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Evaluation of 4 Different Methods of Working Length Determination

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KEYWORDS

Instrumentation, obturation, endodontic, cemento-dentinal

ABSTRACT:

The long-term success of root canal treatment depends upon the relationship between instrumentation, obturation procedures, and the complex anatomy of the apex.[1] Determination of working length is one of the most critical steps in endodontic therapy and a clear understanding of the morphology of the root canal system, including the apex, is imperative. Working length is defined in The Glossary of Endodontic Terms as "Distance from a coronal reference point to the point, at which canal preparation and obturation should terminate."[2] The cleaning, shaping, and obturation of the root canal system cannot be accomplished accurately unless the working length is determined precisely.[2] The anatomical apex is the tip or the end of the root determined morphologically, whereas the radiographic apex is the tip or the end of the root determined radiographically.[2] The cemento-dentinal junction has been recommended as an ideal apical termination for root canal preparation. It is located approximately 1 mm away from the apical foramen. An apical constriction usually occurs in the region of the cemento-dentinal junction and is the narrowest portal of entry of the pulpal vasculature from the periapical tissues.

INRODUCTION:

The long-term success of root canal treatment depends upon the relationship between instrumentation, obturation procedures, and the complex anatomy of the apex.[1] Determination of working length is one of the most critical steps in endodontic therapy and a clear understanding of the morphology of the root canal system, including the apex, is imperative. Working length is defined in The Glossary of Endodontic Terms as "Distance from a coronal reference point to the point, at which canal preparation and obturation should terminate."[2] The cleaning, shaping, and obturation of the root canal system cannot be accomplished accurately unless the working length is determined precisely.[2] The anatomical apex is the tip or the end of the root determined morphologically, whereas the radiographic apex is the tip or the end of the root determined radiographically.[2] The cemento-dentinal junction has been recommended as an ideal apical termination for root canal preparation. It is located approximately 1 mm away from the apical foramen. An apical constriction usually occurs in the region of the cemento-dentinal junction and is the narrowest portal of entry of the pulpal vasculature from the periapical tissues.

To achieve the highest degree of accuracy in working length determination, a combination of several methods should be used.[3] This is particularly important in canals for which working length determination is difficult.[3] Of the several methods used in working length determination, 3 methods- Radiographic Method using IOPA, using RVG and Electronic Method using Apex Locators are widely used and considered clinically more reliable. Intraoral periapical radiography, the Radiographic Method is conventionally used. Over the period, digital radiographic method or Radio-Visiography (RVG) is being an increasingly used tool in WL determination. The Electronic Method using Apex

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Locators is believed to have the highest accuracy and is considered the gold standard in WL determination.[4] With the recent advances in imaging technologies, cone-beam computed tomography (CBCT) emerged as an effective tool and was introduced in Endodontics. CBCT is known to produce undistorted three-dimensional images of the teeth and their surrounding tissues at a substantially lower radiation dose as compared to conventional computed tomography (CT).[5] Considering the availability of CBCT and its widespread application in endodontics, it is necessary to investigate whether CBCT can be utilized as a tool for root canal length determination. Hence, the present study was carried out to comparatively evaluate the efficacy of conventional radiography, apex locator, RVG and CBCT for root canal working length determination in single-rooted mandibular premolar teeth.

MATERIALS & METHODS:

50 single-rooted mandibular premolars, scheduled for orthodontic extraction were selected for the study. The working length was determined by 4 different methods mentioned above. Only non-carious teeth with single canals and closed apices scheduled for orthodontic extraction were included in the study. Carious, periodontally compromised teeth, morphologically defective teeth, teeth with open apices, and teeth of young patients with cardiac pacemakers were excluded.[6]

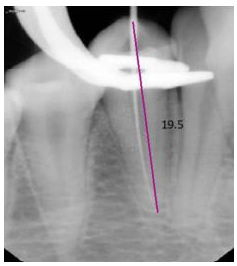
A good quality preoperative radiograph was taken employing the extension cone paralleling technique. The reference point on the preoperative radiograph was marked at the buccal cusp tip, and the length of the tooth was measured using a metal ruler from the reference point to the radiographic apex; the measurements were recorded. Under local anesthesia with rubber dam isolation, an access cavity was prepared by using endo access bur followed by extirpation of pulp. The canal was irrigated using a 2.5% sodium hypochlorite solution and finally flushed with distilled water.[6]

Picture 1- Armamentarium used

For the working length determination using IOPA, a #10k file with a silicone rubber stopper was inserted into the root canal. The working length was measured, and 1 mm was subtracted from the measurement and registered as the 'Radiographic tooth length'.[6] (Picture 2)

Picture 2- Working length determination using IOPA

For radio-visiographic working length determination (using RVG), a #20 K-file with a silicon stop was inserted into the root canal, a digital radiograph was taken and the radiographic working length was measured and then 1mm was subtracted from the measurement and registered as the 'Radio-Visiographic working length'.[7] (Picture 3)



Picture 3- Working length determination using RVG

For working length determination using an Electronic Apex Locator, Root Zx mini digital Apex Locator was used. After copious irrigation, the canal was thoroughly dried with paper points. The lip contact of the instrument was attached to the patient's lower lip. No. #20 K file was used for measuring root canal length. As the instrument moved apically in the canal, the digital display is indicated by the distance from the tip of the file to the apical constriction in tenths of a millimeter. When the instrument reached the apical constriction, the apex locator gave out- a digital display reading, a pulsing audition, and a flashing light. The rubber stop was adjusted on the file shaft in such a way that it touched the reference point. The instrument was carefully withdrawn and the distance from the tip of the

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instrument to the rubber stop was measured using a metal ruler; the value was noted down and registered as 'Electronic Working Length'.[6,7]

For CBCT analysis of Working Length, two dental mandibular models were fabricated with 25 extracted lower premolars. Modeling wax was used to integrate the teeth into the model. The length of the canal space with a field of view (FOV) of 100mm x H 80mm was measured (FIG). The area of interest was then reconstructed with an isometric voxel size of 0.260 mm. The tube voltage was kept at 90kVp and 8 mA and the exposure time was 9.4 seconds. The teeth were inspected in the transversal, sagittal, and coronal aspects. Using the examination tool, the tooth being measured can be depicted independently. The tooth could be rotated by the operator to find a suitable plane for measurement, where the reference point and the foramen are simultaneously visible. A straight line from the cusp tip to the foramen will be drawn, and the distance will be recorded as CBCT WL.[8] (Picture 4)

Picture 4- Sample mounted before CBCT

Actual working length (AWL) determination was done on the extracted teeth by inserting a #20K file into the root canal until the tip of the file was visible at the apical foramen. The visibility of the file tip at the apical foramen was confirmed using a magnifying loupe. (Carl Zeiss Meditec AG SN- 6905702071). The stopper was then adjusted to the reference point. The distance was determined with a digital caliper and detected as the 'AWL'.[8]

STATISTICAL ANALYSIS:

The mean working length Measured by IOPA was 20.61mm. The mean working length Measured by the apex locator was 21.15mm. The mean working length Measured by RVG was 21.05mm and the mean working length Measured by CBCT was 21.32mm.

The comparison of working lengths among the four methods was done by One-way ANOVA test. There was a significant difference in the working length measured using four methods. ($p \leq 0.05$) (Table -1)

Table -1: Comparison of working lengths among the four methods

Group	Mean	SD	p- Value
IOPA	20.61	1.08	0.007*
Apex Locator	21.15	1.01	
RVG	21.05	1.05	
CBCT	21.32	1.02	

The pairwise comparison of the working lengths of the four methods was done by Post hoc Tukey test. The working lengths measured by IOPA and CBCT showed a significant difference. ($p \leq 0.05$) (Table -2)

Table-2: The pairwise comparison of the working lengths of the four methods

Pairwise comparison	Mean difference	p-value
IOPA vs Apex Locator	-0.54	0.054
IOPA vs RVG	-0.44	0.159
IOPA vs CBCT	-0.71	0.004*
Apex locator vs RVG	0.10	0.965
Apex locator vs CBCT	-0.17	0.833
RVG vs CBCT	-0.27	0.554

The working lengths of the four methods were correlated by intraclass correlation test. IOPA showed a good agreement with the apex locator and RVG in working length determination and a moderate agreement with CBCT. The apex locator showed an excellent agreement with RVG and CBCT in working length determination, and RVG showed a good agreement with CBCT in working length determination. (Table-3)

Table -3: Correlation of working length of the four methods

Pairwise comparison	ICC	p-value
IOPA vs Apex Locator	0.783	<0.001*
IOPA vs RVG	0.806	<0.001*

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IOPA vs CBCT	0.684	<0.001*
Apex locator vs RVG	0.961	<0.001*
Apex locator vs CBCT	0.907	<0.001*
RVG vs CBCT	0.841	<0.001*

DISCUSSION:

An accurate working length is one of the most important criteria for achieving successful endodontic results and minimizing post-operative discomfort. An erroneously short working length leaves the apical region uncleaned and unfilled canal space. An erroneously long working length will lead to over-instrumentation and overextended obturation, causing significant post-operative discomfort.[4] The instrumentation and obturation of root canals should end at the apical constriction (physiologic foramen), as there are minimal chances of apical injury or the surrounding periodontal ligament injury. This does not cause any extrusion of root canal filling material, and apical transport of infected pulpal tissues.[9]

The radiographic method described by Ingle is one of the most reliable and simple methods. But, it has certain disadvantages like more radiation exposure, being time-consuming, and in most cases, the cementodentinal junction does not coincide with the point 1 mm short from the radiographic apex.[7] The digital radiography or RVG makes use of an intraoral sensor in place of radiographic film. RVG has certain advantages over conventional radiographs. Advantages of a digital system are image quality, acquisition, editing, qualifying, and distance between 2 points on the image. This system's Greatest advantage is taking on-screen measurement of utility, which allows for additive multiple-point measurement on tenth of a millimetre on screen.[8] An electronic method for root length determination was first put forward by Custer (1918) and this idea was revisited by Suzuki in 1942. Later, Sunada in 1962, constructed a simple device based on these concepts using direct current to measure the canal length. Subsequently, the electronic apex locators have been greatly improvised to increase their accuracy and versatility. They are considered higher in accuracy as compared to the radiographic methods as per the results of multiple in-vivo, ex-vivo, and in-vitro studies. The Electronic Apex Locators have the advantage of reducing the treatment time and nil radiation dose compared to radiographic methods.[10] They are particularly useful in pregnancy to avoid radiation exposure and in patients with high gag reflexes where placement of radiographic film or intraoral sensor in the mouth of the patient is difficult. However, it has a limitation of usage in patients with cardiac pacemakers, as it can interfere with their working. As compared to 2D images formed by conventional or digital radiographs, CBCT produces 3D images and gives volumetric data that provides more diagnostic information. It can be useful in endodontics for the effective evaluation of the root canal morphology, diagnosis of endodontic pathology, assessing root and alveolar fractures, as well as identification of non-endodontic pathology.[11]

The present study showed a significant difference in mean working length measured by IOPA (20.61%), RVG (21.05%), Apex locator (21.15%), and using CBCT (21.32%) measured after orthodontic extraction of mandibular premolar when compared with actual working length value. So, the CBCT shows the highest correlation with the actual working length followed by Apex locator, and then RVG and IOPA showed the least correlation with the actual working length.

The authors Ravanshad et al[12] (2010), F.D. Jarad et al[13] (2011), Pishipati[14] (2013), Jorge Paredes Vieyra et al[15] (2018) compared the efficacy of electronic apex locators with radiographs in determining the working length and concluded that the apex locators give better result than radiographs in the estimation of root canal length. Stavrianos et al (2003)[16] found the accuracy of the electronic apex locator to be 96% when compared to the actual working length measured using loupe. Our study also showed that electronic apex locators are better than radiographs for root canal length assessment.

The present study showed the highest correlation with the actual working length when compared to the other three methods. Our study results were per the other studies as follows. A study by Liang et al 2015[17] showed that CBCT has a positive correlation with gold standard actual working length measured after extraction. Hence for working length determination, CBCT is the best method for ex-vivo working length study according to them. Sherrad et al[18] in 2010 stated that scans with a larger voxel size (0.3mm) are associated with lower levels of radiation exposure. In our study, CBCT scan was done at an isometric voxel size of 0.28mm using the smallest possible FOV. In the present study, the CBCT scanner settings were in accordance with the as low as reasonably achievable

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(ALARA) principle even though the procedure was carried in extracted tooth. In the present study, we used multiplanar reformatted sections for selecting the best sagittal view for the measurement of working length. Similar technique was suggested by Jeger et al[18] in 2012. Previous studies by Kobayashi et al. 2004, Murmulla et al[19] in 2005, Ludlow et al[20] in 2007, Mischkowski et al[21] in 2007, and Stratemann et al[22] in 2008 have confirmed the three-dimensional geometric accuracy of CBCT when compared to radiographic techniques.

Mohamed I. Elshinawy et al[23] in 2017 compared 4 working length measuring techniques- regular radiographic film, digital radiographic image, Cone beam tomographic image, Electronic apex locator and found that electronic apex locator and cbct were more accurate technique to determine the working length than the normal and the 2D radiographic method. Janner et al[24] reported that an existing CBCT is as successful as an EAL. Yilmaz et al[25] in 2017 found that there was a strong correlation between the endodontic working length as measured in the CBCT images and the electronic apex locator measurement which is in accordance with the results of our study. Based on their findings, CBCT can be used to determine the endodontic working length in combination with clinical measurements such as the electronic apex locator.

In this study, the actual working length measurement being the gold standard, had strong positive correlation with CBCT > EAL1 > RVG1> IOPA methods of working length determination which is in accordance with the studies by Jyoti Mandlik et al.[26]

Conclusion:

IOPA and digital radiographic method showed statistically significant difference from the actual working length.

Morden electronic apex locator can determine this position with 96% accuracy with the actual working length, but still have some limitations.

The results of the present study showed that CBCT scans can be used as an alternative method for ascertaining the WL. If a patient has a pre-existing CBCT scan, the clinician should take advantage of this technique as an alternative, reliable method for determining the WL.

Knowledge of apical anatomy, prudent use of radiographs and the productive use of an electronic apex locator, along with a diagnostic CBCT will assist practitioners to achieve predictable endodontic success.

References:

1. Schilder H. Filling root canals in three dimensions. Dent Clin North Am 1967; 723- 744.
2. Chicago I.L.., in Glossary of Endodontic Trems,7th Edition in Ingle's Endodontics, Ed; Ingles,Bakland , Baumgartner 6th Edition, Year 2008 BC Decker Inc. New York.
3. Katz A, Tamse A, Kaufman AY. Tooth length determination: A review. Oral Surg Oral Med Oral Pathol 1991;72:238-42.
4. Mohan, Dr. G. Midhun and V. Susila Anand. "Accuracy of Different Methods of Working Length Determination in Endodontics." IOSR Journal of Dental and Medical Sciences 12 (2013): 25-38.
5. Deepak BS, Subash TS, Narmatha VJ, Anamika T, Snehil TK, Nandini DB. Imaging techniques in endodontics: an overview. J Clin Imaging Sci. 2012;2:13. doi: 10.4103/2156-7514.94227. Epub 2012 Mar 22. PMID: 22530184; PMCID: PMC3328979.
6. Shanmugaraj M, Nivedha R, Mathan R, Balagopal S. Evaluation of working length determination methods: an in vivo / ex vivo study. Indian J Dent Res. 2007 Apr-Jun;18(2):60-2. doi: 10.4103/0970-9290.32421. PMID: 17502709.
7. Goel T, Indushekar KR, Saraf BG, et al. Comparative Evaluation of Working Length Using Conventional Radiographic Method, Radiovisiography, and Apex Locator in Single-rooted Permanent Teeth. J Oral Health Comm Dent 2021;15(2):49–54.
8. Kosta S, Chandwani N, Bopche P. Reliability of CBCT in working length determination for successful endodontic treatment- an in vitro study. Int J Orofac Res 2022;6(2):55-60.
9. Cohen S, Burns RC. Pathways of the pulp. 12th ed. St Louis: CV Mosby, 2012:164-9.
10. Pascon E.A., Marrelli M., Congi O., Ciancio R., Miceli F., Versiani M.A. –An ex vivo comparison of working length determination by three electronic apex locators - Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontics, 2009 Sep; 108(3):147-51.
11. Abraham D, Bahuguna N, Manan R. Use of CBCT in the Successful Management of Endodontic Cases. J Clin Imaging Sci. 2012;2:50. doi: 10.4103/2156-7514.100370. Epub 2012 Aug 30. PMID: 23029633; PMCID: PMC3440931.

Journal of Chemical Health Risks

www.jchr.org

JCHR (2025) 15(1), 922-927 | ISSN:2251-6727

12. Ravanshad S, Adl A, Anvar J. Effect of working length measurement by electronic apex locator or radiography on the adequacy of final working length: a randomized clinical trial. J Endod. 2010 Nov;36(11):1753-6. doi: 10.1016/j.joen.2010.08.017. Epub 2010 Sep 19. PMID: 20951282.
13. Jarad, F., Albadri, S., Gamble, C. et al. Working length determination in general dental practice: a randomised controlled trial. Br Dent J 211, 595–598 (2011). https://doi.org/10.1038/sj.bdj.2011.1052.
14. Pishipati V (2013). An In Vitro Comparison of Propex II Apex Locator to Standard Radiographic Method. Iranian endodontic journal. 8. 114-7.
15. Jorge Paredes Vieyra, Fernando Calleja Casillas, Acosta Guardado Julieta. Comparison of Working Length Determination in Teeth with Vital Pulps with Digital Radiographs and Four Electronic Apex Locators. An In Vivo Study. On J Dent & Oral Health. 1(4): 2018. OJDOH.MS.ID.000516. DOI: 10.33552/OJDOH.2018.01.000516.
16. Stavrianos, C., C. Gogos, L. Vasiliadis and N. Economides, 2003. Clinical comparative evaluation of the accuracy of the electronic apex locators ROOT-ZX and JUSTY-II in the working length measurement of 50 single rooted teeth. Balk. J. Stom., 7: 30-32.
17. Liang X., Lambrichts I., Sun Y., et al. A comparative evaluation of cone beam computed tomography (CBCT) and Multi-Slice CT (MSCT). Part II: On 3D model accuracy. Eur. J. Radiol. 2010;75(2):270–274. doi: 10.1016/j.ejrad.2009.04.016.
18. Sherrard JF, Rossouw PE, Benson BW, Carrillo R, Buschang PH. Accuracy and reliability of tooth and root lengths measured on cone-beam computed tomographs. Am J Orthod Dentofacial Orthop. 2010 Apr;137(4 Suppl):S100-8. doi: 10.1016/j.ajodo.2009.03.040. PMID: 20381750.
19. Murmulla R, Wörtche R, Mühling J, Hassfeld S (2005) Geometric accuracy of the NewTom 9000 Cone Beam CT. Dentomaxillofacial Radiology 34, 28–31.
20. Ludlow JB, Lester WS, See M, Bailey LJ, Hershey HG (2007) Accuracy of measurements of mandibular anatomy in cone beam computed tomography images. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology and Endodontology 103, 534–42.
21. Mischkowski RA, Pulsfort R, Ritter L et al. (2007) Geometric accuracy of a newly developed cone-beam device for maxillofacial imaging. Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology and Endodontology 104, 551–9.
22. Stratemann SA, Huang JC, Maki K, Miller AJ, Hatcher DC (2008) Comparison of cone beam computed tomography imaging with physical measures. Dentomaxillofacial Radiology 37, 80–93.
23. Elshinawy, Mohamed. (2017). In-vitro comparison of four different working length determination techniques. Tanta Dental Journal. 14. 12. 10.4103/tdj.tdj_55_16.
24. Janner SF , Jeger FB , Lussi A , Bornstein MM . Precision of endodontic working length measurements: a pilot investigation comparing cone-beam computed tomography scanning with standard measurement techniques . J Endod . 2011. August ; 37 (8): 1046 – 51 . 10.1016/j.joen.2011.05.005.
25. Yılmaz F, Kamburoğlu K, Şenel B. Endodontic Working Length Measurement Using Cone-beam Computed Tomographic Images Obtained at Different Voxel Sizes and Field of Views, Periapical Radiography, and Apex Locator: A Comparative Ex Vivo Study. J Endod. 2017 Jan;43(1):152-156. doi: 10.1016/j.joen.2016.09.019. PMID: 27986097.
26. Mandlik J, Shah N, Pawar K, Gupta P, Singh S, Shaik SA. An in vivo Evaluation of Different Methods of Working Length Determination. J Contemp Dent Pract 2013;14(4):644-648.