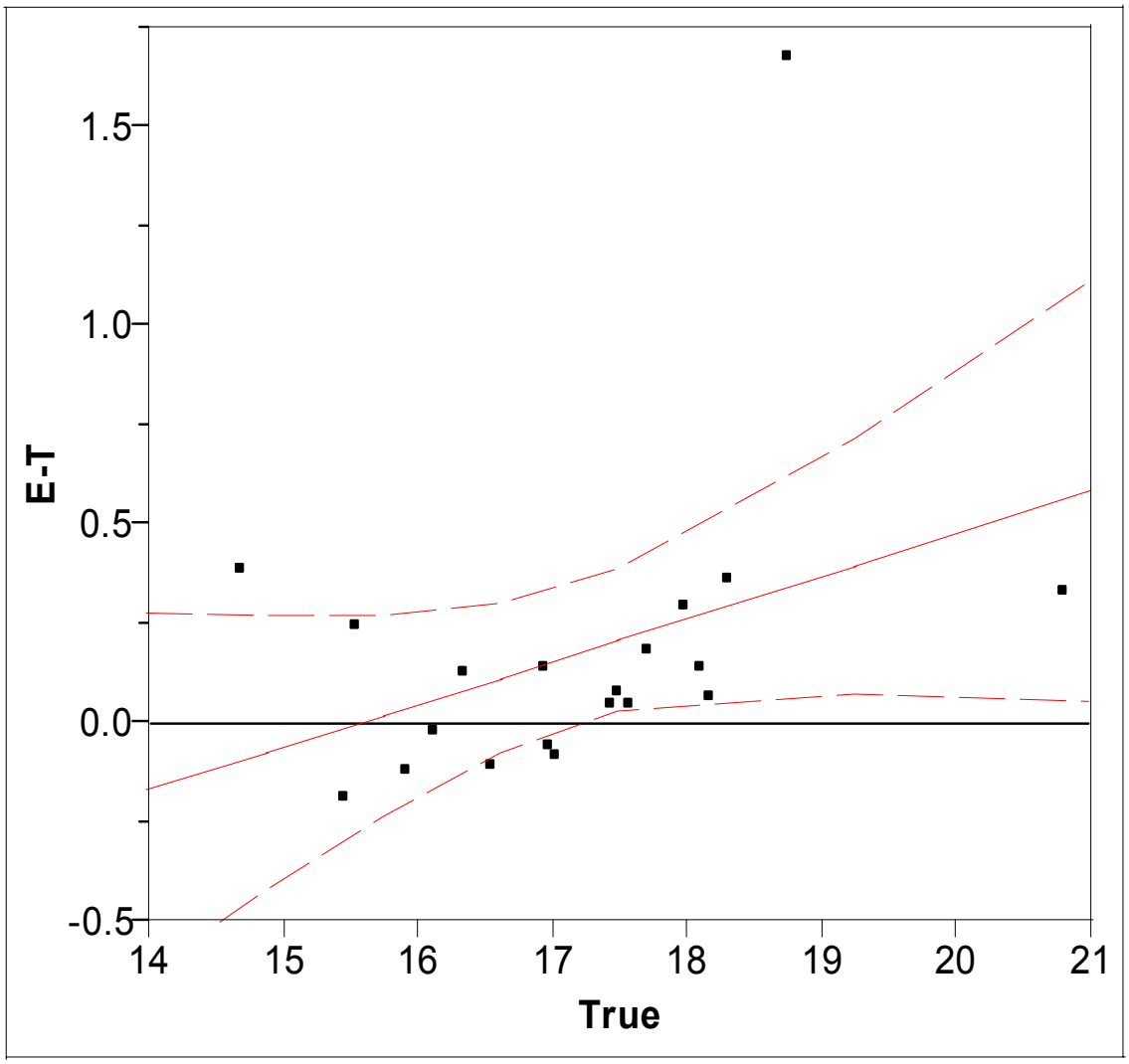

FIG 2. Relationship between the Endo Q Error and True Root Length

Discussion

Kuttler (7) and Green (9) have shown that the apex coincides with the anatomical foramen no more than 50% of the time. This limits the usefulness of radiographs, even if the quality is excellent (10). An excellent adjunct, therefore, is the use of an electronic apex locator. The $\pm$ 0.5mm to the apical foramen range has been considered as the strictest acceptable range (11,12). Thus, measurements attained within this tolerance are considered highly accurate. On the other hand, root canals do not always end with an apical constriction, a clear minor and major diameter or an apical foramen at the exact base of the cemental zone. This is why some authors prefer the $\pm$ 1.0 mm range as the acceptable range (13).

Studies indicate that the electrical resistance between the oral mucous membranes and the periodontium are equal. Studies also indicate that the resistance values between the two tissues are 6.5 ohms. According to the manufacturer the PDL paste with its pro-component and formula will create the resistance at 6.5 ohms between the PDL paste (PDL) and Q-link (lip). This could account for the improved accuracy of the endo Q over the alginate.

Although the alginate system is easy to use and relatively inexpensive compared to the Endo Q system, it quickly dries making it difficult to use long term. The Endo Q system takes more time to mount, but is still relatively easy to use. It does require a

heating device to heat up the Q-box, but provides much better stability of the tooth than the alginate. It can also be stored and used for a longer period of time without drying or cracking and provides realistic radiographic trabecular bone appearance.

The fourth generation Elements unit breaks impedance down into resistance and capacitance, and measures those directly and independently during use. This was done to help eliminate erroneous readings due to different combinations of these properties, which provide the same impedance reading. The Elements unit does not make any calculations internally as the third generation units do. Instead all combinations of capacitance and resistance relating to locations within the canal are calculated in advance and loaded into a matrix database within the unit. This decreases processing time as the unit only has to look up the information rather than going through a lengthy calculation. The result is that more data points can be averaged for each refresh of the display, which makes the displayed information much more stable. This is said to limit "jumpy or erratic readings on the display.

The Elements unit has an optional vitality scanner built in and a satellite display that can be clipped to the patient bib, instrument tray or microscope. At the time of data collection the unit could only be connected through the satellite system, since then an adapter now allows direct connection with the unit. The display has an apex designation and as the file is advanced down the canal a circle appears on the bottom left corner of the display. At .5mm the circular symbol will be complete and rotate.

In Conclusion, the results show the Endo Q system to be more suitable for testing the electronic apex locator than the alginate model. The Elements Apex Locator with the

use of the Endo Q model was highly accurate in locating to within +/- 0.5mm of the apical foramen.

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Appendix A

1	16.53	16.56	16.53
2	17.97	17.95	17.97
3	16.10	16.12	16.10
4	15.44	15.55	15.58
5	15.89	15.88	15.94
6	18.57	17.89	18.41
7	18.69	18.73	18.77
8	15.50	15.41	15.40
9	14.75	14.65	14.62
10	17.56	16.73	16.76
11	17.45	17.41	17.42
12	17.46	17.26	17.70
13	16.24	16.50	16.26
14	17.62	17.48	17.58
15	17.64	17.80	17.66
16	20.89	20.54	20.91
17	16.99	16.97	16.84
18	18.12	18.27	18.06
19	18.21	18.10	17.98
20	16.96	16.96	16.98

True Measurements in Triplicate.

Appendix B

1	19.45	19.54	19.48
2	18.45	18.45	18.52
3	15.80	15.86	15.80
4	16.16	17.12	17.11
5	15.58	15.57	15.58
6	19.12	18.86	18.86
7	19.34	19.42	19.35
8	15.64	15.64	15.65
9	15.63	15.66	15.63
10	16.98	16.98	16.87
11	18.00	18.02	18.01
12	17.76	17.74	17.62
13	17.05	17.05	17.05
14	18.35	18.35	18.44
15	18.57	18.54	18.61
16	20.90	20.94	20.93
17	17.27	17.27	17.33
18	18.35	18.37	18.41
19	18.12	18.10	18.13
20	18.37	18.31	18.34

Alginate Measurements in Triplicate

1	16.58	16.35	16.34
2	18.52	18.11	18.13
3	16.17	16.04	16.03
4	15.87	15.72	15.69
5	15.74	15.82	15.78
6	18.64	18.75	18.54
7	20.42	20.37	20.41
8	15.11	15.33	15.28
9	15.04	15.02	15.10
10	16.83	16.88	17.07
11	17.48	17.47	17.45
12	17.54	17.57	17.52
13	16.47	16.52	16.38
14	17.59	17.62	17.59
15	17.91	17.84	17.88
16	21.07	21.18	21.07
17	17.04	17.10	17.07
18	18.24	18.21	18.18
19	18.27	18.18	18.24
20	16.87	16.91	16.93

Endo Q Measurements in Triplicate

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