

***In vitro* Evaluation of Three Models of Apex Locators in the Determination of Working Length**

Evaluación *in vitro* de Tres Modelos de Localizadores de ápice en la Determinación de la Longitud de Trabajo

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ABSTRACT: The aim of this study was to compare the accuracy of three third-generation electronic apex locators to estimate the working length. Thirty extracted human mandibular incisors were explored with a K file # 15 followed by enlargement of the middle third with rotary instruments. The apical foramen was standardized at 300mm. The teeth were embedded in an alginate model. The electronic apex locators were divided as follows: Group I – Root ZX; Group II – RomiApex D-30; and Group III – NovApex. The results were analyzed by the ANOVA-Tukey tests, at a significance level of 5%. The results showed that no statistical differences could be found amongst the three evaluated apex locators. Based on these results, it was concluded that the use of third-generation electronic apex RomiApex D-30 and NovApex are as effective and safe as the Root ZX apex locator.

KEY WORDS: electronic apex locators, Root ZX, RomiApex, NovApex.

INTRODUCTION

Working length determination is fundamental for the success of endodontic treatment. The radiographic apex is traditionally taken as a reference to establish this length. Since the apical foramen often does not coincide with the tooth apex, working length determination based on radiographies may be doubtful or incorrect (Czerw *et al.*, 1994).

The advent of electronic determination of the working length allowed to locate the apical foramen and undoubtedly enhanced the accurate of this clinical procedure. Since introduction of the first electronic apex locator by Custer (1918), enhanced by Sunada (1962), several other devices have been presented, based on electric resistance (first generation), impedance (second generation) and two-frequency impedance (third generation). Third-generation apex locators are currently the most employed, since they present more accurate values in apical foramen location. The Root ZX is the most traditional and thoroughly investigated

among all. The NovApex and Romiapex were recently introduced and thus few studies are available concerning their effectiveness. The aim of this study is to compare the effectiveness of these three electronic apex locators to determine the working length.

MATERIAL AND METHOD

The study was conducted on 30 extracted human mandibular incisors, stored in 10% formalin solution until used. This study was revised and approved by the Institutional Review Board of Bauru Dental School, University of São Paulo. After preparation of standard access cavities, the canal orifices were identified and the middle third was prepared with rotary instruments Orifice Shaper® .04 and .06 (Maillefer, Ballaigues, Switzerland) used in an electric engine (Endo Plus-Driller, Brazil) under irrigation with 1% sodium

hypochlorite solution (Pharmácia Specifica de Manipulação, Bauru, São Paulo, Brazil). For measurement of the root length the incisal edges were flattened with a round polishing machine model DP 9A (Panambra – São Paulo-Brazil).

With the aid of a surgical microscope DF Vasconcelos (São Paulo - Brazil) at 8.0x magnification, a K file # 15 with a silicon stopper was introduced into the root canal until the tip could be observed at the apical foramen. The stopper was then stabilized on the incisal edge of the teeth. The file was removed from the root canal and the distance was measured with a millimeter ruler with a 0.5mm precision (ARCH, Japan). The apical foramina were standardized at 300 mm by introduction of a K file n. 30 in a balanced force (Roane, 1985) motion until its tip was seen at the apical foramen.

The groups were divided in: Group I Root ZX (J. Morita, Tokyo, Japan); Group II RomiApex (Romidan, Israel) and Group III NovApex (Forum Tec., Jerusalem, Israel). The teeth were embedded in alginate (Geltrate, Dentsply, Brazil) placed in cylindrical polyethylene plastic flasks with 25mm height and 25mm diameter according to Baldi *et al.* (2007). Two orifices were done in the alginate model, one for placement of the tooth and another for the placement of the electrode corresponding to the lip clip of the electronic apex locator.

For the electronic measurement the root canals were filled with 1% sodium hypochlorite solution (Pharmácia Specifica de Manipulação, Bauru, São Paulo, Brazil). An electrode of the apex locator was inserted in the alginate and the other was connected to the file for electronic reading. Reading was based on the apical constriction indicator bar of the devices, at 0.5mm from the apical foramen. When this bar was reached the silicone stop was positioned at the incisal edge and the file was removed. The extent of the file was measured and recorded on a chart. The data obtained with each apex locator was recorded and the

statistical analyzes by the ANOVA test followed by the Tukey tests at a significance level of 5% was performed.

RESULTS

From the 3 apex locators, 90 measurements were performed. Table I presents the mean and standard deviation of the working length obtained by the three apex locators. The results of the statistical analysis revealed that no significant differences were found amongst the three apex locators and the true working length of the teeth evaluated. (Anova- Tukey test, $p < 0.05$).

DISCUSSION

Radiography is the most widely employed technique for working length determination during endodontic treatment. However, it provides a bidimensional image of a three-dimensional structure. Thus, this method may present distortions and errors of 5.4% during interpretation of the images (Vande Voorde & Bjorndahl, 1969).

With the advent of electronic apex locators, difficulties in working length determination by the radiographic method as well as interferences from anatomical structures have been reduced. Since the early report of Sunada (1962), electronic apex locators and their functioning systems were enhanced to allow more precision, with values close to the real root canal length, without interference from electrolytic substances in the root canal or adjacent tissues. Several *in vivo* (Shabahang *et al.*, 1996; Vajrabhaya & Tepmongkol, 1997; Pagavino *et al.*, 1998; Welk, 2003) and *in vitro* studies (Ounsi & Naaman, 1999; Jenkins *et al.*, 2001; Meares & Steiman, 2002) have demonstrated this evolution and enhancement of the operating system of appliances.

Table I. Mean and standard deviation of the working length determined by the three electronic apex locators evaluated. *($p > 0.05$) Anova-tukey test. **true root canal length.

	Tooth**	Root ZX*	RomiApex*	NovApex*
n	30	30	30	30
Minimum	17.00	16.50	17.00	16.50
Maximum	22.50	22.50	22.50	22.50
Mean	19.93	19.65	19.78	19.35
Standard deviation	1.657	1.687	1.674	1.872

This study evaluated whether different appliances with similar operating systems (third generation) presented similar results in the same group of teeth. Thus, an *in vitro* study was designed to allow determination of the real tooth length. The Root ZX apex locator was taken as a reference, since it has presented reliable results with high reliability rates close to 95% since its introduction (Gordon & Chandler, 2004). Considering the measurement at 1mm short of the apex, the reliability rate increases up to 100% (Pagavino *et al.*, 1998).

In this study reading was performed when the bar of the device indicated 0.5mm short of the apical foramen, considering a mean distance of 0.5 mm from the apical foramen to the apical constriction (Kuttler, 1955). This indication of appliances are in accordance with the studies of Fouad *et al.* (1990) Shabahang *et al.* (1996), Elayouti *et al.* (2002), Goldberg *et al.* (2002), Grimberg *et al.* (2002), Tinaz *et al.* (2002), and Welk *et al.* (2003).

The teeth were embedded in alginate, which is often used as a embedding medium (Nguyen *et al.*, 1996) and presents more consistent results in laboratory studies, as previously observed by Baldi *et*

al. (2007). The results revealed evident efficacy of the appliances, since no statistically significant difference was observed compared to the real tooth length, as demonstrated in Table I. These results corroborate the findings of D'Assunção *et al.* (2006), which compared the Root ZX and NovApex on extracted human teeth. In cases of retreatment, *in vitro*, the Root ZX and NovApex also presented similar results in working length determination (Goldberg *et al.*, 2005). The difference between devices was limited to the reading mode, since each device presents a different display and it seems that this fact did not interfere with the results.

The easy utilization combined to the good results of the RomiApex and NovApex is valuable information to general practitioners, since this study has shown that accuracy was similar in comparison to the Root ZX device which is considered the gold standard.

The use of the third-generation electronic apex locators demonstrated to be effective, reliable and easy-to-use equipments for working length determination. No statistical difference was observed amongst the electronic apex locators NovApex, RomiApex and Root ZX.

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RESUMEN: El objetivo de este estudio fue comparar la precisión de tres localizadores apicales electrónicos de tercera generación para calcular la longitud de trabajo. Treinta incisivos mandibulares humanos extraídos fueron explorados con una lima K # 15 seguido por la ampliación del tercio medio con instrumentos rotatorios. El foramen apical se ha estandarizado en 300mm. Los dientes fueron inmersos en un modelo de alginato. Los localizadores apicales electrónicos se dividieron como: Grupo I – Root ZX; Grupo II - RomiApex D-30, y Grupo III - NovApex. Los resultados fueron analizados por las pruebas Tukey-ANOVA, con un nivel de significancia del 5%. Los resultados no mostraron diferencias estadísticamente significativas entre los tres localizadores apicales evaluados. En base a estos resultados, se concluyó que el uso de localizadores apicales de tercera generación RomiApex D-30 y NovApex son tan efectivos y seguros como el localizador apical Root ZX.

PALABRAS CLAVE: localizadores apicales electrónicos, Root ZX, RomiApex, NovApex.

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