TOOTH EMBEDDING MEDIUM INFLUENCES THE ACCURACY OF ELECTRONIC APEX LOCATOR

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ABSTRACT

This study evaluated the influence of tooth embedding media on the accuracy of an electronic apex locator. The root canal length of 20 human mandibular canines was measured by inserting a 15 K-file into the root canal up to the apical foramen. The distance was measured with a digital caliper. The embedding media evaluated were alginate, saline, floral foam or gauze soaked in saline. Electronic root canal length measurement was performed with Root ZX II. Data were analysed using ANOVA for repeated measurements and Tukey test, at a significance level of 5%. There was no difference between the actual root canal length measurement and the electronic reading recorded with alginate medium. The readings obtained with the other media differed from the actual root canal length measurements. Alginate provided greater accuracy in electronic root canal length determination by Root ZX II than saline, floral foam and gauze.

Keywords: *Endodontics; Root canal preparation; Tooth apex.*

MEIO DE IMERSÃO DENTAL INFLUENCIA A ACURÁCIA DE LOCALIZADORES APICAIS ELETRÔNICOS

RESUMO

O presente estudo avaliou a influencia do meio de imersão dental na precisão de um localizador eletrônico apical. Os canais radiculares de 20 caninos inferiores humanos foram mensurados pela introdução de uma lima K 15 no canal radicular até o forame apical. A distância foi medida com um calibrador digital. Os meios avaliados foram o alginato, a solução salina, esponja vegetal ou gaze embebida em solução salina. O comprimento eletrônico do canal radicular foi realizado com o Root ZX II. Os dados foram analisados usando ANOVA e teste de Tukey com um nível de significância de 5%. Não houve diferença entre o comprimento real do canal radicular e a leitura eletrônica realizada nos dentes imersos em alginato. As leituras obtidas nos dentes imersos em outros meios foram diferentes das medidas reais do comprimento do canal radicular. O alginato apresentou uma maior precisão na determinação eletrônica do comprimento do canal radicular realizada pelo Root ZX II em comparação a solução salina, a esponja vegetal e a gaze.

Palavras chave: *tratamento de canais radiculares; Localizador eletrônico apical; comprimento do canal radicular.*

INTRODUCTION

Electronic apex locators (EALs) detect the approximation of the file tip to the periodontal ligament based on impedance values obtained by the application of different frequencies in the root canal[1].

The accuracy of electronic apex locators (EALs) has been evaluated both *in vivo*[2,3] and using extracted teeth[4-9]. For *in vitro* assessment of EAL accuracy, studies have used experimental models designed to simulate the periodontal ligament. These models conduct electric current through tooth embedding media that simulate the impedance values of periodontal ligament [4,10]. Several embedding media are reported in the literature for this purpose, namely alginate[4-8,10,11], 0.9% saline[12-14], floral foam soaked in 0.9% saline[3,9,15], agar[16], gelatine[4,17-19] and 0.9% sodium chloride solution[4]. The variability among the results of different studies, when assessing the same EAL, may be the result of the different physical characteristics of the embedding media in which the teeth are placed[4,10]. Therefore, the purpose of this *ex vivo* study was to evaluate the influence of four different tooth embedding media on the accuracy of the electronic readings obtained with Root ZX II apex locator.

MATERIALS AND METHODS

The research protocol was independently reviewed, and approved by the Ethics in Research Committee of the University. Twenty mandibular canines were selected after radiographs taken in both buccolingual and mesiodistal directions revealed the pres-

ence of a single root canal and no calcification or internal resorption. The apical root surface was examined with an operating microscope at x25 magnification to confirm the absence of apical cementum resorptions.

After coronal opening, the root canals were explored with a 15 K-file (Dentsply/Maillefer, Ballaigues, Switzerland) to remove any debris and pulp remnants and check apical foramen patency. The cervical and middle root canal thirds were enlarged with sizes 2, 3 and 4 Gates Glidden drills (Dentsply/Maillefer). To measure the actual tooth length, a coronal reference plane was first prepared by leveling the cusp perpendicular to the long axis of the tooth. A 15 K-file (Dentsply/Maillefer) fitted with a silicone stopper was then inserted into the root canal and moved forward until its tip was seen through the apical foramen. This was done with aid of an operating microscope (D.F. Vasconcellos, São Paulo, SP, Brazil) at ×25 magnification. When the file tip was observed through the apical foramen, the silicone stopper was stabilized at the coronal reference plane, the file was carefully removed from the root canal and the distance between the silicone stopper and the tip of the measuring file was determined using a digital calliper (MTI Corporation, Tokyo, Japan) accurate to 0.01 mm.

Electronic root canal length measurements were performed with Root ZX II apex locator (J Morita, Tokyo, Japan) using four experimental models with different tooth embedding media simulating the periodontal ligament. In Groups I (0.9% saline), II (floral foam soaked in 0.9% saline; Floral Atlanta, São Paulo, SP, Brazil) and III (alginate; Jeltrate; Dentsply, Petrópolis, RJ, Brazil), each embedding medium was placed in plastic cylindrical tubes measuring 30 mm in height and 30 mm in diameter. Two orifices were made in the tube lids, one in the centre for placing the tooth, and the other laterally for placing the lip electrode of the electronic apex locator. In these groups, the teeth were placed in the embedding medium of each experimental model up to their coronal reference plane. In Group IV, each tooth was individually secured by a metallic holder with gauze soaked in 0.9% saline wrapping the entire root surface and the lip electrode of the EAL. The root canals were filled with 2.5% sodium hypochlorite solution at the time of the EAL reading. The lip electrode was inserted in the appropriate orifice on the lid, coming into contact with the medium simulating the periodontal ligament. A size 20 K-file was inserted into the root canal and connected to the other EAL electrode for electronic measurement of root canal length. In Group IV, the lip electrode remained attached to the root/gauze set. In all groups, the EAL was operated according to the manufacturer's instructions. Readings were taken when the signal on the display of Root ZX II device reached the "Apex" mark. When this mark was reached, the silicone stopper was positioned at the incisal edge, and the file was removed. The length on the file was measured with a digital calliper and recorded.

After electronic measurements in each test medium, the teeth were externally washed and the root canals were thoroughly irrigated with distilled water. Thus all teeth were used for each medium. Actual root canal length measurements and the electronic measurements obtained in each experimental model were recorded by a single, calibrated operator. Data were recorded and statistical analysis was performed by analysis of variance (ANOVA) for repeated measurements and Tukey test, at a significance level of 5%.

RESULTS

Table 1 shows the actual root canal length measurements and the electronic readings obtained with the EAL using the four embedding media. There was no statistically significant difference between the actual root canal length measurements and the electronic readings recorded with the alginate medium ($p>0.05$). The readings obtained with the other media were statistically lower than the actual root canal length measurements ($p<0.05$).

Table 1: Actual root canal length measurements and the electronic readings with a Root ZX apex locator using the four embedding media.

	Actual root canal length	Alginate	Floral foam	Saline	Metallic holder
Mean	25.72	25.57	25.46	25.33	25.30
SD	1.48	1.58	1.53	1.65	1.50

SD: standard deviation

DISCUSSION

The methodologies used to assess the accuracy of root canal length determination with EAL differed in two aspects: the apical level established for reading and the precision of the instruments used to measure the distances obtained in the electronic readings.

In several studies, the readings have been based on the apical constriction indicator bar of the Root ZX device at "0.5 mm" from the apical foramen[7,10,14,15,20,21], while other studies have considered the indicator bar on the meter designated by the manufacturer as the "Apex" marker, as being indicative of apical foramen location[5,6,13,22-24]. However, it should be taken into account that the location of the apical constriction in relation to the apical foramen varies according to the physiologic cementum deposition in this region, which may increase this spatial relationship[25]. In addition, apical constriction morphology may vary[26]. Thus, the apical foramen is considered to be a more appropriate reference point, because it is easier to see and establish than is the apical constriction in microscopic analyses[13].

Regarding the accuracy of the instruments used for measuring the distances recorded in electronic working length determination, studies have used 0.50 mm[10,20,21], 0.25 mm[7,18] or 0.10 mm[12,27]. In our study, a digital caliper accurate to 0.01 mm was used to reduce the measurement error.

Mandibular canines were used because they have a relatively large, straight root canal, which minimizes the influence of complex anatomical variations on the electronic readings. Additionally, leveling the cusp offered a stable coronal reference plane for all measurements. The cervical and middle root canal thirds were preflared with Gates Glidden drills because this procedure has been shown to enhance the accuracy of the readings performed with Root ZX apex locator[28].

The Root ZX II apex locator was used in this study because it has a high reliability index in readings[3,19,29].

The Root ZX II apex locator operates by measuring the impedance difference between high (8 kHz) and low (500 Hz) frequencies of alternating electric current. Because of this difference of frequency thresholds, the internal circuit of this EAL can establish a quotient between the impedances without being influenced by the presence of liquids in the root canals. Thus, the electronic readings remain stable until the tip of the file being inserted in the root canal approaches the periapical tissues[1].

Ideally, the embedding medium should have electroconductive properties, surround the root apex and maintain close contact with it in order to reproduce, as reliably as possible, clinical periapical conditions[4,10,11]. All embedding media evaluated in this study fulfil the primary prerequisite of having electroconductive properties.

Alginate had higher accuracy than the other media, showing that the physical properties of the embedding medium influence the accuracy of the electronic root canal length measurements. As a colloidal gel, the alginate probably met the requirements of electroconductivity and contact with root more adequately than the other embedding media[4,10,11].

The lower accuracy of the other media might be due to the saline entering the root canal through the apical foramen, leading to premature readings[30]. In addition, the floral foam cannot provide ideal contact between the electroconductor and the apical foramen region[10].

Another possible explanation for the results of metallic holder/gauze is that the gauze did not maintain close contact with the root, leaving voids that were filled the saline solution in which the gauze was soaked. This could have generated a facilitated current passage between the lip electrode, positioned close to root surface, and the electrode connected to the measuring file.

Regarding practicality, the experimental model using the metallic holder was not advantageous compared to the other models because for each tooth, the holder had to be opened to readapt the gauze/lip electrode attached to the tooth to be measured.

The results of this study are consistent with others[4,10,11] and suggest alginate as the tooth embedding medium of choice for *in vitro* studies with EALs, since it provided readings consistent with the actual root canal lengths. It should be mentioned that the humidity seems to be a critical factor for recording accurate readings in models that using alginate[6,31], which must be prevented from drying, as it causes contraction or deterioration of its structure, producing readings beyond the limits of acceptability for electronic canal length determination[31].

The findings of this study showed that an experimental model using alginate as a tooth embedding medium provided greater accuracy in electronic root canal length determination by Root ZX II than saline, floral foam soaked in saline and gauze soaked in saline.

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