ORIGINAL ARTICLE

Comparative Evaluation of Intraoral and Extraoral Periapical Radiographic Techniques in Determination of Working Length: An *In Vivo* Study

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Abstract

Objectives/aims: This study was designed to determine the endodontic working length (WL) of root canals using digital extraoral periapical radiography (EOPAR) technique and comparing its accuracy with the standard digital intraoral periapical radiography (IOPAR).

Materials and methods: Sixty single-rooted mandibular first premolars indicated for orthodontic extraction were radiographed preoperatively to ensure closed apices. After gaining endodontic access, WL was determined by IOPAR using paralleling technique, followed by EOPAR, by placing a cone at +35° from the contralateral side. Accessed tooth was then extracted to obtain the actual root canal length and was compared with the radiographic lengths. Data were subjected to statistical analysis using paired *t* test.

Results: The actual length and the extraoral radiographic length showed no statistical significant difference ($p = 0.326$). The difference between the mean WL obtained by IOPA and EOPA was also not statistically significant ($p = 0.096$). The accuracy of IOPA technique was 97.87 ± 0.91% and that of EOPA technique was 94.65 ± 2.57%.

Conclusion: The EOPA technique with an angulation of +35° can be used as an alternative to IOPA for mandibular premolars in apprehensive children, dental phobic patients with low pain threshold, neurological difficulties, and exaggerated gag reflex.

Keywords: Extraoral periapical radiographic technique, Intraoral periapical radiographic technique, Working length determination.

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Introduction

Intraoral periapical (IOPA) radiographs form the backbone of imaging of teeth and its associated structures. The IOPA radiograph is an essential aid in determining the working length (WL) during endodontic procedures, reroot canal treatment assessment, and postoperative appraisal of endodontic therapy. One of the most critical steps during endodontic therapy is determination of an accurate working root length.[1] Therefore, accurate tooth length measurements are extremely important to ensure that the file does not pass beyond the apical foramen and causes injuries to the periapical tissues.[2] Inaccuracy in determining the WL of tooth can lead to various complications such as ledge formation, apical perforation, and overextension of irrigants through the apical constriction leading to periradicular inflammation, pain, and ultimately lowering the overall outcome of treatment.[1]

Periapical radiographs due to its high image resolution and excellent image contrast have always been considered for radiographic diagnosis technique by diagnostician to determine the nature and characteristics of bone, dental structures, and lesion. In recent times, digital dental radiography has preceded imaging dentistry as a new standard.[3] Image manipulation that enhances the perceived image quality, patient education, lower radiation exposure to patients, and instant imaging are the advantages of the digital system over the conventional radiographs.[4–6]

Certain conditions and anatomical difficulties such as large tongue; shallow palate and/or floor of mouth; impacted third mandibular molar; maxillary and mandibular tori; restricted mouth opening; neurological difficulties; exaggerated gag reflex; children; dental phobic patients with low pain threshold; painful mucosal conditions such as ulcers, infections, and intraoral abscesses; differently abled patients who are unable to follow the clinician's instructions; residual ridge resorption in edentulous patients; and any lingual interference make the placement of IOPA radiographs challenging. Thus, intraoral film/sensor placement in a large group of patients becomes challenging.[7] In such cases, extraoral periapical (EOPA) radiographic technique can be used as an alternative.

Extraoral technique is relatively a novel approach for periapical imaging and was introduced by Michael Newmann and Seymour Friedman in 2003 for maxillary and mandibular teeth.[8]

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The technique involves placement of the radiographic film sensor extraorally parallel to the teeth to be imaged, such that the tooth of interest comes in the center and the beam is directed through the opposite side buccal soft tissue without exposing the crowns of opposite side teeth.[9]

Extraoral radiographic technique can be as an alternative in pediatric patients who are generally anxious and unwilling to intraoral film placement. Intraoral radiograph with placement of rubber dam along with the WL files during endodontic procedures is both time-consuming and uncomfortable for patients.[10]

Since the introduction of extraoral radiographic technique, clinical usage has not been validated and is still used as a supplementary aid in dental radiography.[11] Thus, the present study aimed to evaluate and compare the accuracy of extraoral and intraoral radiographic technique in determination of WL.

Materials and Methods

The study included healthy cooperative patients, aged between 13 years to 25 years who visited AECS Maaruti Dental College. 60 mandibular first premolars indicated for orthodontic extraction having a straight root morphology with fully formed apices were included in the study. Patients who are contraindicated for X-rays, grossly carious or fractured teeth, and teeth with external and internal root resorption were excluded.

After obtaining an informed consent from the patient. The radiographic, endodontic, and extraction procedures were performed.

Preoperative radiographs were taken using paralleling technique (Rinn System, Dentsply) to ascertain the type of tooth selected had a representative of canal system with typical morphology. The selected canals were of Weine's and Vertucci's type I configuration.

Endodontic Procedure

Following oral prophylaxis, selected tooth was anesthetized using a local anesthetic agent (Lignox 2%). A #02 round bur was used to prepare the access cavity, after which barbed broaches were used to extirpate the pulpal tissue. Sodium hypochlorite of 3% concentration was used to copiously irrigate the canals along with suction. The excess of solution in pulp chamber was absorbed with a sterile cotton pellet and paper points (#20) to ascertain the canals were dry. The K file was then placed into the canal to estimate the WL using the Ingles method that is 1 mm short of the radiographic apex, with the tip of the buccal cusp as a coronal reference point.

Radiography

The patient was seated upright and lead aprons were used to minimize radiation. The IOPA radiograph was acquired for determination of WL, which was determined by radiovisiograph using the extension cone paralleling technique and standard position indicating device (Dentsply-Rinn Corporation).

For IOPA radiographs, posterior receptor holding device (Dentsply-Rinn Corporation) was assembled and the receptor sensor of radiovisiograph (RVG) was inserted horizontally on the posterior bite block. An RVG sensor of size 1 was used. The tube head was aligned close to the aiming ring and center. The X-ray equipment was set at 70 kVp and 7 mA, and an exposure of 160 milliseconds was the parameter followed for exposure (Fig. 1). On acquisition of the digital image, the difference between the tip of the file inserted and the radiographic apex was measured to ensure it is 1 mm short of the radiographic apex using the calibrated electronic ruler.

The WL was determined using extraoral periapical radiography (EOPAR) was done using the modified intraoral position indicating device that was constructed as indicated by Chen et al.[12]

The beam aiming device for the EOPA radiographic technique was aligned to the X-ray beam which was directed at the RVG sensor with the locator ring as a guidance such that the tooth of interest comes in the center of film. The X-ray cone was positioned with a vertical angulation of +35°, so that the beam was directed through the buccal soft tissue of the opposite side. The X-ray equipment was set at 70 kVp and 7 mA and exposure was provided for 180 milliseconds. The RVG software was used to capture the image (Fig. 2).

The radiographic WL was determined for both intraoral and extraoral radiographs, on the screen of a high-resolution monitor. The measurement method was done using calibrated electronic ruler of the RVG system software (version 6.14.3; Carestream Technologies). Using the left mouse button, a multiple-click measurement was performed for determining the WL, which consist of the first click at the visible edge of the crown that is the tip of buccal cusp and multiple clicks following the curvature of the file till the root apex.

Fig. 1: Intraoral periapical radiographic technique

Fig. 2: Extraoral periapical radiographic technique

Enhancement features, such as brightness and contrast, were not used for the on-screen measurement (Figs 3 and 4).

The tooth was then extracted carefully, and the extracted tooth was preserved in 5.25% NaOCl solution, so that it would aid in the removal of any periodontal tissue remnants from the root surface for the actual WL determination.

Determination of Actual Working Length

The determination of actual length of the tooth was done using the same reference point and the previously used file. Using the 4× magnification, the inserted file into the root canal was visualized from a tangential angle until the tip exits at the apex. A file was reintroduced through the access cavity and the stopper was set at the occlusal reference point as the file reached the apical foramen under 4× magnification for confirmation. The same vernier caliper was used to measure the length for all the tooth. Based on the distance between apical constriction and apical foramen, 0.5 mm short of the apex of the tooth[13] served as the actual WL (Figs 5 and 6).

The measured WL were documented and then tabulated and compared statistically using paired *t* test. Accuracy was calculated for each radiograph of two different techniques separately and the mean WL values of both the techniques were evaluated.

Accuracy was calculated for each case using the following formulas:

- If radiographic WL < actual WL, accuracy is calculated using the formula

$$\text{Accuracy (RWL} < \text{AWL)} = \frac{\text{Radiographic working length} \times 100}{\text{Actual working length}}$$

- If actual WL < radiographic WL, accuracy is calculated using the formula

$$\text{Accuracy (AWL} < \text{RWL)} = \frac{\text{Actual working length} \times 100}{\text{Radiographic working length}}$$

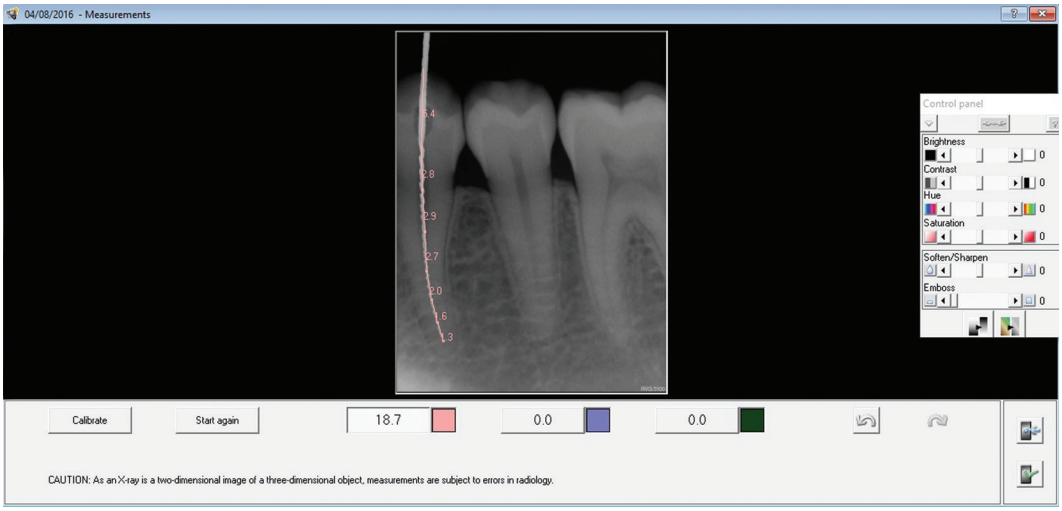

Fig. 3: On screen measurements of intraoral periapical radiograph

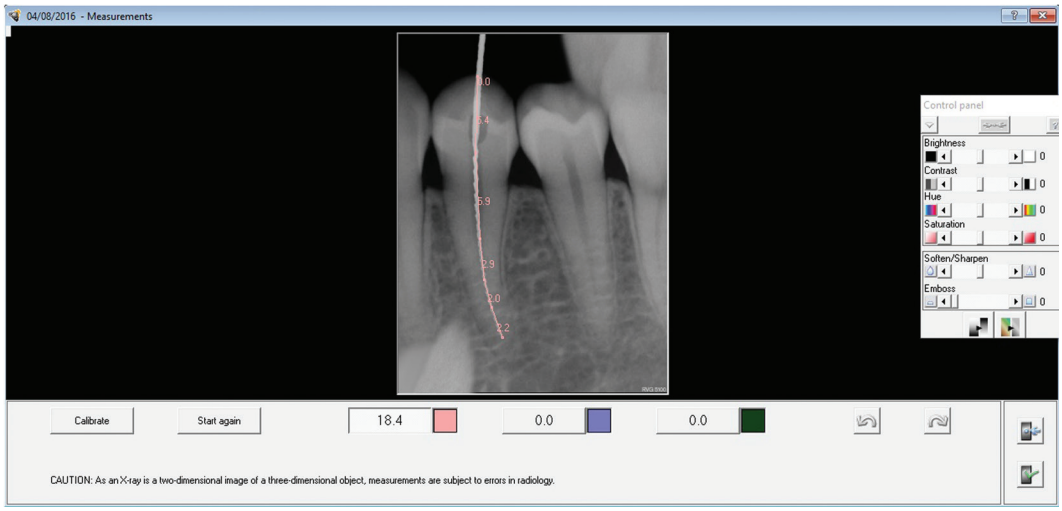

Fig. 4: On screen measurements of extraoral periapical radiograph

Fig. 5: Visualization of the file at the apical foramen using 4x magnifying glass

Fig. 6: Measurement of actual working length using vernier caliper

Table 1: Comparison of actual working length and working length obtained by IOPA

				Paired difference			
	n	*Mean*	*SD*	*Mean*	*SD*	*t*	*Paired t test*
Actual working length	60	18.68	0.66	−0.095	0.43	−1.716	$p = 0.091$
IOPA	60	18.78	0.66				

Table 2: Comparison of actual working length and working length obtained by EOPA

				Paired difference			
	n	*Mean*	*SD*	*Mean*	*SD*	*t*	*Paired t test*
Actual working length	60	18.68	0.66	0.147	1.15	0.991	$p = 0.326$
EOPA	60	18.53	0.66				

Table 3: Comparison of working length obtained by IOPA and EOPA

				Paired difference			
	n	*Mean*	*SD*	*Mean*	*SD*	*t*	*Paired t test*
IOPA	60	18.78	0.66	0.242	1.11	1.694	$p = 0.096$
EOPA	60	18.53	0.66				

Table 4: Accuracy of IOPA and EOPA compared to actual working length

					Percentiles				
	n	*Mean*	*SD*	*SE*	*25*	*50 (Median)*	*75*	*Min*	*Max*
IOPA	60	97.87	0.91	0.12	97.30	97.44	98.48	96.26	100
EOPA	60	94.65	2.57	0.33	92.90	94.36	97.02	89.11	99.46

Results

The difference between WL obtained from intraoral periapical radiographic technique (18.78 ± 0.66) and actual WL (18.68 ± 0.66) was not statically significant *t* (1.716), $p = 0.091$ (Table 1).

The difference in measurements between the actual length (18.78 ± 0.66.) and the EOPA radiographic length (18.53 ± 0.66) was also not statistically significant, *t* (0.991), $p = 0.326$ (Table 2).

The difference between the mean WL by IOPA (18.78 ± 0.66) and WL by EOPA (18.53 ± 0.66) was also not found to be statistically significant *t* (1.694), $p = 0.096$ (Table 3).

In the present study, accuracy of IOPA technique was 97.87 ± 0.91% and the accuracy of EOPA technique was 94.65 ± 2.57% (Table 4).

Discussion

The EOPA technique is easy, repeatable, less time-consuming, and has reduced cross contamination. Sadeghi and Esmi[14] and Zafar and Javed[1] have suggested that the extraoral approach can be used as an auxiliary aid in determining the WL using conventional films.

The EOPA technique is not routinely used in clinical practice due to increased amount of radiation exposures in conventional films.

However, in digital radiography, exposure is often 70 to 80% lower than that of traditional film X-rays, negating the risk of overexposure as compared to conventional films. Moreover, the RVG images can be adjusted digitally within radiographic software programs with no gross decline in the resolution of the image.[11]

The data comparison of EOPA technique in determining WL with the standard IOPA technique is very scanty in literature search. Furthermore, the EOPA technique has not been sufficiently validated.

An alternative technique for diagnostic periapical radiographs using the extraoral approach was first introduced by Newman and Friedman in the year 2003. Since then there has been various modifications in techniques. Reddy[15] et al. in their review have concluded that EOPA image was best obtained when maxillary molars and premolars are projected at −20 to − 30° from the opposite side by making the patient to sit upright with mouth wide open to avoid overlapping of contralateral teeth on the image receptor[12] and with a tilt of the head 10° toward the side to be imaged.[16] Mandibular molars and premolars are projected at +20 to +30° from the opposite side by making the patient mouth wide open to avoid overlapping of contralateral teeth on image receptor.[9]

In the present study, the patient was positioned upright with mouth wide open and the sensor was then set outside on the cheek with the utilization of position-indicating device as described by Chen et al.,[12] positioning the beam buccal to the tooth using an aiming device. However, the 10° tilt as suggested by Saberi et al.[16] was not used. In order to compensate the head tilt, an angulation of +35° was set to X-ray cone for the mandibular premolars from the horizontal plane. A series of clinically successful radiographic images of the mandibular premolars, with a very minimum overlapping of teeth from contralateral opposing arch and opposite teeth of the same arch, was obtained and hence a +35° cone angulation was decided for mandibular premolars to determine the WL.

Comparison of digital and conventional intraoral radiographs with gold standard of extracted teeth was done by Lamus et al. who found no statistical significant difference between the groups. Thus, in the present study, we used radiovisogram. The direct digital images showed a difference of 0.46 mm from the extracted teeth.[17] However, in present study, the difference between WL obtained from IOPA and actual WL was found to be only 0.1 ± 0.66 mm which was not statistically significant ($p = 0.091$). A higher difference was quoted by Lamus et al. which could be due to the lack of a standard reference point.

A study conducted by Zafar et al. determined the accuracy of extraoral radiographic technique in estimating WL on mandibular premolars and also showed that the mean difference between the actual length and the extraoral radiographic length was 1.19 ± 0.9 mm, where the cone angulation of −35° was set from horizontal plane and perpendicular to the film on the opposite side of the face.[1] However, in our study, the difference in measurements between the actual length and the extraoral radiographic length was only 0.15 ± 0.66 mm, which was not statistically significant ($p = 0.326$), recommending that the extraoral radiographic technique can be used effectively in clinical practice when the X-ray cone is angled at +35° for the mandibular premolars.

The difference between mean WL obtained by IOPA and WL obtained by EOPA in the present study was 0.25 ± 0.66 mm. The difference was not statistically significant ($p = 0.096$). Signifying that EOPA technique is as effective as the IOPA technique in determining WL.

In the present study, the accuracy of IOPA technique 97.87 ± 0.91%, which is similar to a previous study done by El Ayouti[18] et al. where intraoral radiography was 95% accurate in measuring WL of premolars.

An *in vivo* study conducted by Sadeghi and Esmi[14] compared the accuracy of EOPAR with the intraoral radiography for WL determination in molar teeth. They found 75% magnification accuracy using EOPA technique, in open-mouth approach with angulations of −25 ± 5° for maxillary and −15 ± 5° for mandibular teeth. Nazeer et al.[19] in an *in vitro* study on mannequin heads found an accuracy of 82.6% using EOPA technique, when the X-ray cone was angled −20 to −30° for maxillary posterior teeth and +20 to +30° for mandibular posterior teeth from the horizontal plane. Zafar and Javed[1] in an *in vivo* comparative study between IOPA and EOPA techniques with actual WL on premolars found that when the X-ray cone was angled at –35° from horizontal plane and perpendicular to the film on the opposite side of the face, a majority of extraoral radiographs (86%) determined average tooth length accurately with magnification error of less than 10%. Sudhakar[11] et al. in an *in vivo* study on EOPA technique also found the accuracy to be 90.7% when the X-ray cone was angled vertically at −20 to −25° for maxillary projections and for mandibular projection vertically at −15 to −20° with a head tilt of 10° for both maxilla and mandible. However, in our study, the accuracy of EOPA technique was 94 ± 2.57%.

In the present study, the radiographic images did not show any dimensional inaccuracy using EOPAR technique as suggested by some authors.[19] In patients with exaggerated gag reflex, the extraoral technique was found to be a more comfortable imaging procedure. With regard to its diagnostic utility, EOPAR can be used in pediatric patients with noncompliance for placement of sensors, reducing errors while receptor positioning during IOPA procedure and therefore reducing multiple X-ray exposures. Furthermore, the technique is easy, repeatable, less time-consuming, and has minimal contamination.

Conclusion

The study strongly suggests that extraoral radiography can be a consistent, convenient, and an effective technique for clinical dentistry and endodontic WL determination particularly where the use of intraoral radiography is difficult or unmanageable.

The EOPA technique is as good as the IOPA technique in determining WL and can be used as a diagnostic aid in determining WL.

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