

Accuracy in Detection of Apical Patency Using Different 5th Generation Electronic Apex Locators: An In-Vitro Study

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ABSTRACT

Aim: Among various techniques available, to determine the working length of the root canal, electronic apex locators help in overcoming the technical limitation of complex root canal anatomy and determining the apical constriction. The aim of this study was to analyse the importance of apical patency and its influence on the accuracy of 3 apex locators. **Materials and Methods:** Sixty intact extracted maxillary molars were collected and were divided into 3 groups (n = 20): Group 1 Propex II (Dentsply Sirona), Group 2 Propex Pixi (Dentsply Sirona) and Group 3 Woodpecker V (Woodpecker). Readings of the 3 apex locators were then compared with the actual microscopic working length. Data were statistically analyzed. **Results:** After using Chi – Square test, Propex II showed statistically significant difference in determination of apical patency followed by Propex Pixi and Woodpecker V.

Conclusion: Foramina patency could be considered as a prerequisite for a reliable working length determination with apex locators, all the test groups exhibited statistically significant differences, i.e. Propex II > Propex Pixi > Woodpecker V.

Key-Words: Apex locator, Apical Patency, Maxillary Molar

INTRODUCTION

Successful root canal treatment depends on shaping of the whole length of the root canal space for meticulous cleaning and disinfection, followed by 3-dimensional obturation. This necessitates accurate determination of the apical constriction. The apical constriction, which is described as the minor apical diameter, is the point beyond which the periodontal tissues exist. Thus, maximizing the outcome of root canal treatment is closely related to limiting all the instruments, antimicrobial agents, and filling materials to the confines of the root canal system at the apical constriction.¹ One of the most essential tools for working length determination are the Electronic apex locator (EAL) because it overcomes the drawbacks of periapical radiography which demonstrates the 2-dimensional image. There has been a series of generations since the first launching of apex locator, which relied on direct electrical current and resistance. All the recent generations rely on alternating current of more than one frequency and on impedance rather than resistance. The main concept of all of these generations

is electrical conductivity between the attached file clip and the lip clip where the root dentin acts as an insulator and the periodontal ligament is the conductor. The electrical circuit is closed when the current passes through periodontal ligament to the oral mucosa and then to the lip clip.^[2] A technique where the apical portion of the canal is maintained free of debris by recapitulation with a small file through the apical foramen is defined as apical patency.³ The aim of the present study was to shed light on the importance of apical patency and its influence on the accuracy of 3 apex locators Propex II (Dentsply Sirona), Propex Pixi (Dentsply Sirona) and Woodpecker V (Woodpecker) among the many choices available. The null hypothesis to be tested was that there would be no statistically significant difference between the three tested groups. The alternate hypothesis was that there would be statistically significant difference between the three tested groups.

MATERIALS AND METHODS

The master article along with the reference articles was sent to the statistician and sample size was calculated using G Power Software (Version 3.1.9.6) and set at 60 (n=20) based on the 95% power of the study, 5% type I error and effect size of 0.57. The descriptive statistics will include mean, standard deviation frequency and percentage. The level of the significance for the present study will be fixed at 5%. After securing Committee

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Fig 1A: Sample Image



Fig 1B: Image Under Dental Operating Microscope

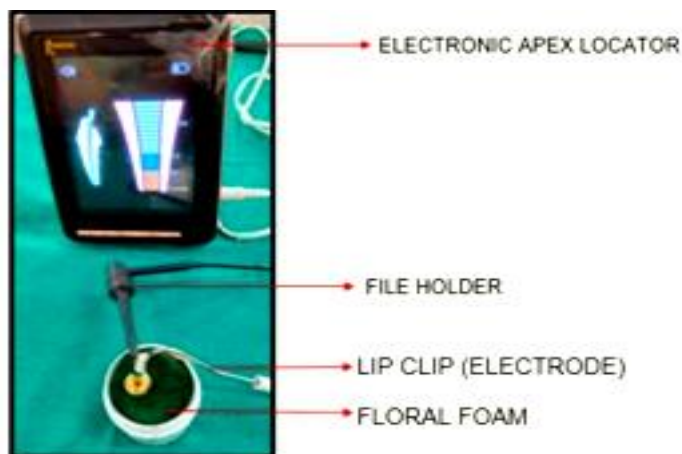


Fig 2A: Experimental Set-up

clearance, 60 human maxillary molars were taken for the study. Teeth with open apices, fractures and resorption were excluded. Figure 1A shows the sample with access cavity. Patency was confirmed, and then the canals were irrigated by 5 mL 2.5% NaOCl. K-file #10 was

advanced inside the root canal until it became visible at the apical foramen under a dental operating microscope at X25 (Figure 1B). The file was withdrawn, then the length was recorded. The mean of the obtained length was considered as the representative measurement of that sample. It was subtracted 0.5 mm from this measurement and then recorded it as actual working length (AWL). Figure 2 demonstrates a plastic mold with floral foam were used, within the molds in which the roots were embedded. 3 apex locators were calibrated to ensure proper function before measurements. Then inserted #15 K-file with silicone stopper inside the canal until the apex reading was reached. The extent of penetration inside the root canal of each sample was measured with each EAL and compared with the AWL. Canal blockage was intentionally induced Hedstrom stainless steel files (Mani) to create dentinal mud or plug. This dentinal plug was then forced to the apical foramen until the loss of canal patency was verified. During electronic measurement #10 K-file was inserted to the same previously recorded length for 3 apex locators, and then new readings were recorded. Positive difference meant that the measured length after blockage was longer than that before blockage, whereas negative measurements indicated shorter length, and 0.0 meant coincident measurements.



Fig 2B: Experimental Set-up



Fig 2C: Experimental Set-up

RESULTS

After using Chi – Square test (Table 1), Propex II showed statistically significant difference in determination of apical patency followed by Propex Pixi and Woodpecker V as shown in Figure 3.

Table 1

Before blockage	Distances in mm between file tip and the major foramen	Group			p-value
		Group 1 (Propex pixi)	Group 2 (Propex II)	Group 3 (Woodpecker V)	
0 to -0.05		30 (50.0)	38 (63.3)	20 (33.3)	0.001 *
After Blockage	0 to -0.05	30 (50.0)	40 (66.7)	25 (41.7)	0.000 *

Figure 3A: Graphical representation of the results

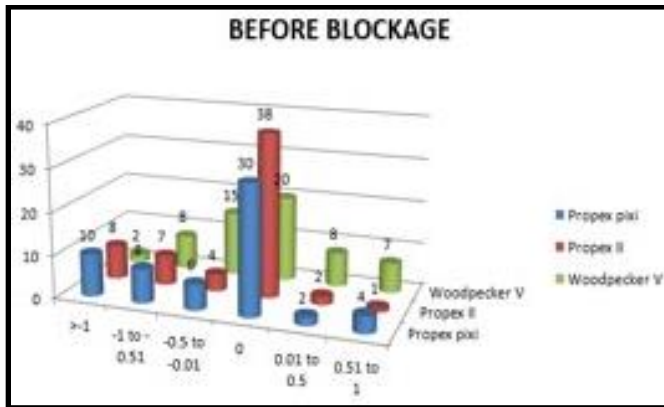
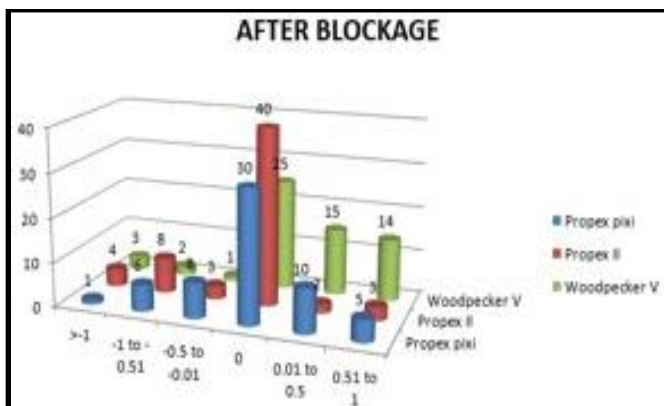


Figure 3B: Graphical representation of the results



DISCUSSION

Working length determination using apex locators are at present the most pleasant chairside tool. As periapical radiograph is not an accurate tool for locating the working length, especially if the apical foramen opens laterally⁴ in the present study the actual length was

determined with the dental operating microscope (x25). First Generation Electronic Apex Locators: they are based on resistance. They are unreliable as readings being significantly longer or shorter than the accepted working length. Second Generation Electronic Apex Locators are Impedance Based. The working principle is based on electrical impedance across the wall of the root canal due to the presence of transparent dentin. Third Generation Electronic Apex Locators are frequency dependent comparative impedance based. Identical to the 2nd generation EAL's but distance from the end of the canal are determined using multiple frequencies. Fourth Generation Electronic Apex Locators are based on ratio. These apex locators have built in electronic pulp tester and determine the impedance at five frequencies. The drawback with them is that they need to perform in relatively in partially dried canals or dry.⁵ Fifth generation apex locators are based on dual frequency ratio which measures the capacitance and resistance of the circuit individually. They provide relevant readings in the presence of exudate and blood. The electrical circuit of EAL is considered complete when the electric current passes through the file attached to the clip, inside the root canal, then out of the apical constriction to the periodontium, and finally through the mucosa into the clip on the patient's lip. Sixth Generation Electronic Apex Locators are known as adaptive apex locators their efficacy in long term use yet to be established.⁶ Inadequate irrigation and failure to establish apical patency accompanied with packing of the dentin chips in the apical part of the canal during root canal preparation causes apical canal blockage.⁷ Extrusion of debris into the periapical tissue establishes the apical patency, with the ensuing flare-up or infection in case of necrotic pulp with contaminated debris using a large file. However, a small patency file such as #10 k file would not push the debris but rather pierces the accumulated debris in the canal to displace it and facilitates its removal with the help of irrigants.⁸ According to a study done in 2013, Propex II apex locator was more accurate than the radiographic method in determining working length.⁹ A study done in 2020 concluded that Apex ID, Root ZX mini, and Propex Pixi performed equally well in determining a position 0.5 mm short of the major foramen.¹⁰ In this study, blockage was created by filing the middle and coronal thirds, followed by pushing and packing the cut debris apically to replicate the clinical condition of apical blockage. The flow of the current through the insulated file within the encased dentin and cementum inside the root canal would be disrupted.⁸ The null hypothesis was rejected in the study as all the test groups exhibited statistically significant differences, i.e Propex II> Propex Pixi> Woodpecker V, and thus the alternate hypothesis was accepted.

CONCLUSION

The study was performed to compare the accuracy of 3 different apex locators in human maxillary molars. Readings were taken and compared with microscopic working length. After which the apical blockage at the apical foramen was established. Variation in the readings of apex locators after blockage was compared with original readings before blockage to determine the measurement error. Under the limitations of this in-vitro study, the authors concluded that foraminal patency could be considered as a prerequisite for a reliable working length determination with apex locators, all the test groups exhibited statistically significant differences, i.e. Propex II > Propex Pixi > Woodpecker V.

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