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# Comparative Evaluation of Accuracy of Four Different Electronic Apex Locators in Working Length Determination in Teeth with Irreversible Pulpitis - An in Vivo Study

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**Abstract:** ***Aim: The purpose of this clinical study is to compare and evaluate the accuracy of four different apex locators with intraoral periapical (IOPA) radiograph in multirooted teeth with and without rubber dam isolation. Methods and materials: Eighty Canals in multirooted teeth were selected for this clinical study. After anesthesia and endodontic access cavity preparation, the orifices of root canals were irrigated with 2ml of 3% sodium hypochlorite solution. Working length determination was done using #10 k file. Canals were divided into two groups and 8 subgroups. Group-1 with rubber dam isolation and Group-2 without rubber dam isolation. Apex locators: Dentaport ZX, E-pex Pro, Romiapex A-15, Raypex-6 were used to determine the working length with and without isolation in each subgroup. Statistical analysis: Student Paired t Test and McNemar's Test. Results: Dentaport ZX has given the highest accuracy with and without isolation, followed by Romiapex A-15 and E-pex pro without isolation. Conclusion: Dentaport ZX is a promising apex locator with and without isolation.***

**Keywords:** Dentaport ZX, Epex Pro, Romiapex A-15, Raypex-6

## 1. Introduction

The removal of infected pulp tissue, necrotic material, and microorganisms from the root canal system is essential for endodontic success. This can be achieved if the length of the root canal is determined with accuracy.[1]

Electronic apex locators have been developed with the aim of increasing the success of endodontic treatment and reducing disadvantages associated with conventional radiography.[2] Cluster (1918) was the first to determine working length electronically. Suzuki (1942) investigated the electrical resistance produced by the oral tissue and developed first electronic apex locator. The device was resistance based and measured the resistance between two electrodes to determine location of instrument in root canal. Later devices were impedance based (Nekoofar etal.2006) and used multiple frequencies. More recently resistance and capacitance based emerged that measures resistance and capacitance independently.[3]

Dentaport ZX (J. Morita Corp, Tokyo, Japan) is a third generation EAL that uses the "ratio method" to measure the root canal length. This method measures impedence values at two frequencies (8 KHz and 0.4 KHz) claims to work in the presence of electrolytes & non electrolytes.[4]

Romiapex A-15 (Romidan Ltd, Kiryat Ono, Israel) is a third generation EAL measures the working length by calculating the mean square root values of the impedance at two different frequencies (0.5 and 8.0 kHz), measured separately.[5]

Raypex-6 (VDW, Munich Germany) is a fifth generation EAL has been developed based on comparison of impedance with different frequencies.[6]

E-pex Pro is a fourth generation EAL. It works on advanced multiple frequency network impedance measurement technology. High precision in apical foramen localization in wet and dry canals.

In the present clinical study, the accuracy of the above apex locators was determined with and without isolation in same subjects.

## 2. Materials and Methods

The study was conducted in Department of Conservative Dentistry and Endodontics at P. M. N. M Dental College and Hospital Bagalkot, Karnataka.

Canals of 80 multirooted teeth with irreversible, infected or necrotic pulp tissue and completely formed roots were


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included in the study. Patients using cardiac pacemakers, who had a contributory medical history and teeth with no apical patency, radiographic evidence of resorption and bone loss were excluded from this study.

Canals of multirooted teeth of same subjects were divided into two groups and eight subgroups and working length determination (W. L) was done.

**Group-1** With Rubber dam isolation:
- Sub group-1 W. L with DENTAPORT ZX (n=20)
- Subgroup-2 W. L with E-PEX PRO (n=20)
- Subgroup-3 W. L with ROMIAPEX A 15 (n=20)
- Subgroup-4 W. L with RAYPEX-6 (n=20)

**Group – 2** Without Rubber dam isolation:
- Sub group-5 W. L with DENTAPORT ZX (n=20)
- Subgroup-6 W. L with E-PEX PRO (n=20)
- Subgroup-7 W. L with ROMIAPEX A-15 (n=20)
- Subgroup-8 W. L with RAYPEX-6 (n=20)

Teeth were anesthetized with 2% lignocaine, endodontic access cavity was made and a straight line access to the root canals was achieved. The orifices of the root canal were irrigated with 2ml of 3% sodium hypochlorite solution and the excess was removed from the pulp chamber with cotton pellet. No attempt was made to clean pulp tissue remnants before introducing K file. Following preparation of access cavity, apex locators were used to determine the working length.

Electronic measurements were made with #10 K file with firm silicone rubber stopper for every canal and was advanced till signal was given to indicate apex. The following signal was used as an indication for accurate working length with apex locators.

Dentaport ZX - Green line just in the middle of apex and marks 1 which corresponds to 0.5mm short of radiographic apex.

Raypex-6 - Third green line, just before the Yellow lines, which corresponds to 0.5mm short of radiographic apex.

Romiapex A-15-Green bar which corresponds to 0.5mm short of radiographic apex.

E-Pex Pro-Green indicated strips at 00 mark which corresponds to 0.5 mm short of radiographic apex.

The confirmation of accurate working length was done using conventional radiograph, which is considered as gold standard method.

## 3. Statistical Analysis

Statistical analysis was done using Student Paired t Test and McNemar's Test.

## 4. Results

Dentaport ZX – Without rubber dam isolation showed 90% accuracy, with rubber dam isolation showed 95% accuracy.
Romiapex A-15-Without rubber dam isolation showed 75% accuracy, with rubber dam isolation showed 90% accuracy.
E-pex Pro-Without rubber dam isolation showed 75% accuracy, with rubber dam isolation showed 85% accuracy.
Raypex-6 – Without rubber dam isolation showed 60% accuracy, with rubber dam isolation showed 75% accuracy.

## 5. Discussion

Correct determination of working length is a crucial step for the success of endodontic treatment. Working length is defined as the distance from a coronal reference point to the point which canal preparation and filling should terminate. Traditional methods of determining the working length includes the use of anatomic averages and knowledge of anatomy, tactile sensation, paper point method, apical periodontal sensitivity, radiography, electronic apex locators.[7]

The use of an electronic apex locators to determine the working length has gained in popularity. Even though the clinician must be aware of the possible sources of error (metallic restorations, salivary contamination, dehydration etc), studies have shown that accuracy of electronic apex locators are superior to radiographs.[8, 9] Electronic apex locators are particularly useful when the apical portion of the canal system is obscured by certain anatomic structures such as impacted teeth, tori, zygomatic arch, excessive bone density, overlapping roots and shallow palatal vaults. Electronic apex locator helps to reduce the treatment time and radiation dose, which may higher with conventional radiographic measurements.[10]

The concept of isolating teeth undergoing root canal treatment was first introduced 150 years ago.[11] Proper isolation using rubber dam provides accurate working length in electronic apex locators. Isolation with rubber dam placement provides a dry and sterile operative field and also prevents hemorrhage from gingiva, does not interfere with working length determination.

Intact vital tissues, inflammatory exudates and blood can conduct electric current and cause inaccurate readings in electronic apex locators. Electronic apex locator works best in relatively dry environment. But extremely dry canals results low readings. So, proper isolation provides better and quality treatment.

In the present study, working length determination with four different electronic apex locators was done under with and without rubber dam isolation. Since isolation with rubber dam is more time consuming procedure, most of the practitioners do not perform root canal treatment under rubber dam isolation.

In the present study, working length determination was done by using four different apex locators, with and without rubber dam placement. Apex locators which were used in the present study includes Dentaport ZX, Romiapex A-15, E-pex Pro, Raypex-6 (Figure 1 & 2)


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**Figure 1**
A) Dentaport ZX B) Romiapex A-15
C) Raypex-6 D) E-pex Pro



**Figure 2**
A) With rubber dam isolation
B) Without rubber dam isolation

Dentaport ZX is a third generation apex locator uses ratio method to measure the root canal length. These units have more powerful microprocessors and are able to process the mathematical quotient and algorithm calculation required to given accurate readings. The device operates most accurately when canal is filled with electrolyte (saline/ Naocl) and non electrolyte.[12]

Romiapex A-15 is a third generation apex locator based on comparison of mean square root levels of two signals at 8 and 0.5kHz.[13]

E-pex Pro is a fourth generation apex locator. It is based on technology of multiple frequency, and impedance measurement.[14] this electronic apex locator determine impedance at five frequencies. It claims to work in wet and dry canals.

Raypex-6 is a fifth generation apex locator has been developed based on comparison of impedance with different frequencies. They have best accuracy in root canal condition (dry, wet, bleeding, EDTA, NAOCL).[15, 16] during clinical work it is noticed that accuracy of electronic root canal length measurement varies with pulp and periapical condition.[17]

This study, however, was a true reproduction of what occurs during routine endodontic treatment. Radiographs are universally accepted, easily available, and meaningful method of working length assessment in the clinic. In the present study, Ingle's method of radiographic measurement was taken and all the values of electronic apex locators were compared.

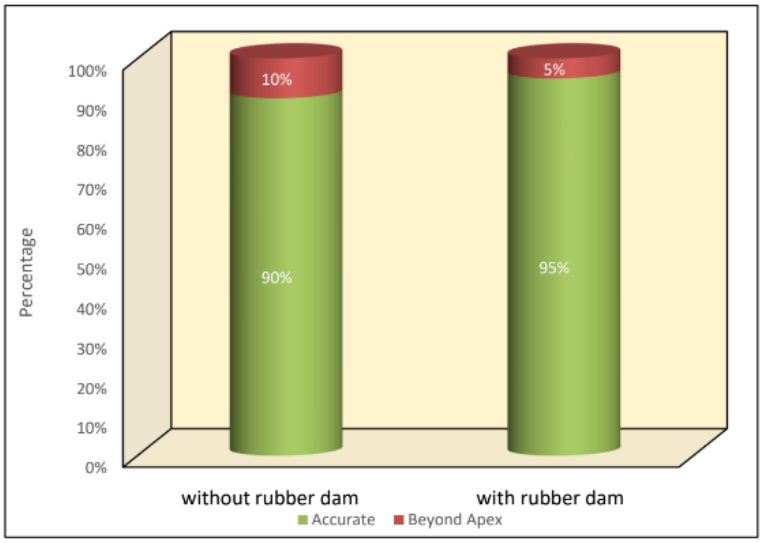
In the present study, Dentaport ZX has shown highest accuracy in working length determination with and without rubber dam placement and Raypex-6 have shown the least accuracy. (Tables 1 & 2) (Graphs 1 & 2)


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**Table 1:** Comparison of mean working length (in mm) between radiographic and different apex locator's measurements without and with rubber dam isolation using Student Paired t Test

| Groups | Time | N | Mean | SD | Mean Diff | P-Value |
|---|---|---|---|---|---|---|
| Dentaport ZX (Sub group-5) | Radiograph | 20 | 19.75 | 1.41 | - 0.05 | 0.54 |
| | Without Rubber Dam | 20 | 19.80 | 1.45 | | |
| (Sub group-1) | Radiograph | 20 | 19.75 | 1.41 | - 0.02 | 0.33 |
| | With Rubber Dam | 20 | 19.78 | 1.39 | | |
| Romiapex A-15 (Sub group-7) | Radiograph | 20 | 19.93 | 1.71 | 0.38 | 0.03* |
| | Without Rubber Dam | 20 | 19.55 | 1.99 | | |
| (Sub group-3) | Radiograph | 20 | 19.93 | 1.71 | | |
| | With Rubber Dam | 20 | 19.90 | 1.74 | 0.03 | 0.33 |
| E-Pex Pro (Sub group-6) | Radiograph | 20 | 19.03 | 1.74 | 0.42 | 0.02* |
| | Without Rubber Dam | 20 | 18.60 | 1.59 | | |
| (Sub group-2) | Radiograph | 20 | 19.03 | 1.74 | | |
| | With Rubber Dam | 20 | 19.10 | 1.73 | - 0.07 | 0.08 |
| Raypex-6 (Sub group-8) | Radiograph | 20 | 19.63 | 1.46 | 0.55 | 0.01* |
| | Without Rubber Dam | 20 | 19.08 | 1.70 | | |
| (Subgroup-4) | Radiograph | 20 | 19.63 | 1.46 | 0.32 | 0.03* |
| | With Rubber Dam | 20 | 19.30 | 1.56 | | |

*-Statistically Significant

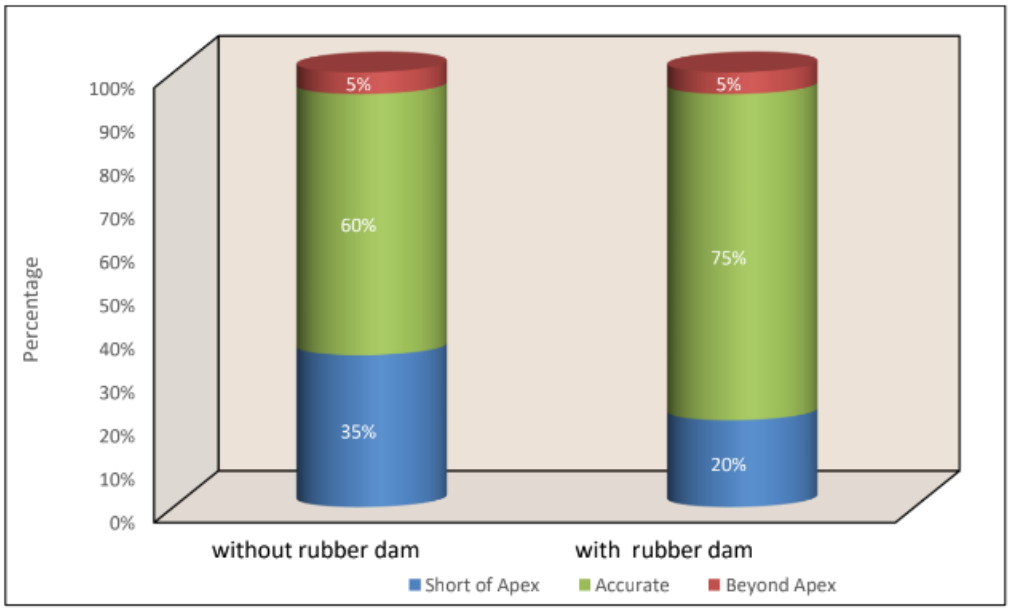



**Graph 1:** Working length status without and with rubber dam placement in Dentaport ZX group

**Table 2:** Comparison of mean working length (in mm) between radiograph and different apex locator's measurements without and with rubber dam isolation using McNemar's Test

| Dentaport ZX Working Length | Without Rubber Dam | | With Rubber Dam | | P-Value |
|---|---|---|---|---|---|
| | n | % | n | % | |
| Short of Apex | 0 | 0% | 0 | 0% | 0.90 |
| Accurate | 18 | 90% | 19 | 95% | |
| Beyond Apex | 2 | 10% | 1 | 5% | |
| Romiapex A-15 Working Length | Without Rubber Dam | | With Rubber Dam | | P-Value |
| | n | % | n | % | |
| Short of Apex | 5 | 25% | 2 | 10% | 0.25 |
| Accurate | 15 | 75% | 18 | 90% | |
| Beyond Apex | 0 | 0% | 0 | 0% | |
| E-Pex Pro Working Length | Without Rubber Dam | | With Rubber Dam | | P-Value |
| | n | % | n | % | |
| Short of Apex | 4 | 20% | 2 | 10% | 0.16 |
| Accurate | 15 | 75% | 17 | 85% | |
| Beyond Apex | 1 | 5% | 1 | 5% | |
| Raypex-6 Working Length | Without Rubber Dam | | With Rubber Dam | | P-Value |
| | n | % | n | % | |
| Short of Apex | 7 | 35% | 4 | 20% | 0.08 |
| Accurate | 12 | 60% | 15 | 75% | |
| Beyond Apex | 1 | 5% | 1 | 5% | |


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**Graph 2:** Working length status without and with rubber dam placement in Raypex-6 group

Moscoso et al. (2014) compared in-vivo accuracy of Dentaport ZX and Raypex-6. It was reported that there were no statistically significant differences were observed between the performance of Dentaport ZX and Raypex-6 under clinical condition[18].

Stavrianous et al. (2007) compared the accuracy of working length determination of Dentaport ZX and Raypex-4 under clinical condition. He reported that Dentaport ZX detected apical foramen in 97.5% cases and Raypex-4 in 95% cases.[19]

Sommal et al. (2012) compared the in vivo accuracy of three electronic root canal length measurement devices Dentaport Zx, Raypex-5, Propex II and concluded that there was no significant differences in terms of locating major foramen.[20]

Batista et al. (2016) analysed the ex-vivo accuracy of Root ZX II, Romiapex A-15, Smar pex electronic apex locators to determine the location of apical constriction and reported that Root ZX II is more accurate than Romiapex A-15.[21]

Filho et. al (2014) evaluated the ex-vivo accuracy of electronic apex locators Root ZX II and Romiapex A-15 for working length determination in permanent teeth and concluded that Root ZX II and Romiapex A-15 had similar accuracy.[22]

Alutunbas et. al (2017) assessed the in-vitro accuracy of Dentaport ZX and Rootor apex locator in detecting root perforations in dry conditions and in the presence of irrigation solution 2.5 Naocl, Nacl, 17% EDTA. It was found that Dentaport ZX was accurate compared with Rootor in the presence of different irrigant.[23]

Vaid et al. (2015) compared the accuracy of Root ZX II and Root ZX mini in the presence of QMix, 7% Maleic acid, 2.5% Sodium hypochlorite. He reported that QMix does not affect the accuracy of apex locators. Root ZX II is more accurate than Root ZX Mini apex locator in presence of 7% Maleic acid and 2.5% Sodium hypochlorite.[24]
Dentaport ZX has shown highest accuracy in working length determination. It is a third generation apex locator that uses ratio method to measure the root canal length. Ratio method works on the principle that two electric currents with different sine wave frequencies will have measureable impedances that can be measured and compared as a ratio regardless the type of the electrolyte in the canal. The capacitance increases significantly and thus increases at the apical constriction and the quotient of the impedances reduces rapidly as the constriction reached. The change in electrical capacitance at the apical constriction is basis for the operation of Dentaport ZX and its reported accuracy.

To the best of our knowledge, no in-vivo studies of E-pex Pro and accuracy of 4 different apex locators with intraoral periapical (IOPA) radiograph in multirooted teeth with and without rubber dam isolation had no published data. Accuracy of apex locators without rubber dam placement could be useful information for practitioners.

## 6. Conclusion

Within the limits of this study,

Dentaport ZX can be promising electronic apex locator with and without rubber dam isolation. Romiapex A-15 and E-pex Pro have shown similar accuracy without rubber dam isolation. E-pex Pro is inexpensive than Romiapex A-15, can be helpful to practitioners as a cost benefit. Further clinical trials are recommended with large sample size.

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