Contrary electrode positions and its effect on the accuracy of apex locator

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Received: 24-10-2014
Accepted: 26-03-2015

ABSTRACT

Aim: Clinically evaluate the effect of varying the conditions and the position of the contrary electrode on the accuracy of apex locators to determine the working length.

Methodology: Thirty patients requiring endodontic intervention of as many maxillary anterior teeth were randomly selected. Root ZX, a 3rd generation apex locator was used to determine the electronic working length (EWL). Three positions of the contrary electrode were evaluated Group I: held at the corner of the patient's mouth in contact with oral mucous membrane, Group II: held in the patients' dry hand, Group III: held in patients moist hands. Three consecutive readings were taken at each position and the mean calculated.

Results: The readings obtained for group II & III were analyzed against group I using Altman Criterion for Agreement Analysis. A mean difference of 0.73 and 6.52mm was observed between group I & III and between groups I & II respectively.

Conclusion: Moist hands can be an alternate placement position for the contrary electrode during EWL determination.

INTRODUCTION

Accurate determination of the root canal length is imperative for the success of endodontic therapy. Grove (1930) stated that 'the proper point to which root canals should be filled is the junction of the dentin and the cementum and that the pulp should be severed at the point of its union with the periodontal membrane' (1). The cemento dentinal junction (CDJ) is the anatomical and histological landmark where the periodontal ligament begins and the pulp ends. Root canal preparation techniques aim to make use of this potential natural barrier between the contents of the canal and the apical tissues (2). It is generally accepted that the preparation and obturation of the root canal should be at or short of the apical constriction (3). The problem clinicians often encounter is the inability to accurately identify and prepare up to this landmark. Traditional methods for establishing working length include the use of anatomical averages, digital tactile sensation, paper point and radiographs. In endodontics, the preoperative radiograph is essential to determine the presence or absence of disease, anatomy of the root canal system and to act as an initial guide for working length. Radiograph based method for working length determination has an inherent drawback of being a 2D representation of a 3D object. Moreover apical constriction is a histological landmark and hence cannot be identified on an x-ray and the apical foramen may not always correspond with the radiographic apex (lateral exit).In addition the anatomic noise, variation in the techniques', and observer's bias in radiographic interpretation can reduce the accuracy of this method. Above all,the hazard of radiation exposure always remains as a concern.

Electronic method for root length determination is an adjunct to radiographs. It was first investigated by Custer in1918 and revisited by Suzuki in 1942 who studied the flow of direct current through the teeth of dogs. Since then several advancement and modifications have led to the advent of various generations. This classification is based on the type of opposition to the current flow and the number of frequencies involved.

The first generation apex locators exhibited erroneous readings in the presence of electrolytes. This was overcome with the development of the self-calibrating Root ZX (J. Morita, Tokyo, Japan) apex locator. This is a 3rd generation EALs that uses dual-frequency and is based on comparative impedance principles that was described by Kobayashi & Sunada (6). The Root ZX mainly detects the change in electrical capacitance that occurs near the apical foramen. Intracanal, the Root ZX simultaneously measures two impedances at two frequencies (8 and 0.4kHz). A microprocessor in the device calculates the ratio of the two impedances. The quotient of the impedances is displayed on a liquid crystal display meter panel and represents the position of the instrument tip inside the canal. A number of in-vitro and in-vivo studies have reported on the accuracy and reliability of the Root ZX apex locator (7, 8).

Basically all electronic apex locators function by using the human body to complete an electrical circuit (9). One side of the apex locator's circuitry is connected to the oral mucosa through a contrary electrode (lip clip) and the other side to an endodontic file which is introduced into the root canal and advanced apically till its tip touches the periodontal tissues at the apex. This completes the electrical circuit and device indicates that the apex has been reached. Human

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body is a good conductor of electric current (11) so if the contrary electrode is placed in the hands the circuit should be completed and the apex locater should give reliable readings. Hence the aim of this clinical study was to evaluate the effect of varying the conditions and the position of the contrary electrode on the accuracy of apex locators to determine working length. The null hypothesis tested was that varying the position of the lip clip would have no effect on the accuracy of apex locators.

MATERIALS & METHOD

Thirty patients with maxillary anterior teeth indicated for root canal therapy were randomly selected to be part of the study. Informed written consent was taken. Pre-operative X-ray was taken and presence/absence of periapical radiolucency were noted .Access opening under rubber dam with a nonmetallic frame was done. A crown down technique for root canal preparation was followed. Root ZX a 3rd generation apex locator was used in this study. It was operated according to the operating manual (10). The first file which closely approximated to the apical diameter of the canal was used to determine the working length

Three positions of the contrary electrode were evaluated

Position I: Corner of the patient's mouth in contact with oral mucous membrane

Position II: Contrary electrode held in the patients' dry hand

Position III: Contrary electrode held in patients moist hands

Patient preparation:

For position II patients' were asked to hold contrary electrode with visibly dry hand.

For position III patients' were asked to hold contrary electrode with moist hand.

At position I, the file was advanced till the "apex reading" on the apex locator. Three consecutive readings at this point were taken and the mean calculated.1mm was subtracted from this reading and the instrument was set and a digital radiograph taken to correlate radiographic working length with electronic working length (_+.5mm-1mm from the radiographic apex was kept as the acceptable limit, and was taken as the final working length.)

Similarly, at position II & III three consecutive readings were taken, mean calculated, 1mm subtracted and this was taken as the final working length.

The results were tabulated and compared.

RESULTS

The final working length readings at position I was taken as the standard after verifying it with digital radiograph. The readings obtained at position II & III were also tabulated and analyzed against position I using Altman Criterion for Agreement Analysis (Table 1). Results of the study have showed that, there was a mean difference of 0.73mm (0.5- 1mm) between group I & III and an average difference of 6.52mm (5-6mm) between group I & II.

Table 1: Altman Criterion for Agreement Analysis between Different Groups with Root ZX

	r	β	$\overline{r}$	ICC	Mean Difference (mm)
Gr I - Gr II	0.78	0.94	N.S	0.82	6.52
Gr I - Gr III	0.97	0.99	N.S	0.99	0.73

r = correlation/β = regression coefficient/ $\overline{r}$ = Diff. value in methods Vs mean value of methods/N.S = non significant/ICC = Intra class corrélation

DISCUSSION

There is a general consensus that root canal procedures should be limited within the confines of the root canal (3), with the logical end-point for preparation and filling being the narrowest part of the canal. It is not possible to predictably detect the position of the apical constriction clinically, indeed, the constriction is not uniformly present, or may be irregular. Equally, it is not logical to base the end-point of root canal procedures on an arbitrary distance from the radiographic apex as the position of the apical foramen is not related to the 'apex' of the root. Electronic root canal length measuring devices offer a means of locating the most appropriate end-point for root canal procedures, albeit indirectly. The principle behind most apex locators is that tissues have certain characteristics that can be modeled by means of a combination of electrical components. Then, by measuring the electrical properties of the model (e.g. resistance, impedance) it should be possible to detect the canal terminus.

In the impedance ratio-based apex locators the AC source is a two-frequency source, i.e. it comprises two sine waves with a high and a low frequency (fH and fL respectively). The impedance of the model is measured at each frequency and the position of the file is determined from the ratio between these two impedances: ratio =Z (FH)/Z(Fl).Kobayashi & Sunada (1994) proved that the ratio had a definite value determined by the frequencies used and that the ratio indicates the location of the file tip in the canal. When the impedances to two frequencies are measured Z1 is always less than Z2 i.e. the ratio Z1:Z2 is always less than one. This is due to the electrical properties and capacitance of the canal .Since the walls of the canal has a much lower electrical capacitance than the apical foramen, the quotient of the two impedances is nearly one when the tip of the file is some distance from the apical foramen but at positions close to the canal terminus, however, the capacitive characteristic of the impedance starts to appear. The influence of the capacitance on the overall impedance is proportional to the frequency of the measurement. At high frequencies (fH) the overall

impedance value will be much lower than at low frequency (fL). That means, at the apical constriction the ratio tends to be towards a small value. This ratio is independent of the electrolyte liquid and conditions inside the canal. This is because a change in the electrolyte material will influence equally the numerator and denominator of equation and hence the final ratio will still remain constant. This concept underpins the development of the Root ZX apex locator. This fundamental operating principle could explain why there was no statistically significant difference between their ability to determine the apical constriction in roots with vital pulps versus those with necrotic pulps (8) and/or various irrigants (12).This was also the basis of our study. The role of the contrary electrode is to complete the circuit using the human body .It is usually placed at the corner of the mouth in the vestibule area to provide a moist contact which in turn minimizes contact resistance allowing efficient current flow and also since the current has to take a smaller path from the lip through the gums to the periodontal ligament, to complete the electrical circuit. The device would be sensitive to even small changes in the electrical properties of the tooth. In our study the contrary electrode was held in the hand which also served to complete the electrical circuit using the human body. When we held it in a moist hand the current had to flow through a longer electrical path, therefore the impedance Z which depends on resistance and capacitance, would now include the total resistance of the path which would be more than the previous due to the lip clip, therefore the values of resistance and capacitance will change, changing the reactance values of its capacitor Xc and hence impedance Z. But, since this device measures a ratio of Zh/Zl, any change in the numerator will also be shown in the denominator such that the ratio will be constant and we do get a clinically acceptable reading. The fact that we were getting a false reading with a dry hand means that there is already an increase of the total capacitance which is not due to the pathway but due to the conditions i.e. dry hand. The dry hand is probably acting as an insulator and behaving as a bad conductor. An insulator always has a high dielectric constant and hence there is an increase in capacitance .Even when the file is half way through the canal the increase in capacitance is considerable such that Zh/Zl quickly becomes less than one and we get a false reading which means the apex locator is reading it as the apex.

The probable advantages of the contrary electrode being held in the moist hand are no chance of getting a false reading due to the contrary electrode coming in contact with metal restoration in the mouth, sterilization would not be a critical issue since it would not come in direct contact with body fluid and it can also be used in patients with severe xerostomia where a moist oral contact would not be possible otherwise.

The purpose of this study was to present an observation which has been made during the course of this study. This needs to be further investigated by the manufacturers of (various) apex locator and scientific evidence provided, changes incorporated in the circuit of the device before it can be used for working length determination clinically. Electronic apex locators have become indispensable adjuncts to the root canal therapy. Application of rubber dam is an essential practice that helps in preventing root canal re-infection and procedural mishaps, that can sometimes be life threatening. Using an apex locator with lip clip attached under rubber dam is a cumbersome procedure.

CONCLUSION

Moist hands can be an alternate placement position for the contrary electrode during electronic working length determination.

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How to cite this Article: Logani A, Singh A, Chawla A, Kumar V, Shah N. Contrary electrode positions and its effect on the accuracy of apex locator. J Dent Specialities,2015;3(1):40-42

Source of Support: NIL
Conflict of Interest: None Declared