Accuracy of the Justy II Apex locator in determining working length in simulated horizontal and vertical fractures

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Abstract

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Aim To study the effectiveness of an electronic apex locator (EAL; Justy II; Yoshida Dentcraft, Tokyo, Japan) in locating simulated horizontal and vertical fractures in single roots.

Methodology An EAL was used to measure the distance within the canal of horizontal ($n = 31$) and vertical ($n = 31$) fractures, created with a disk in single-rooted teeth. Accuracy of the EAL was evaluated by comparing the measurements with those made using a size 10 file. Data were analysed with the non-parametric Passing and Bablok method.

Results For simulated horizontal fractures, the EAL measured exactly the same length as a size 10 file, without constant or proportional errors. In vertical simulated fractures, the EAL measured (on average) with a constant error of 7.5 mm shorter than the size 10 file; the difference had a wide confidence interval (−72.3 to 2.6 mm).

Conclusions In this laboratory study, the Justy II EAL was able to determine accurately the position of simulated horizontal fractures, but was unreliable when measuring simulated vertical fractures.

Keywords: electronic apex locator, endodontics, horizontal root fractures, vertical root fractures.

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Introduction

To achieve success in root canal treatment, it is important to determine accurately the canal length (Weine 1996). Unfortunately, neither tactile perception nor radiographs produce objective or accurate measurements of canal length (Pallarés & Faus 1994, Pratten & McDonald 1996, Steffen *et al.* 1993).

Electronic apex locators (EAL) were unreliable when first introduced, and are difficult to use when fluids are present in the canal (Huang 1987, Fouad *et al.* 1993). Third-generation EALs use the 'ratio method' for estimating the canal length by measuring the impedance of the canal contents with at least two currents of different frequencies, and by calculating the quotient of impedances that is used to indicate the position of the file inside the canal. This measurement is reliable and objective (Fouad 1993, Czerw *et al.* 1995, Kobayashi 1995, Vajrabhaya & Tepmongkol 1997, Ounsi & Haddad 1998, Pagavino *et al.* 1998). Various authors have confirmed the efficacy of EALs to detect radicular perforations (Nahmias *et al.* 1983, Kaufman *et al.* 1997) and lateral canals (Goldberg *et al.* 2001).

Because of the physical principles on which they are based, EALs should detect and record horizontal root fractures and root fractures or fissures reaching the pulpal chamber. EALs would theoretically mark 'apex' from the beginning of the defect because of the periodontal connection.

The objectives of this study were (i) to measure with an EAL the position of simulated simple horizontal fractures and to compare it with the real measurement; and (ii) to determine whether an EAL was able to determine

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the position of fracture in roots with simulated vertical fractures.

Materials and methods

The EAL used in this study was a Justy II (Yoshida Dentcraft, Tokyo, Japan; Serial no. IH0408Jb).

Sixty-two recently extracted single-rooted teeth with no visible radicular resorptions or fractures were used. They were stored in 10% formalin and randomly assigned to one of the two groups (H, horizontal; V, vertical).

The crowns of the teeth were removed with a water-cooled diamond disk. To assure that every specimen was usable and all canals were patent, working length (up to the apical constriction (AC)) was determined with an EAL using a size 10 K-File. The resulting measurements were not used in the study.

Roots of both groups were embedded in a holder containing alginate (Alginoplast; Heraeus-Kulzer, Hanau, Germany). Each holder held 31 roots and had an appropriate zone to place the labial connector, thus establishing the circuit. Holders were flushed with water to prevent alginate desiccation and shrinkage.

In group H, an incomplete horizontal fracture was simulated with a 0.2-mm thick disk. Roots were cut until the root canal was exposed. In group V, incomplete vertical fractures were simulated by preparing a vertical straight incision through its entire length, exposing the root canal in the coronal portion.

To establish the electrical circuit, the labial clip was introduced in the alginate and the instrument clip was attached to a file. Length determination of defects was established when the indicator reached the yellow sector in the dial.

In group H, the length up to the simulated fracture was established with the EAL. The roots were then removed from the alginate, the fracture was completed with the disk and the real length was measured with a size 10 file under 2.5 × magnification (Leica MZ12, Wetzlar, Germany).

In group V, the length up to the coronal end of the simulated fracture was determined with the EAL and with a size 10 file.

Measurements with the file and EAL for each group were compared using the Passing and Bablok regression method (Passing & Bablok 1983; MedCalc 5.00.13 for Windows; Medcalc Software, Mariakerke, Belgium). In calculations, the EAL measurements were considered to be the dependent variable and the file measurements were considered to be the independent one, as is given in the formula EAL = $\alpha + \beta \cdot$ File + ε.

Table 1 File-Justy II differences and their percentage distribution per group

	Type of fracture			
	Horizontal		Vertical	
Difference (mm)	*n*	%	*n*	%
−1.0	1	3.2	–	–
−0.5	1	3.2	–	–
0	23	74.2	–	–
0.5	5	16.1	–	–
1.0	1	3.2	–	–
2.0	–	–	1	3.2
3.0	–	–	2	6.5
3.5	–	–	2	6.5
4.0	–	–	2	6.5
4.5	–	–	1	3.2
5.0	–	–	2	6.5
6.0	–	–	1	3.2
7.0	–	–	3	9.7
7.5	–	–	2	6.5
8.0	–	–	1	3.2
8.5	–	–	2	6.5
9.0	–	–	3	9.7
10.0	–	–	1	3.2
10.5	–	–	1	3.2
11.0	–	–	2	6.5
11.5	–	–	1	3.2
12.0	–	–	1	3.2
12.5	–	–	3	9.7
Total	31	100	31	100

n, Number of cases.
%, Percentage in each group.

Results

Differences between measurements and their percentage distribution obtained with the file and with the EAL are shown in Table 1. Results for the Passing and Bablok regression are shown in Table 2. Regression results for the H group was EAL = File and for the V group, it was EAL = −7.5 + File.

In 74.2% of the horizontal fractures, the EAL measured exactly the same distance as the size 10 K-File (Fig. 1). In 19.7% of the cases, this measurement showed a 0.5 discrepancy.

For the vertical fractures, the EAL method produced an intrinsic underestimation of distances of

Table 2 Passing and Bablock regression results

	Intercept (α; 95% CI)			Slope (β; 95% CI)		
Group	Value	Lower	Higher	Value	Lower	Higher
Horizontal	0	0	0	1	1	1
Vertical	−7.5	−72.3	2.6	1	0.13	6.5

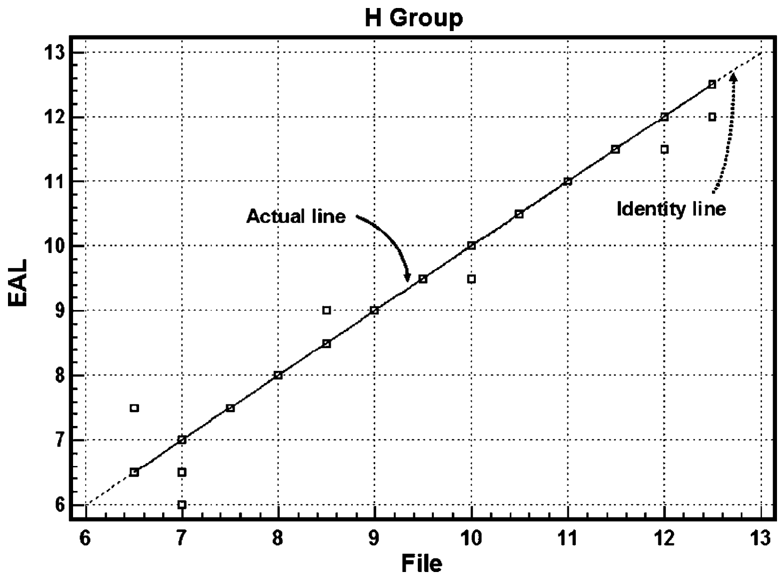

Figure 1 Passing and Bablok regression (horizontal group). Identity (dotted) and actual (continuous) regression lines are superimposed.

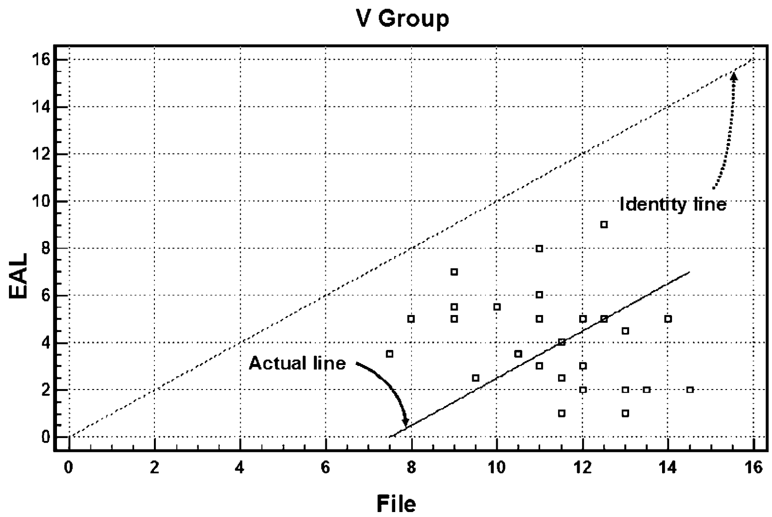

Figure 2 Passing and Bablok regression (vertical group). Identity (dotted) and actual (continuous) regression lines are parallel (no proportional error) and distant (constant error).

approximately 7.5 mm on average (Fig. 2). The 95% CI of this estimation was −72.3 to 2.6.

Discussion

In vitro studies on the accuracy of EALs are problematic, as the human periodontium is excluded. To minimize drawbacks, a number of experimental models have been proposed. One model (Donnelly 1993, Czerw *et al.* 1994, Jenkins *et al.* 2001) used a 0.9% sodium chloride solution in a plastic container. Kaufman *et al.* 1997) developed the alginate model, which was also used in other studies (Pallarés & Faus 1994, Fuss *et al.* 1996). Alginate is a good medium to establish the necessary electric circuit for a correct EAL measurement, because it mimics well the electric impedance of the human periodontium (Kaufman 1997).

From a theoretical point of view, EALs would mark the first zone having a periodontal communication as the 'apex', rather than marking the true foramen. This communication could be a fracture, a fissure, a perforation (Pallarés & Faus 1994, Fuss *et al.* 1996) or a lateral canal.

In this study, all fractures were simulated with a disk, producing an incomplete fissure of approximately 0.2 mm. Of course, the clinical situation may differ in that fractures or fissures are probably narrower and may be oblique. So, it is still unclear how accurate the EALs would be in horizontal or oblique narrow fissures or fractures, with minimum separation of fragments.

Accuracy is generally accepted as the ability of a variable to indicate what it is intended to measure. In this study, the accuracy of an EAL under laboratory conditions, as well as the bias because of the instrument itself, was established. This was accomplished using a 'gold standard', universally accepted as accurate: the measurements with the K-file. Although EAL is widely used, there is no information about the concordance of its measurements with such a golden rule.

Clinical experience demonstrates that there are some circumstances where EALs indicate 'apex' when just entering the root canal. Extensive carious lesions or metallic restorations usually cause this abnormality. However, in the absence of disease or a restoration, a vertical fissure or fracture may be present.

In horizontal fractures, the EAL was accurate. However, in simulated vertical fractures, the EAL was unreliable in determining the position of the defect. The EAL identified the apex consistently shorter than the file.

Conclusions

In this laboratory study:

1 The Justy II EAL was able to determine accurately the position of simulated horizontal root fractures.

2 The Justy II EAL was unreliable in determining the position of simulated vertical root fractures.

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