

### **Determination of Working Length Using Different Methods - An In vivo Invitro Study**

<sup>1</sup>Noushad M C, Prof and HOD, Dept of Conservative Endodontics, Kannur Dental College, Kannur, Kerala

<sup>2</sup>Fathimath Suhara, Post Graduate, Kannur Dental College, Kannur, Kerala

<sup>3</sup>Kavya Maheesan, Post Graduate, Kannur Dental College, Kannur, Kerala

<sup>4</sup>Roopesh C, Reader, Kannur Dental College, Kannur, Kerala

**Corresponding Author:** Kavya Maheesan, Post Graduate, Kannur Dental College, Kannur, Kerala

**Citation of this Article:** Noushad M C, Fathimath Suhara, Kavya Maheesan, Roopesh C, “Determination of Working Length Using Different Methods - An In vivo Invitro Study”, IJDSIR- February - 2020, Vol. – 3, Issue -1, P. No. 317 – 325.

**Copyright:** © 2020, Kavya Maheesan, et al. This is an open access journal and article distributed under the terms of the creative commons attribution noncommercial License. Which allows others to remix, tweak, and build upon the work non commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

**Type of Publication:** Original Research Article

**Conflicts of Interest:** Nil

#### **Abstract**

**Aim:** The aim was to determine the accuracy in measuring the working length of root canal using tactile method, radiographic method, electronic apex locators as Root ZX mini and I Pex in vivo and comparing the length so measured to the actual working length invitro after extraction.

**Materials and methods:** The present study involved thirty patients who were scheduled to have teeth extracted with mature apices. A good quality preoperative radiograph was taken. Working length was determined using by tactile method, and Ingle’s radiographic method and by using Electronic apex locators as Root ZX mini and I Pex. After determining the working length by the three methods, the teeth were extracted carefully. Endodontic file was inserted into the root canal until the tip of the file was just visible at the apical foramen. Actual working length was determined by deducting 0.5 mm from this length. The values obtained by the different

methods were cross tabulated with the levels of coincidence of actual working length values.

**Results:** Using reliability analysis it is evident that the most accurate method for measurement before tooth extraction is the electronic method. Of the two electronic methods, the most accurate method was found to be Root ZX method followed by the Ipex method. After the electronic methods the accuracy was higher for the radiographic method. The least accurate method was found to be the tactile method

**Conclusion:** The most accurate method for working length measurement before tooth extraction is the electronic method..The tactile method was found to be least accuracy

**Keywords:** Electronic apex locator, Radiographic working length, Actual working length determination

#### **Introduction**

The success of endodontic treatment is highly dependent on the adequate three-dimensional cleaning, shaping,

disinfection, and obturation of the root canal system. It is universally accepted that the correct determination of the working length is one of the crucial step for the successful treatment .1Inaccurate determination of working length may lead to short or overextended obturation.3

The glossary of endodontic terminology of the American Association of Endodontists defines the working length as “the distance from a coronal reference point to the point at which canal preparation and obturation should terminate”3 .Classic concept of apical root anatomy is based on three anatomic and histologic landmarks in the apical region of a root: the apical constriction, the cementodentinal junction, and the apical foramen. Usually, the apical foramen opens 0.5 – 1.0 mm from the anatomical apex. Apical portion of the root canal having narrowest diameter is called apical constriction.Cementodentinal junction is the region where the dentin and cementum are united. It is a histological landmark and cannot be located clinically or radiographically. It does not always coincide with apical constriction and is located 0.5 -3mmshort of anatomic apex

Different methods have been used for locating the position of canal terminus and measuring the working length of root canals. These include radiographic methods, electronic methods, tactile method and other adjunctive methods. 6 The tactile perception is the simple and the virtual effective method, because of these factors clinicians still follow this technique. But this is inaccurate in root canals with immature apex, excessive curvature and if the canal is constricted throughout its length7Radiographic method, traditionally the most popular way for length measurement in the field of endodontics has many advantages, like direct observation of the anatomy of root canal system, number and curvature of roots and in addition acts as an initial guide for working length estimation. There are, however a

number of disadvantages like radiation hazard both to the patient and dental personnel, image distortion and observer’s bias in radiographic interpretation which may lead to errors.7

The development and production of electronic devices for locating the canal terminus have been major innovations in root canal treatment. An electronic method for root length determination was first conceived by Custer (1918) and the idea was revisited by Suzuki (1942).The electronic apex locators are equal or higher in accuracy compared with radiographic methods and this has been shown by various, in-vivo, and in-vitro studies.10

Even though electronic apex locators are considered as most reliable method, they cannot be considered a panacea for this purpose owing to their limitations. The main disadvantages of electronic apex locators are that it cannot be used in patients with, perforations, fractures of root and their accuracy in cases of immature apex, root resorption, hemorrhage and swelling are also questionable. Thus there is no consensus on the best working length determination method in the literature.

No individual technique is truly satisfactory in determining endodontic working length. Knowledge of apical anatomy, prudent use of radiographs and the correct use of an electronic apex locator will assist practitioners to achieve predictable results.10

The purpose of this study was to determine the accuracy in working length determination by using different methods tactile, radiographic, and electronic apex locators as Root ZX mini ,I pex by in vivo and comparing the length so measured to the actual working length invitro after extraction.

### **Methodology**

The present study involved thirty patients who were scheduled to have teeth extracted with mature apices. Informed written consent was obtained from each patient

before treatment. A good quality preoperative radiograph was taken employing the extension cone paralleling technique by using Rinn XCP instruments the presence of single canal is confirmed by tube shift technique. Working length was determined using by tactile method, and Ingle's radiographic method and by using Electronic apex locators as Root ZX mini and I Pex.

#### **Working length determination by tactile method**

Access opening was done under local anesthesia with rubber dam isolation followed by extirpation of pulp. The canal was irrigated using 3% sodium hypochlorite solution and finally flushed copiously with distilled water. No. 15 K-file was introduced into the canal until an increase in tactile resistance was detected.

The root canal orifices were enlarged and coronal preflaring was done with Gates Glidden drills. Rubber stop was adjusted on the file in such a way that it touches the reference point. The 15 K-file was carefully withdrawn and the distance from the tip of the file to the rubber stop was measured using a graduated metal scale; the values were noted down, two readings are recorded, mean value was taken as tactile working length.

#### **Working length determination by radiographic method [Ingle's method]**

The reference point was marked on the preoperative radiograph at the incisal edge, and the tooth length was measured using a graduated metal scale from the reference point to the radiographic apex; the measurements were then recorded. A file with a length 1 mm less (safety factor) than the tooth length as noted from the preoperative radiograph was kept in the root canal and another radiograph was taken. On the radiograph, the difference between the tip of the file and the apex was measured. This amount was added or subtracted to the original measured length. From this adjusted length of tooth, 1 mm was subtracted to confirm with the cemento dental

junction, two readings are recorded, mean value was taken as radiographic working length.

#### **Working length determination by Electronic apex locator**

Two electronic apex locators are used-Root ZX Mini and I Pex apex locators. Root ZX mini was used according to the manufacturer's instructions. The clip was applied to the patients lip and no. 15 K-file was connected to the electrode of the device. Then the file was apically advanced in the canal, until it reached the previously calibrated 0.5 mm sign on the screen of the device, which is accepted as the apical constriction, two readings are recorded, mean value was taken as electronic working length.

With the iPex locator, the file was advanced until the "APEX" signal was seen on the LCD display and then withdrawn until the display showed the 0.5-mm mark. Which would signify 0.5mm short of actual working length value. Two readings are recorded, mean value was taken as electronic working length.

#### **Actual working length determination after extraction**

After determining the working length by the above three methods, the teeth were extracted carefully and placed in 3% NaOCl for 15 minutes to remove any residual organic tissue from the root. They are stored in 0.9% saline solution. Endodontic file was inserted into the root canal until the tip of the file was just visible at the apical foramen. The stopper was adjusted to the reference point and the file was withdrawn. The canal length was determined and the working length was established by deducting 0.5 mm from this length; these readings were registered as actual working length value. The values obtained by the different methods were cross tabulated with the levels of coincidence of actual working length values. The reliability analysis was also done to analyze the reliability levels of each group with the actual working

length. The working length determined by various methods were compared with the Actual working length value, and their levels of coincidence were calculated as follows

**Exact coincidence:** Zero difference between the value obtained by any of the methods and the value obtained using the AWL method.

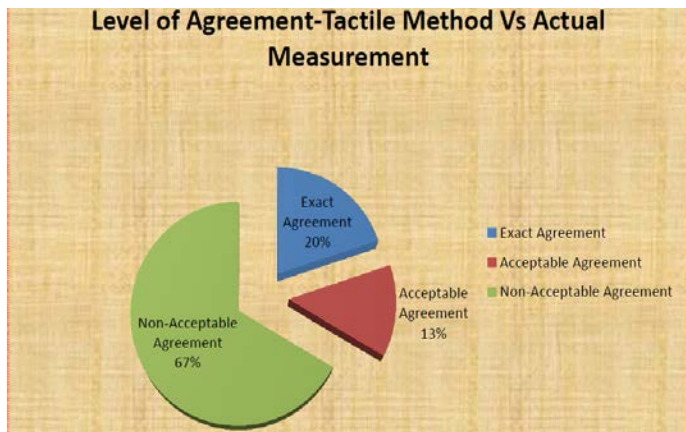
**Acceptable coincidence:** 0.5 mm short of the actual working length when compared with that obtained using AWL method.

**Non-acceptable coincidence:** >0.5 mm short of the actual working length or more than the AWL

**Result**

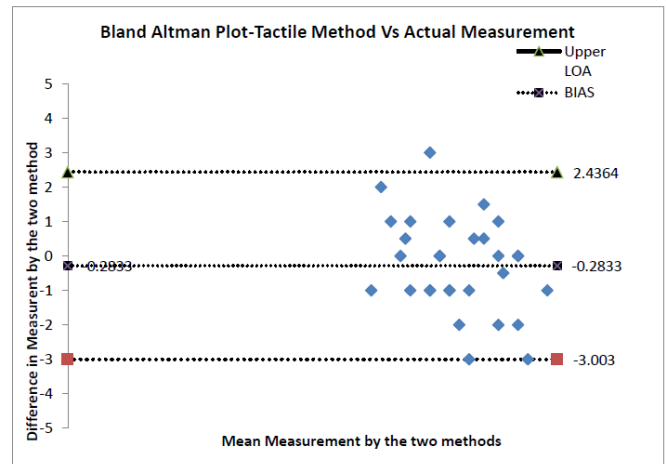
The levels of coincidence obtained by the different working length determination methods were cross tabulated and reliability analysis was done to analyze the reliability of each group with Actual working length values using the Bland- Altman plots.

Using reliability analysis it is evident that the most accurate method for measurement before tooth extraction is the electronic method. Of the two electronic methods, the most accurate method was found to be Root ZX method followed by the Ipex method. After the electronic methods the accuracy was higher for the radiographic method. The least accurate method was found to be the tactile method

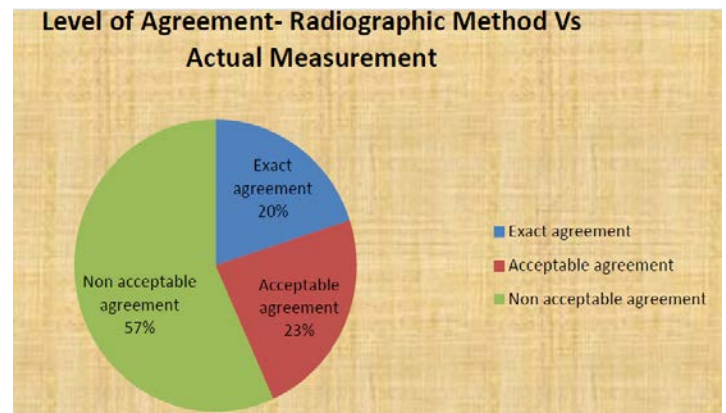


Graph: 1

Bias	-0.283333333
Std Dev	1.387650789
LOA	-3.00312888
ULA	2.436462213



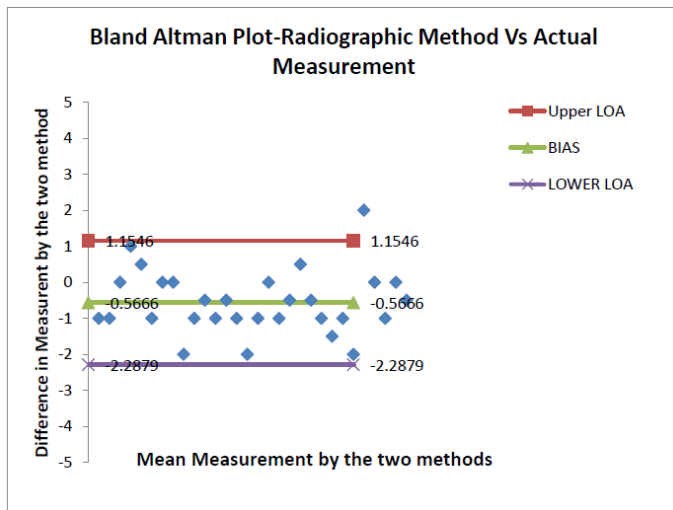
Graph: 2



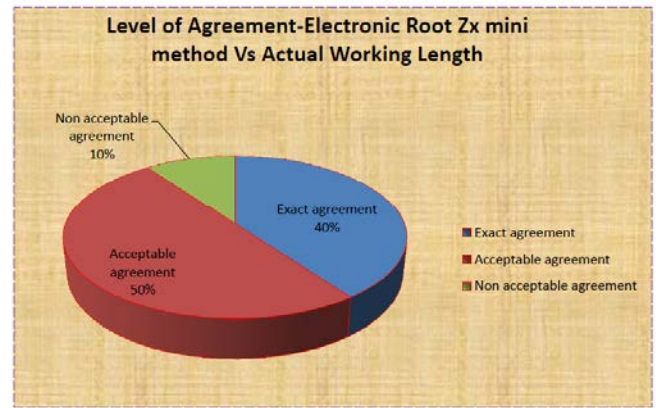
Graph : 3

Bias	-0.566666667
Std Dev	0.878216584
LOA	-2.287971171
ULA	1.154637837



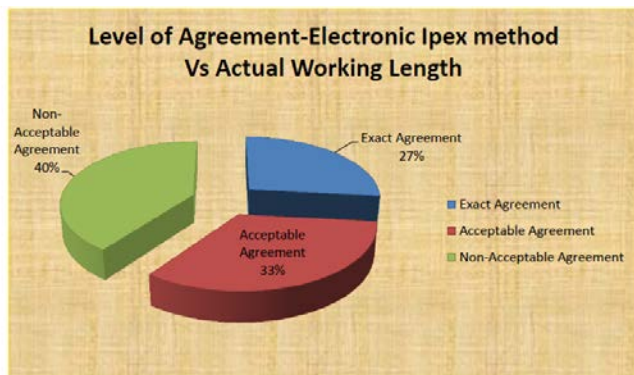


Graph: 4



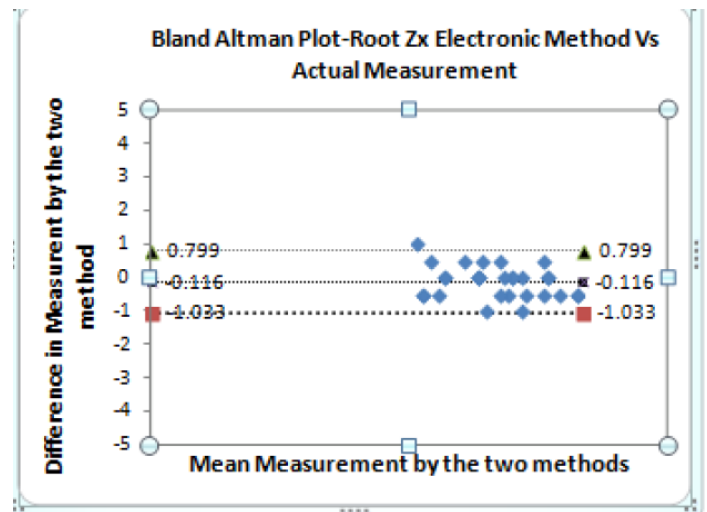
Graph: 7

Bias -0.11666667  
 Std Dev 0.467630368  
 LOA -1.033222188  
 ULA 0.799888854



Graph: 5

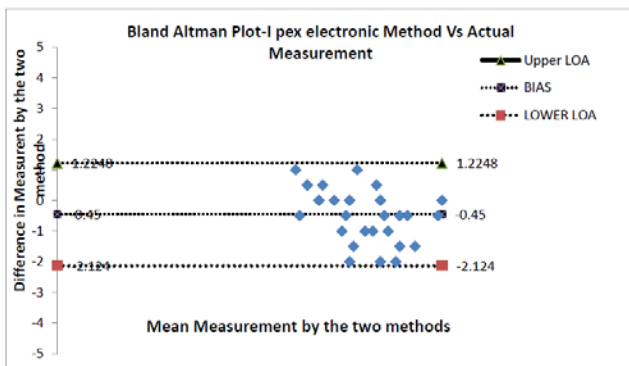
Bias -0.45  
 Std Dev 0.854501266  
 LOA -2.124822482  
 ULA 1.224822482



Graph: 8

**Discussion**

The determination and maintenance of the working length is an important step in root canal treatment. It ensures an efficient chemo mechanical preparation and a three dimensional seal of the root canal system, both of which are necessary to avoid damage to the periradicular tissues. Root fillings terminating at the apical constriction or cemento dentinal junction provide optimal healing conditions with minimal contact between the filling material and the apical tissue. This reduces tissue



Graph: 6

destruction, persisting inflammatory responses and foreign body reactions.

Locating the apical constriction and cemento dentinal junction is clinically challenging because of their variable positions and topography<sup>40</sup> According to *Kuttler*, The average distance between the minor and the major diameter was 0.524 mm in teeth examined with an age group of 18 to 25 year and 0.659 mm in a 55 year old group.<sup>(7)</sup>

Traditionally, the point of termination of endodontic instrumentation and obturation has been determined by digital tactile sense, apical periodontal sensitivity, paper point measurement, and radiographic technique<sup>10</sup>. To achieve the highest degree of accuracy in working length determination, a combination of several methods should be used.<sup>(11)</sup>

The tactile perception because of the simplicity of the technique and its virtual effectiveness are factors that motivate the clinicians in endodontic practice But this technique is in general inaccurate in root canals with immature apex, excessive curvature and if the canal is constricted throughout its length.<sup>(12)</sup>

Radiographic working length is the standard measure for endodontic instrumentation in the root canal. This measurement is difficult to achieve because the cemento-dentinal junction, the most apical portion of the dentinal canal, cannot be determined from a radiograph. Also, the cemento-dentinal junction can vary in relationship to the major foramen. Variables in the radiographic technique, angulation, and exposure distort this image and lead to clinician error (Stein 1992).<sup>(13)</sup>

The most commonly employed radiographic WL determination method is that of Ingle. It depends on estimating the distance between the file tip and the radiographic apex and adjusting it until the file tip is 0.5- 1 mm short of the radiographic apex.

An *in vivo* study compared the accuracy of several radiographic methods for WL determination including those of Best, Bergman, Bramante and Ingle, when the bisecting angle technique was used. The results of the study showed that the best length determination was obtained using Ingle's technique.<sup>(14)</sup>

All EALs function by using the human body to complete an electrical circuit One side of the apex locator's circuitry subsequently is connected to the oral mucosa through a lip clip and the other side to a file. The file is placed into the root canal and advanced apically until its tip touches the periodontal tissue at the apex, to complete the electrical circuit.<sup>15</sup> The electrical resistance of the EAL and the resistance between the file and oral mucosa are now equal, which results in the device indicating that the apex has been reached.<sup>(16)</sup>

The Root ZX mini is a third-generation EAL devices that uses dual-frequency and comparative impedance principles. It was described by Kobayashi & Sunanda. The electronic method employed was the "ratio method."

The Root ZX mini mainly detects the change in electrical capacitance that occurs near the apical constriction. Some of the advantages of the Root ZX mini are that it requires no adjustment or calibration and can be used when the canal is filled with strong electrolyte or when the canal is "empty" and moist.<sup>(17)</sup>

The I Pex is claimed to be a fourth-generation apex locator, fourth generation EALs measure capacitance and resistance simultaneously to determine the location of the file tip in the canal.

Recent guidelines recommend a combination of electronic and radiographic method, with several studies which have recommended part of the root canal, which makes it obligatory to utilize multiple WL determination techniques in the same canal.<sup>(18)</sup> The combined method raised the accuracy to 96%. Another advantage of the

combined method is the reduction in the number of radiographs needed for WL determination, reducing clinical time and radiation hazards. The present study used combination of electronic and radiographic working length determination.

The result of the study shows that most accurate method for measurement before tooth extraction is the electronic method. Of the two electronic methods, the most accurate method was found to be Root ZX method followed by the IPex method. After the electronic methods the accuracy was higher for the radiographic method. The least accurate method was found to be the tactile method.

The results are in accordance with similar study done by Muthu Shanmugaraj et al on evaluation of working length determination methods using tactile method, electronic apex locator and radiographic method, in vivo, and, comparing the lengths so measured to the actual working length, ex vivo, after extraction, The results showed that the EWL method gives the highest rate of exact coincidence followed by RWL method, and the least accuracy was obtained by tactile working length method. The results of the radiographic and AWL are in agreement with other studies.(7)

Among the two electronic apex locators Root ZX mini is more accurate than I Pex. These results are also in accordance with in-vivo study done by Stober. al. compared the accuracies of working length of two different generations of electronic apex locators. The two different electronic apex locators used were Root Zx , and IPex .

In the present study, the assessment of accuracy was based on the ability of both apex locators to locate a position 0.5mm coronal to major foramen .But another in vivo study conducted on evaluation of Root ZX and iPex Apex Locators by Eva K. Stober et al concluded that, no

statistically significant differences were observed between the Root ZX and I Pex EAL.

While comparing the the levels of agreement with Root ZX mini apex locator to the actual working length after extraction shown that there was an exact agreement between the two measurements by 40%. However acceptable agreement was 50%. There was no agreement between the measures in only 10% of the cases. The present study shows that Root ZX mini is the most reliable method for working length determination in accordance with various invivo and invitro studies.

While comparing the levels of agreement with I Pex apex locator to actual working length after extraction shown that there was an exact agreement between the two measurements of 27%. However acceptable agreement percentage was 33%. There was no agreement between the measures in 40% of the cases with IPex apex locator. This shows that after Root ZX, it is the reliable method.

Results from this study indicate that the sole use of tactile method is generally depreciated because of its nonreliability (67%). Though the use of radiographs is well established, it has inherent limitations of projecting a three-dimensional object in a two-dimensional radiograph. There was a significant difference between conventional method and actual WL but EAL showed the most accurate reading when compared to actual WL.

similar results were found in other studies which stated that the correct use of EAL may help to reduce the risk of instrumentation beyond the apical foramen and also to reduce the repeated radiation exposures. But the EALs used alone without the radiographic method cannot give any information about the curvature and direction of the root canal. Thus, it can be stated that one should use the combination of radiographic and electronic method for determining the WL. The knowledge of apical anatomy or curvature by prudent use of radiographs and the correct

use of EAL will assist practitioners to achieve predictable results.

### Conclusion

According to the findings and within the limitations of this study, it was concluded that

1. Most accurate method for working length measurement before tooth extraction is the electronic method.
2. In between two electronic methods, the Root Zx mini method was found to be more accurate when compared to I Pex
3. The radiographic method showed the next best accuracy
4. The tactile method was found to be least accuracy
5. Thus more long term follow up studies evaluating postoperative success comparing electronic apex locators and radiographic methods are needed to appreciate the best method of working length determination in endodontics.

### References

1. Malkhassian G, Plazas A, Nahmias Y. Electronic Apex Locators and Conventional Radiograph in Working Length Measurement. Endodontic Radiology. 2012 Jul 31;218.
2. Thomas MS, Acharya S, Kundabala M. A comparative evaluation of the accuracy of third generation electronic apex locator (root zx) and conventional radiography to determine working length-An in vivo study. Endodontology.2008; 20 (1): 14-21.
3. Sadaf D, Ahmad MZ. Accurate Measurement of Canal Length during Root Canal Treatment: An In Vivo Study. International journal of biomedical science: IJBS. 2015 Mar;11(1):42.
4. Ehsan S. Comparative role of radiographs and electronic apex locator in working length

determination. Pakistan Oral & Dental Journal. 2011 Jun 1;31(1).

5. Akashi Chaudhari et al. Significant of Apical Third: A Review .Sch. J. App. Med. Sci., 2014; 2(5B):1613-1617
6. Diwanji A, Rathore AS, Arora R, Dhar V, Madhusudan A, Doshi J. Working length determination of root canal of young permanent tooth: An in vitro study. Annals of medical and health sciences research. 2014;4(4):554-8.
7. Shanmugaraj M, Nivedha R, Mathan R, Balagopal S. Evaluation of working length determination methods: an in vivo/ex vivo study. Indian journal of dental research. 2007 Apr 1;18(2):60.
8. Mohan GM. Accuracy of different methods of working length determination in endodontics. IOSR Journal of Dental and Medical Sciences (IOSR-JDMS). 2013;1(12):25-38.
9. Ebrahim AK, Wadachi R, Suda H. Electronic apex locators a review. Journal of Medical and Dental Sciences. 2007;54(3):125-36.
10. Saru Jain, Ravi Kapur comparative evaluation of two electronic apex locators in presence of various irrigants. Contemporary Clinical Dentistry.2012,(3); Supplement 2
11. Soi, Sonal, Sumit Mohan, and Vineet Vinayak Prabhjot Kaur. "Electronic apex locators." Journal of dental science and Oral rehabilitation (2013): Jan-March
12. Jeger FB, Janner SF, Bornstein MM, Lussi A. Endodontic working length measurement with preexisting cone-beam computed tomography scanning: a prospective, controlled clinical study. Journal of endodontics. 2012 Jul 31;38(7):884-8
13. Shivamurthy G, PATHAK P, SHIVANNA V. A Comparison between In Vivo Working length



- determination complemented with Electronic Apex locator and measurement after extraction. Editorial 5 Original Research. 2011 Dec;23(2):13
14. Alothmani OS, Friedlander LT, Chandler NP. Radiographic assessment of endodontic working length. Saudi Endodontic Journal. 2013 May 1;3(2):57.
15. Srivastava V, Jain N, Bagchi S, Negi MP. Evaluation of the Use of Sixth Generation Apex Locators as a Diagnostic Tool to Detect Root Perforations. International Journal of Dental and Medical Specialty. 2015;2(4):10-4.
16. Nekoofar MH, Ghandi MM, Hayes SJ, Dummer PM. The fundamental operating principles of electronic root canal length measurement devices. International Endodontic Journal. 2006 Aug 1;39(8):595-609.
17. Orosco FA, Bernardineli N, Garcia RB, Bramante CM, Duarte MA, Moraes IG. In vivo accuracy of conventional and digital radiographic methods in confirming root canal working length determination by Root ZX. Journal of Applied Oral Science. 2012 Oct;20(5):522-5.
18. Bhatt A, Gupta V, Rajkumar B, Arora R. Working Length Determination- The soul of root canal therapy: A review.