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ORIGINAL ARTICLE

Working Length Determination in Simulated Apical Resorption and Horizontal Root Fracture Using Root ZX and a Novel Integrated Apex Locator: A Comparative Study

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ABSTRACT

Aim: The current study aimed to compare the efficacy of working length measurement in different simulated clinical scenarios-apical root resorption and horizontal root fracture using a new integrated apex locator SCM 008 (Fanta dental materials) and ROOT ZX (J Morita).

Materials and methods: Forty recently extracted single-rooted mandibular premolar teeth were taken. Allotted into two major groups under two apex locators. Each group was subdivided into two, based on the different simulated conditions. In horizontal root fracture group, an oblique notch was made on the external root surface 8 mm from the anatomic apex. To simulate apical root resorption, an irregular defect was drilled at the apex with a round bur. Teeth were embedded in a customized holder containing alginate simulating the periodontal ligament. Electronic measurements were taken and compared.

Statistical analysis: One sample t-test.

Results: Though values were more accurate in the case of Root ZX, the result obtained was not significant statistically.

Conclusion: In the case of both horizontal fracture and apical resorption, Root ZX and the new integrated apex locator could perform with superior efficacy in the given experimental conditions.

Keywords: Apex locator, Apical resorption, Horizontal fracture, Working length.

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INTRODUCTION

Identification of exact working length and maintaining the estimated length is a challenging step during pulp space therapy. This is to ensure a strict check on the potential for inflammation and tissue destruction, along with a reduction in foreign-body reactions.[1] In case of root canals with necrotic pulps and apical periodontitis, instrumenting short of the working length can lead to persistence of infection and consequently diminished success rates. Similarly, overinstrumentation results in widening of the minor constriction, injury to the apical tissues, apical extrusion of infected debris and violation of the apical binding point for the root filling. This will also adversely affect the outcome of pulp space therapy leading to failure.[2] Estimation of working length by tactile sensation alone is not preferable. The radiographic method is suggested as an appropriate option.[3] Though radiographs still remain an important diagnostic aid, they possess several demerits such as frequent overestimation of working length, hazards of ionizing radiation and errors of superimposition being a representation of a three-dimensional (3D) object in two dimensions.[4]

Electronic apex locators (EAL) serve as an adjuvant to conventional radiographic method to aid in the calculation of working length. Studies regarding the efficacy of these apex locators have yielded conflicting results. Among the vast array of apex locators available at present, one successful candidate showing consistently good results in either *in vitro* or *in vivo* studies is the root ZX apex locator (J Morita, Tokyo, Japan). It generates an impedance ratio between 500 Hz and 8 KHz for gauging root canal length. Its reliable accuracy has been undisputedly proved by various studies over the years.[5]

Often there are chances for the working length to vary during instrumentation, and hence constant monitoring of working length becomes vital during pulp space preparation. This is especially true in curved canals. There will be heightened removal of dentine from the inner walls of the curved canal by the endodontic instruments that tends to straighten the root canal.[6] Any error at this point can lead to increased chance of over-instrumentation or underinstrumentation. To prevent

this, a combination of EAL and low-speed endodontic handpieces have been introduced which has an additional benefit of determining working length during canal shaping.[7] These devices were developed with inbuilt torque control and speed settings. Few examples are TriAuto ZX, Dentaport ZX, etc. In the present study, a recently introduced Integrated apex locator by Fanta Dental Materials has been used.

Apex locators must be efficient enough to provide correct readings in different challenging situations which will ultimately help the endodontist in achieving a perfect seal. In this study, two such situations are considered–apical root resorption and horizontal fracture. When a tooth has been involved in a traumatic episode and chronic inflammation of the pulp or periodontal tissue or both, there is possibility for apical resorption to occur. In such an instance if the apical constriction has been pathologically altered it may be difficult to establish the working length.[8] Often the coronal segment of the pulp of teeth with fractured roots will become nonvital with time in the case of horizontal fracture. Here apical root canal segment must be left untreated and endodontic therapy should be done up to the fracture line. Angulation of the fracture plane makes determination of the working length an even greater challenge. Radiographic interpretation is difficult because of buccopalatal bevel often present.[9]

Thus the aim of the present study was to compare the efficacy of root ZX apex locator and the new integrated apex locator in two simulated clinical conditions—apical resorption and horizontal fracture.

MATERIALS AND METHODS

Sample Preparation

Forty intact single-rooted mandibular premolar teeth were selected (Fig. 1). Ultrasonic scalers were used to clean the root surfaces. To dissolve any tissue on the root surface, teeth were immersed in 5.25% sodium hypochlorite solution for 24 hours. Twenty teeth were selected randomly. An irregular defect was created at the apex using a round bur to simulate apical resorption (Fig. 2). In the labial surface of the apical third of the remaining samples, an incomplete oblique notch (approximately 45°) was created using a 0.2 mm diamond disk under constant water cooling to simulate oblique root fracture. The notch was created 8 mm from the anatomic root apex (Fig. 3). The length was standardized to 15 mm in case of apical resorption samples and 11 mm in horizontal fracture samples by grinding the occlusal surfaces. All samples were then numbered for identification purposes. Standard access cavities were prepared with an Endoaccess bur. The patency of the canals was verified using No. 10 K file. Irrigation was done using 5.25% NaOCl, 17% ethylenediaminetetraacetic acid (EDTA) and finally with saline. Pulp chambers were dried using cotton pellets.

Total samples were allotted into two groups I and II (n = 20) based on the Apex locators (Root ZX and Fanta

Fig. 1: Total samples

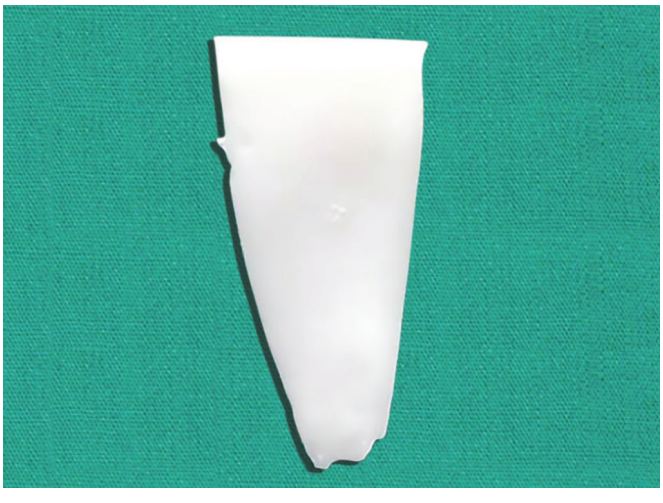

Fig. 2: Simulated apical resorption

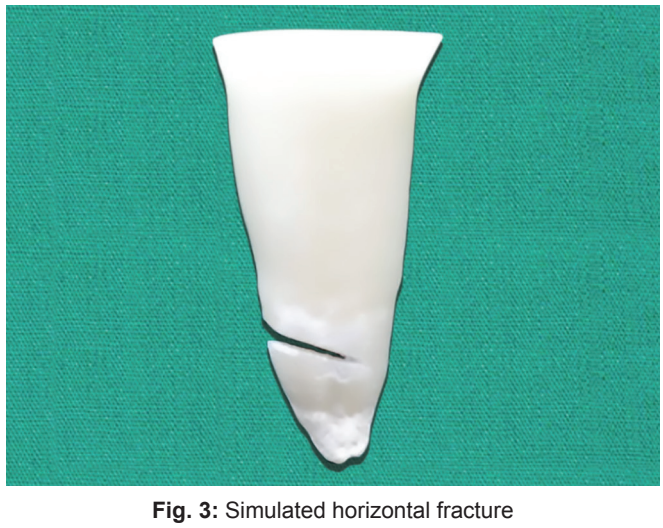

Fig. 3: Simulated horizontal fracture

SCM 008). Each group was further subdivided into two (IA, IB, IIA, IIB) based on the simulated clinical situation (apical resorption and horizontal fracture). Freshly mixed alginate impression material (Zelgan 2002, Dentsply) was poured into a small plastic container. This acted as an electroconductive medium. Four such customized holders were made. Roots of 10 teeth (representing a group) and lip clip of the apex locator used in that group were inserted into the alginate in each holder.

The samples were grouped as follows:

- *Group IA:* Working length in samples with apical resorption was measured using root ZX apex locator (Fig. 4)
- *Group IB:* Working length in samples with horizontal root fracture was measured using root ZX (Fig. 5).

Working length was measured using a no: 10 K file connected to the file clip of EAL, which was inserted slowly inside the canal in each sample.

- *Group IIA:* Working length in samples with apical resorption was measured using the integrated apex locator (Fig. 6).
- *Group IIB:* Working length in samples with horizontal root fracture was measured using Integrated Apex locator (Fig. 7)

Canals were enlarged until no. 15 K file fit loosely. Protaper S1file was connected to the file clip of EAL and was advanced slowly into the canal in each sample until the display showed the apex was reached.

RESULTS

Mean values of the working length in all the groups were calculated (Table 1).

The statistical significance of the difference of values of the two apex locators was calculated using one sample t-test. As p-value was greater than 5% in all cases, the result showed no significant difference.

In this study, the tolerance limit was kept as ±0.5 mm. Based on this, accuracy of both apex locators was calculated (Tables 2 and 3).

Maximum accuracy was seen with root ZX in both apical resorption and horizontal fracture, but the difference was not relevant statistically.

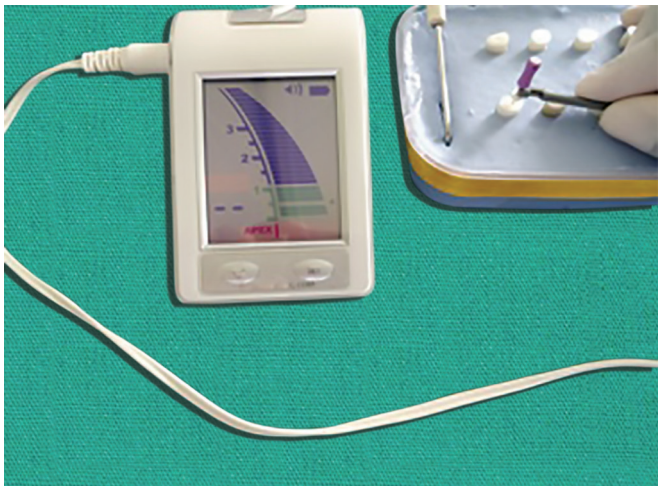

Fig. 4: Working length calculation in apical resorption using root ZX

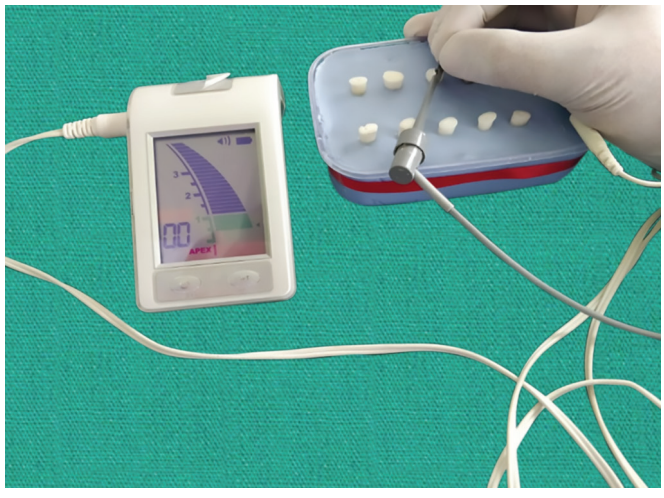

Fig. 5: Working length calculation in horizontal fracture using root ZX

Fig. 6: Working length calculation in apical resorption using integrated apex locator

Fig. 7: Working length calculation in horizontal fracture using Integrated apex locator

Table1: Mean values of working length measurements

Modes	*Mean ± Sd (Horizontal fracture)*	*Mean ± Sd (Apical resorption)*
Root ZX	10.9700 ± 0.3654	14.0500 ± 0.6503
Integrated apex locator	10.9900 ± 0.4691	13.8000 ± 0.5669

Table 3: Accuracy rates in horizontal fracture

Accuracy	*Root ZX (n%)*[10]	*Integrated Apex locator (n%)*[10]
Accurate (0.5 mm tolerance)	8/80	7/70
Non-accurate	2/20	3/30
Long*	2	1
Short**	–	2

*Overextension
**Underextension

DISCUSSION

Exact determination of root canal working length is a prerequisite for proper cleaning and shaping which will eventually lead to the success of endodontic treatment.[10] Currently, EAL has become an indispensable device used to aid in determining the working length. Kuttler and Green have established that the apex coincides with the anatomical foramen no more than 50% of the time. This diminishes the significance of radiographs, even if the quality is excellent.[11]

Rather than marking the true foramen, EALs would mark the first zone having a communication with the periodontium as the 'apex'.[12] Kobayashi et al. introduced the ratio method and played an instrumental role in the introduction of the unique root ZX apex locator (J Morita, Tokyo, Japan).[13] The most recent innovation of root ZX uses multiple frequencies and can be classified under fourth generation EAL.[10] It has been extensively tested *in vivo* and ex vivo and has become the gold standard to which new devices are compared.[14] Former studies have used an error range of ± 0.5 mm to assess the efficacy of the EAL. Measurements obtained within this tolerance are considered highly accurate. Plotino et al. reported that root ZX showed 97.4% accuracy within ± 0.5 mm in determining working length.[15] Goldberg et al. have obtained 95% accuracy with Root ZX.

Integrated apex locators are a more convenient approach in apex locators where a combination of the endodontic handpiece and apex locator is built in a single unit. Various studies evaluating the efficacy of these apex locators were done, and results show they are no less efficient than conventional apex locators.

TriAuto ZX, an integrated apex locator having a Root ZX unit within it, showed 70% accuracy at 0.5 mm tolerance, according to Alves et al.[16] While another study by Stoll et al. showed higher accuracy of 97.4% for integrated apex locator Dentaport ZX.[17]

Table 2: Accuracy rates in apical resorption

Accuracy	*Root ZX (n%)*[10]	*Integrated Apex locator (n%)*[10]
Accurate (0.5 mm tolerance)	9/90	8/80
Non-accurate	1/10	2/20
Long*	1	–
Short**	–	2

*Overextension
**Underextension

Variations from normal situations can bring about change in the accuracy of these equipments. Horizontal fractures and root resorptions are routinely seen during endodontic treatment of pathological conditions and in victims of road traffic accidents. Various articles have evaluated efficacy of apex locators in these adverse situations.

In a previous study by Sreenivasan et al.[18] examining accuracy of apex locators in horizontal fracture, an accuracy of 63.3% with Root ZX in oblique fractures was obtained. During apical resorption, in a study by Goldberg et al., Root ZX showed the accuracy of 62.7% within 0.5 mm of the direct visual measurements.

In present study, we compared the accuracy of root ZX with a new integrated apex locator introduced by Fanta Dental Materials. An accuracy of 80% (within ± 0.5 mm) was obtained in the case of root ZX and 70% for Integrated apex locator in case of horizontal fracture. The 90% accuracy was seen with root ZX in apical resorption and 80% in integrated apex locator. But there was no statistically significant difference in both cases. This is similar to results obtained by Suman et al. who got a result of 66.6% accuracy with Dentaport ZX in apical resorption when they compared it with Propex II.

In this study, an alginate model was used to simulate periodontal ligament, as proposed by Kaufman et al.[19] Alginate being a commonly used embedding media for *in vitro* assessments of working length using EAL possess the advantages of good electrical conductivity and matching electrical impedance with the human periodontium. It is also compatible with different irrigation solutions. In the present study, alginate was mixed in a very fluid consistency, to allow it to flow into the fracture and resorption site.

CONCLUSION

Within the limitations of this study, it can be concluded that:

- In situations like apical resorption and horizontal root fracture, Root ZX showed most accurate results.
- The new integrated apex locator was also equally effective.

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