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Comparative Evaluation of Accuracy of two Different Electronic Apex Locators In Presence of Various Herbal Irrigating Solutions : An in Vitro Study.

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Abstract
Objectives*: The aim of this study was to compare the efficacy of two electronic apex locators in presence of herbal irrigants after cleansing and shaping of the root canals .*
Materials and methods: *Sixty five extracted human permanent single rooted teeth with mature apices were selected. Electronic working length was measured following manufacturers instruction after access opening and then before the bio mechanical preparation and after the preparation with Root ZX mini and Propex PIXI respectively using Tulsi, Turmeric and Green Tea extract. The difference between electronic length and actual length was calculated.*
Statistical analysis: *The data were statistically analyzed using ANOVA and paired t-test at 0.05 level of significance.*
Results: *There was no statistical difference recorded in the measurements of both the apex locators. Although there was no statistical difference between all the herbal irrigants but some variation had been seen with Tulsi solution.*
Keywords: *Apex locator, Tulsi, Turmeric, Green Tea, Working length.*

I. Introduction

In endodontic therapy, cleansing, shaping, and obturation of the root canal system cannot be accomplished perfectly unless the working length is determined precisely. [1] Working length is the distance from a coronal reference point to a point at which the canal preparation and obturation should terminate. [2] It is generally accepted that root canal procedures should be limited to the confines of the root canal system for which an accurate working length is of paramount importance. [3]

A wide spectrum of synthetic antimicrobial agents, like sodium hypochlorite and chlorhexidine etc., are being used over the years as endodontic irrigants. As because of their increased antibiotic resistance to these antimicrobial agents, toxic and harmful side effects of few common antibacterial agents, there is a requirement for alternative agents which are affordable, non-toxic and effective in the market.It is also found that natural plant extracts can also be used as effective endodontic irrigants. [4] The ideal properties of a root canal irrigant are: it should be systemically nontoxic, should not harm the periodontal tissues, should not cause anaphylaxis, possess a broad antimicrobial spectrum, should be capable of dissolving necrotic pulp tissue, inactivating endotoxins, and either preventing the formation of a smear layer or dissolving it once it has formed. [5]

Conventional methods for estimating working length include radiography, anatomical averages and knowledge of anatomy, tactile sensation, and moisture on a paper point. These methods have limitations and do not allow precise localization of apical constriction. Since quite some years, to overcome the limitations offered by traditional methods, new techniques have been introduced, which include digital radiography and apex locators. [6] Thus, in addition to radiographic measurements, electronic root canal working length determination and digital radiology has become increasingly important. [6, 7]

As the electronic apex locator has become an invaluable tool in modern endodontic practice. These devices were based on electrical resistance and they function by using the human body to complete an electrical circuit. These first-generation apex locators provided rather inaccurate and unstable measurements as a result of the presence of vital pulp tissue, excessive blood, exudates or moisture within the canals. [8]The more recent

resistance-based apex locators provided the accurate location of apical constriction in 55--75% of the cases. However, their accuracy was further diminished by the presence of fluids. [9]

Second-generation apex locators -- also known as impedance apex locators -- measure opposition to the flow of alternating current or impedance. [10] Therefore, impedance rather than resistance became the characteristic used to mark the depth of canal penetration. Shortcomings of first- and second-generation Electronic Apex Locators were overcome by the introduction of third-generation apex locators in the 1990s [11]

In 1991, Kobayashi *et al [12]]*.reported on the ratio method for measuring the root canal length, which is the basic working mechanism of Root ZX mini. The ratio method works on the principle that two electric currents with different sine wave frequencies will have measurable impedances that can be measured and compared as a ratio regardless of the type of electrolyte in the canal. The capacitance of a root canal increases significantly at the apical constriction, and the quotient of impedances reduces rapidly as the apical constriction is reached. This principle forms the basis for operation of Root ZX mini [13].

The present study was devised to achieve certain objectives that were to determine the efficacy of electronic apex locators after pulp extirpation and whether there was any alteration in accuracy when used in the presence of various herbal irrigants.

II. Materials And Methods

Sixty five extracted human single rooted teeth with mature apices were selected. The teeth were cleaned of calculus, soft tissues, and debris with ultrasonic scaler and stored in distilled water until used.
Access cavity was prepared with no.4 round plus taper fissure bur and canal orifice was located with DG-16. The actual root canal was measured by inserting a #10 K file (Mani Inc., Japan) into the root canal until the file tip was just visible at the level of apex.. In vitro model was made up of alginate mould. A mould was manufactured using natural teeth, and alginate impression material (Velplast), to simulate oral conditions for electronic measurement of the working length. The stopper of the file was adjusted to flush with the coronal reference plane and file withdrawn from the canal; the length was measured with the help of Endobloc (Dentsply Mini-Endobloc). Electronic working length measurements were taken with Root ZX mini (J. Morita MFG Corps, Japan) and ProPex Pixi (Dentsply, Mallifer, USA) electronic apex locator by attaching the lip clip to the conductive alginate gel and other end of the electrode to #10 K file placed into the root canal and recorded.

The teeth were divided into 3 groups:
Group I – ROOT ZX mini (30 samples)
Group II- ProPex Pixi (30 samples)
Group III- Control (5 samples)
Group I and Group II were further subdivided into 3 subgroups each. (Table 1)

The herbal extracts were obtained in a powder form from a herbal shop in Ahmedabad city. The solutions were prepared by mixing the powder in 100ml distilled water each in test tubes and were strained before use. After the actual root canal length measurements with both the apex locators was recorded the apical third of all root canals was enlarged and prepared to #35 K-file diameter following the step back technique as described by Ingle[6] and copious irrigation was done with the help of three herbal irrigating solutions while the preparation of the root canals. After root canal preparation, electronic working length measurements were again taken using Root ZX mini followed by ProPex pixi following similar regime as described earlier.

The Data Was Statistically Analyzed Using

1. one-way analysis of variance (ANOVA) at 0.05 level of significance and
2. Comparison between actual and electronic measurements before and after the preparation of the root canal in the presence of various irrigants (paired t-test) after verifying the correlation for the paired sample test.

III. Result

Table 2 shows the mean and standard deviation differences between actual (AL) and final length (FL) and electronic lengths after preparation (EAL) with Root ZX mini and propex pixi using the various herbal test irrigants .*P*-values for actual and final length were statistically significant ($P < 0.05$).

- T-TEST PAIRS=ACTUAL WITH POST -(PAIRED), P<0.05 – SIGNIFICANT

EAL : final length after preparation.

Table 3 shows the mean and standard deviation differences between actual (AL) and final length (FL) and electronic lengths before and after preparation with Root ZX using the various test irrigants.*P*-values for actual and final length and for employing herbal irrigating solutions were not statistically significant ($P > 0.05$)

Table 4 shows the mean and standard deviation differences between actual (AL) and final length (FL) and electronic lengths before and after preparation with ProPex pixi using the various test irrigants. *P*-values for actual and final length and for employing all the test irrigants were not statistically significant ($P > 0.05$).

IV. Discussion

The first-generation EALs were resistance-based and the second-generation EALs were impedance-based apex locators. [15] The main shortcomings of these EALs included poor accuracy in the presence of fluids and pulp tissue, and the need for calibration.[16] The frequency-based third-generation EALs have more powerful microprocessors and are able to process mathematical quotient and algorithm calculations required to give accurate readings.[17]

Root ZX mini (J. Morita Mfg Corp., Kyoto, Japan) is a third-generation EAL that uses dual frequency and comparative impedance principle is based on the "ratio method" for measuring canal length. This method simultaneously measures the impedance values at two frequencies (8 and 0.4 kHz) and calculates a quotient of impedances. This quotient is expressed as a position of the file in the canal.[18] Root ZX mini requires no calibration, and can be used when the canal is filled with a strong electrolyte. Multifrequency based EALs have been developed to further increase the accuracy of EALs.[19]

The fourth-generation apex locators do not process the impedance information as a mathematical algorithm, but instead they take the resistance and capacitance measurements separately and compare them with a database to determine the distance to the apex of the root canal.However, there is still a concern as to whether high electroconductive irrigants such as saline, anesthetic solution, and sodium hypochlorite can affect the of these new-generation EALs performance[21]. The effect of irrigation solutions on working length determination was also evaluated. Early generation electronic apex locators were often inaccurate in the presence of conductive fluids. However, manufacturer claims that ProPex pixi locates the foramen under any canal condition (wet, dry, sodium hypochlorite etc.) as a result of its multi-frequency technology.[27]

In this *in vitro* study two modern electronic apex locators namely Root ZX mini and ProPex pixi were used to calculate the length of the root canal.An *in vitro* model was used in the study and the advantages of the model were its simplicity, ease of use, and the ability to have strict control over the experimental conditions tested. This alginate model embedded with extracted teeth provides electrical resistance corresponding to that of periodontium. These in vitro models do provide a valuable insight into the function of EALs and enable objective examination of a number of variables that cannot be practically tested clinically.

Distilled water has been chosen as a vehicle for the herbal irrigating solutions because it does not contain any electrolytes ,so its electrical conductivity is zero and its neutral in nature (Ph-7). Green tea have significant anti oxidant, anti cariogenic, anti inflammatory, thermogenic, probiotic and anti microbial properties. Green tea are preferred over the traditional root canals irrigants due to their curative properties such as anti oxidant, anti inflammatory and radical scavenging activities. In an in vitro study conducted by J.Prabhakar et al Green tea were found to have significant anti microbial activity against E.faecalis biofilm formed in tooth substrate. [24]. In another study by Madhu Pujar et al, antimicrobial efficiency of green tea polyphenols and 3% sodium hypochlorite were compared against and E.faecalis and it was observed that and green tea showed significantly better antibacterial activity against 2 week biofilm. [23]Turmeric [Curcuma longa] is extensively used as a spice, food preservative and coloring material in India, China and South East Asia. It has been used in traditional medicine for the treatment of numerous diseases.Curcumin [diferuloylmethane], the main yellow bioactive component of turmeric has been shown to have a wide spectrum of biological actions, including antimicrobial, anti-inflammatory and antioxidant activities.[25] A recent report suggested that curcumin in aqueous preparations exhibits phototoxic effect

against gram positive and gram negative bacteria. The exact mechanism by which curcumin causes light induced cell death has not yet been established, but it is generally accepted that a prerequisite for photosensitisation of a microbial cell is the binding of the photosensitizer to the outer membrane.Tulsi (*Ocimum sanctum*) is a holy plant of Indian origin. It is known as the mother medicine of nature. It is an easily available and economical material without side effects. It has antimicrobial properties and is most commonly used for treating variety of diseases such as arthritis, bronchitis, diabetes, and skin diseases.[27] Tulsi has been tested for its antimicrobial properties against *Escherichia coli*, *Klebsiella*, *Candida albicans*,*Staphylococcus aureus*, *Enterococcus faecalis*, and *Proteus*.[27,28] *O. sanctum* is mainly responsible for the therapeutic effect of tulsi. Antimicrobial activity of tulsi is due to its constituents, ursolic acid and carvacrol.Although there is not much difference between Root ZX and ProPex pixi in the presence of various herbal irrigating solutions mentioned above as they do not posses any kind of electroconductive properties , therefore these solutions could be used as irrigating solutions because they have great antimicrobial , antioxidant properties although certain

properties like tooth discoloration , pulp tissue dissolution , and their effect on root dentin strength etc are yet to be studied.

V. Conclusion

The contents of the root canal influenced the results of the measurements with both the EALs, but the ifferences were not statistically significant. Within the different variables tested in the present study, measurements recorded after using Turmeric and Green tea matched more precisely as compared to Tulsi.

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Table: 1

No.	Group I ROOT ZX mini (30 samples)	GROUP II ProPex Pixi (30 samples)	GROUP III Control Distilled water (5 samples)
1	Subgroup I A Green tea (10 samples)	Subgroup IIA Green tea (10 samples)	
2	Subgroup IB Turmeric (10 samples)	Subgroup IIB Turmeric (10 samples)	
3	Subgroup IC Tulsi (10 samples)	Subgroup IIC Tulsi (10 samples)	

Table:2 the mean and standard deviation differences between actual (AL) and final length (FL) and electronic lengths after preparation (EAL) with Root ZX mini and propex pixi using the various herbal test irrigants.

Sr no	Group		Mean	Std Deviation	P value
1	Green Tea	AL EAL	22.25 21.85	1.55 1.24	0.104
2	Turmeric	AL EAL	22.00 22.10	2.82 2.64	0.343
3	Tulsi	AL EAL	21.450 21.225	2.30 2.227	0.025

Table:3 P value for ROOT ZX

This table shows the mean and standard deviation differences between actual (AL) and final length (FL) and electronic lengths before and after preparation with Root ZX using the various test irrigants.*P*-values for actual and final length and for employing herbal irrigating solutions were not statistically significant ($P > 0.05$)

Group		Mean	Std. Deviation	P value
Green Tea	Pre Bmp Post Bmp	21.95 21.90	1.53 1.54	0.343
Turmeric	PreBmp Post bmp	22.50 22.20	2.59 2.61	0.081
Tulsi	Pre bmp Post bmp	20.450 20.250	1.42 1.23	0.104

Table 4: P value for ProPex Pixi

This table shows the mean and standard deviation differences between actual (AL) and final length (FL) and electronic lengths before and after preparation with ProPex pixi using the various test irrigants. *P*-values for actual and final length and for employing all the test irrigants were not statistically significant ($P > 0.05$).

Group		Mean	Std. Deviation	P value
Green Tea	Pre Bmp Post Bmp	21.95 21.90	1.53 1.54	0.343
Turmeric	PreBmp Post bmp	22.50 22.20	2.59 2.61	0.081
Tulsi	Pre bmp Post bmp	20.450 20.250	1.42 1.23	0.104

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