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Comparative Analysis of Digital Radiography and Conventional Radiography in Endodontic Treatment

Amreen Tahera[1], Shazia[2], Fath U Min Ullah*[3]
[1]Hussain Lakhani Hospital, Karachi, Sindh 74600, Pakistan
[2]Department of Computer Sciences, Abdul Wali Khan University Mardan
[3]Sejong University, Seoul, Republic of Korea
Correspondence: fath3797@gmail.com

Abstract: Dental radiography plays a significant role in endodontics due to its wide range of applications in treatment process. Similarly, the radiographs such as periapical x-rays are frequently used that visually present the internal structure of tooth roots with bones area. However, practice using conventional radiography is a traditional approach that fails in to perform complex tasks. Inspire of new invention of digital radiography, this study aims to correlate the efficiency between two radiographic instruments during endodontic therapy. To this purpose, we take about 150 periapical radiographs prior to root canal therapy and during therapy via conventional and digital radiographic instruments. Next, the obtained radiographs are compared sidewise to examine the performance and quality of measurements recorded for the treatment. Prior to endodontic treatments, the x-rays are taken to discover the infection depth and the affected area. The x-rays are also recorded during canal preparation, gutta-percha transformation, horizontal build-up, and obturation. Furthermore, the final radiographs are taken at the end of treatment to evident the treatment completion. During the analysis, the conventional radiographs are observed on a film viewer while the digital radiographs were evaluated on Digora dental software. We experimentally prove that there is no massive variation between the digital radiographs and conventional radiographs results during the endodontic treatment. However, the digital radiographs are more accurate and visible to naked eye for further assessment.

Keywords: Conventional radiography, digital radiography, DIGORA, periapical radiography, medical image analysis, dentistry.

1. Introduction

Endodontics is the part of dentistry that deals with the removal of the protective crown and the filling inside the tooth to properly fill and retreat the injured tooth [1]. Many procedures are used in endodontics; Root canal treatment is a common procedure which is mainly used in moderate-to-severe tooth damage. Here the protective crown of the decayed tooth is opened and all the infected materials are removed. After cleaning, the opened tooth is enlarged so that it can be filled temporarily for some time. When the tooth heals properly, the temporary filling is removed and again filled by a permanent filling. Eventually, the tooth is sealed properly to prevent it from infections and for protecting the protective crown is placed over it.

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Secondly, endodontic retreatment surgery; here the protective crown over the tooth is removed and filled the area which is not growing properly. Thirdly, the injuries and cracks that are treated include dental pulp [2][3].

The establishment of a long-term and successful outcome for any case of root canal treatment is based on a few fundamentals that are; appropriate diagnosis, forming a correct treatment plan, having a precise knowledge of anatomy for a certain specimen, and then proceeding to correct steps of cleaning, shaping and obturation [2]. Utilizing diagnostic modality with any sort of lesser precision will lead to incorrect diagnosis and treatment plan formation [2]. We evaluate each step of procedure by using different modalities; radiography being of the prime significance. Advent of radiographic modalities serves a very crucial benefit for the avoidance of mishaps and unsuccessful treatment outcomes.

In the field of endodontics acquiring the correct working length is crucial for successful root canal treatment in a longer run [3, 4]. Working length is thus defined as; The distance from a predetermined reference point on a crown (that is usually a point on cusp or an incisal edge) to a point at which cleaning, shaping, and obturation should ideally terminate. Any reference point that is taken should be stable enough to resist fracture in between the proceeding appointments of the therapy in order that the reference point is stable throughout the procedure so that the estimated final working length remains stable over the concurrent appointments [5]. Cleaning and shaping of the pulp chamber and canal framework are crucial for the rightful attempt of root canal treatment and also these steps are irreversible once proceeded. Hence, the correct assessment of the root canal working length is fundamental before proceeding to further steps of the therapy. Estimated working length can be calculated by the following methods; Conventional parallax radiograph, digital radiograph (i.e.: DIGORA Software) or via electronic apex locater [5]. Error in estimating the correct working length could prompt terrible outcomes for both the patient and the care provider, such as the patient's agony and inconvenience, need for retreatment, root-end resection, and even the need for eventual tooth extraction [2, 6]. The correct estimation of desired working length for the biometrical preparation and resultant obturation of the passage system is one of the foremost important phases of endodontic treatment. Following are the circumstances and requirements of endodontic imaging; Identification of pathology, visibility of root/s and root canal/s morphology, moving the hindering or superimposed anatomical structures by different angulations, assessing the extent of accuracy for each step, and the initial and long term outcome determination after the procedure [5]. Equipment of 2D image capturing (in other words conventional radiography) are Standard Wall Mounted Units or Handheld units.

Conventional radiography is a method which is used in endodontic treatment where the interior structure of the teeth and gums are picturized in a film form. As this method is not efficient because some internal features cannot be properly portrayed here, also it takes large amount of time and the image created in these methods are small and difficult to interpret. Conventional intraoral imaging is another commonly used

modality for working length determination; however, its shortcomings include two-dimensional replication of a three-dimensional object, possibilities of size and shape distortion, the need for a darkroom and sophisticated equipment, and the wish for the top level of x-ray exposure. Due to these shortcomings the digital radiography has been developed. Though, nowadays, modern convolutional neural based methods [7-9] showed promising results in vision that encouraged the dentists for their inclusion in the Endodontics treatment.

Digital radiographic method is commonly used in endodontics where the Kodak digital radiography [10], Cone Beam [11] and Panoramic Scanner [12] are used to provide the patient clearest picture of the state of their oral health. It exposes the patient to much less radiation than the conventional method. It creates instant results, furthermore clear and utilizes less time as compared to the conventional methods [13]. Types of Digital radiographic image receptors are; Photo Stimulable Phosphor Plates [14], Solid state (direct) sensors [15], and Dental films [16]. Digitalized radiographic software further allows the accessibility to quantify a visual distance into metrics, that will further facilitate correct amount of amendments into the physical specimen, they further allows the enhancement of contrast and density on an image projected on the monitor, these properties also held a major significance over a conventional form of radiography in terms of interpretation and precision [3]. Digital radiography further limits the requirement of film processing and fixing that requires specific amount of time and armamentarium, this also poses an operator friendly quality for this type of radiography. Albeit computerized radiography holds a few favorable circumstances over traditional radiographs, and the aim of this study is to further evaluate and prove the proposed statement of benefits described for the digital form of radiography.

The reminder of the paper is given as follows: Section 2 discuss the literature review and Section 3 explains the proposed study while Section 4 and Section 5 discuss the results and conclusion, respectively.

2. Literature review

Conventional radiography was generally utilized in clinical cases in the previous era; it shows the subtleties of projected image with an average quality. But the further steps for fixation of film demands added manual work which also is subjected to errors during the procedure and increase in procedural time, also it does not allow the further changes in quality and enhancement of contrast [17] whereas, Digital radiography permits quicker display (generally within 3 to 5 secs), ability to upgrade image quality, and easier and well organized storage of data [5] it also incorporates advanced metric for measurements and densitometers for different quality enhancements of image. Apart from all the additional benefits projected by digital radiography they demand additional armamentarium like computer units and explicit receptors that may not be readily accessible in certain health care facilities [18]. Even with the additional demand of certain equipment the use of direct computerized radiography has expanded during the recent era due to certain qualities that hold the superiority over conventional means [2][19]. Considering the pros and cons of both

technologies, literatures of recent past states the more regular use of conventional means of radiographs due to ease of availability and general preference by considerable population of operators. Up to date, conventional E and F Speed films are the most commonly utility for general endodontic assessment. Literature on the other hand, also acknowledges advantages of digital radiography on the basis of properties such as lesser biohazard for the patients and other factors such as; image quality and data storage considering for the care provider. The aim of the present study is to analyze and compare digital radiography and conventional radiography during different appointments of root canal therapy to further prove the better version of technology; the considered appointments are of initial working length assessment, during and after obturation and the subsequent follow up [20].

This research further opens new doors for debate on certain aspects of imaging that should be taken under consideration to formulate an opinion of whether which source of radiographs provides better benefits of technology in the current era of modern dentistry.

3. Study Case

This study was performed in Zia Uddin Hospital, Karachi, Pakistan where Radiographs of 150 teeth specimen of single and multirooted teeth were taken during different steps of endodontic assessment and procedure by using the paralleling and bisecting angle techniques. Radiograph in each set of case corresponds to a specific step of the treatment i.e.: before the procedure, taking initial working length, master cone placement and after lateral condensation. Each set of radiographs is examined by two different examiners to eliminate any visual bias. We are utilizing two different kinds of radiographic modalities to formulate a comparison of the two armamentariums. The considered radiographic modalities of this research are Conventional Film Radiography and Digital Radiography (i.e.: DIGORA Software). The films were compared side by side of each other to check visual comparisons of properties for these two techniques. However, results of visual differences were compared in three different categories of visual clarification, blurriness and the presence or absence of artefacts as shown in the picture. The general dental practitioners on different sessions selected the radiographs randomly and compared each of the conventional radiograph with the digital images taken from the same angle and technique. They arranged the radiographs according to the clarity while assessing the diagnostic quality making sure to minimize the artefacts as much as possible. Furthermore, Statistical analyses by using Mean and Standard Deviation were calculated on the basis of these described categories of evaluation of the two group. These two groups are further calibrated by using Chi square testing which results in P value of >0.05 for conventional method of radiography and >0.001 for digital radiography.

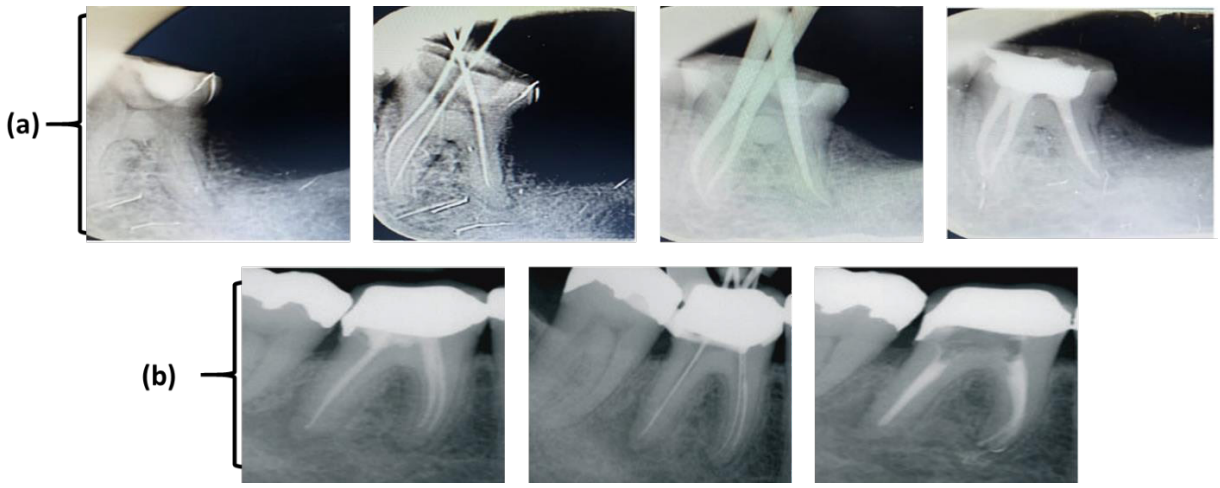

Fig. 1. Collected sample of Radiographs from oral cavity. **(a)** Images taking by using Digital Radiograph **(b)** Images taken by using Conventional Radiograph.

4. Experimental Results

Radiographs of each step of treatment were taken separately. Conventional Radiographs as well as Digital x-rays have been visualised and analysed statistically.

4.1. Visual Difference Before Endodontic Treatment

The given demonstration of following pie chart illustrates characteristics for the formulation of treatment plan before the start of any endodontic procedure. The discussed properties are enhanced clarity of anatomic structures such as in this case, 70% clarity enhancement for digital radiographs as compared to 40% for conventional ones. The second key property is around visual blurriness of 20% for the digital mean as compared to 30% for the conventional mean. Whereas, according to obtained data, presence of artefacts is also significantly reduced for digital radiographs that are 10% as compared to 30% for conventional techniques.

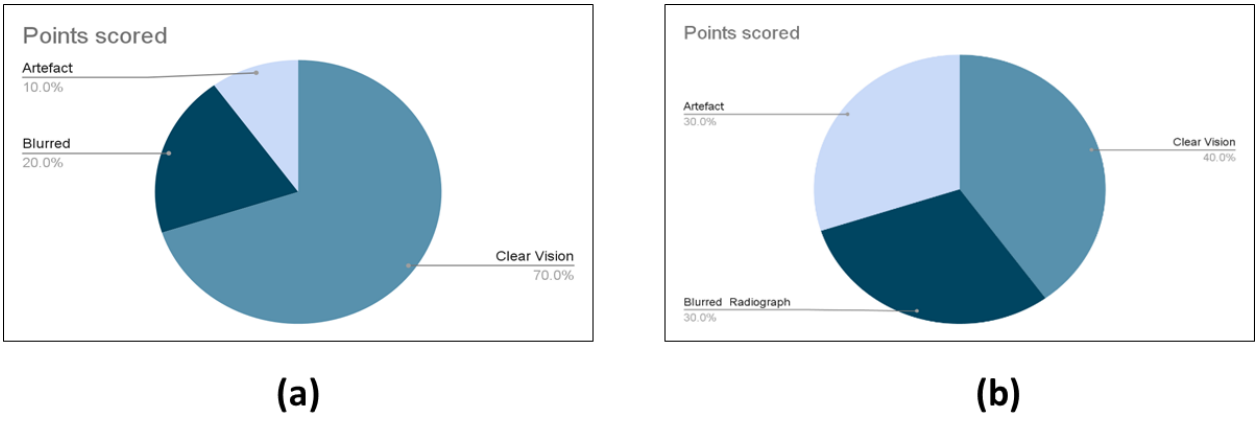

Fig. 2. Pie chart shows different visuals found in radiographs. **(a)** visuals found in Digital techniques **(b)** visual

difference found in Conventional Technique.

Table 1. Percentage of clear vision procedure.

Measurements	Conventional radiography	Digital radiography
Working Length	60%	80%
Gutta-percha point	80%	90%
Obturation	90%	90%
Total	**76%**	**86%**

4.2. Visual Differences During Endodontic Treatment

In this part, the study utilizes both ways of radiography to gather information presented in the following tabulation. The steps under consideration of this heading are working length estimation, Gutta percha master cone placement and final obturation. The process of obturation in considered specimens is lateral condensation. However, the visual representation of each armamentarium differs in different phases of treatment as shown below.

Table 2. Percentage of blurred vision procedure.

Measurements	Conventional radiography	Digital radiography
Working Length	30%	17%
Gutta-percha point	15%	09%
Obturation	5%	5%
Total	**16%**	**10%**

4.3. Visual Difference after Endodontic Treatment

After completion of root canal therapy, a complete coronal coverage is generally necessary to provide sufficient fracture resistance to given tooth. No different picture quality is observed for both techniques.

Table 3. Artefactual images

Measurements	Conventional radiography	Digital radiography
Working Length	10%	03%
Gutta-percha point	5%	01%
Obturation	5%	5%
Total	**6%**	**3%**

4.4. Statistical Analysis

The data collected was recorded and analysed by utilizing Statistical package for social sciences (SPSS 20.0). Groups of data were analysed by using statistical tests i.e., chi-square, a p-value of >0.05 is calculated for conventional method of radiographic analysis whereas p-value for digital radiographic technique is calculated to be >0.001.

Table 4. Mean and Standard deviation of radiographic images obtained via conventional radiography of original images.

Phase of Treatment	Measurements	Percentages	Mean	Standard Deviation
Before		40	0.266	3.244
During	Woking length	76	0.50	5.67
	Gutta-Percha Point			
	Obturation			

Table 5. Mean and Standard deviation of radiographic images obtained via conventional radiography of blured images.

Phase of Treatment	Measurements	Percentages	Mean	Standard Deviation
Before		30	0.2	2.4
During	Woking length	16	0.10	1.29
	Gutta-Percha Point			
	Obturation			

Table 6. Mean and Standard deviation of radiographic images obtained via conventional radiography of Artefactual images.

Phase of Treatment	Measurements	Percentages	Mean	Standard Deviation
Before		30	0.2	2.43
During	Woking length	6	0.04	0.47
	Gutta-Percha Point			
	Obturation			

Table 7. Mean and standard deviation of radiographic images obtained via digital radiography of Cleared Images.

Phase of Treatment	Measurements	Percentages	Mean	Standard Deviation
Before		70	0.46	5.67
During	Woking length	86	0.57	6.97
	Gutta-Percha Point			
	Obturation			

Table 8. Mean and standard deviation of radiographic images obtained via digital radiography of blured Images.

Phase of Treatment	Measurements	Percentages	Mean	Standard Deviation
Before		20	0.13	1.62
During	Woking length	10	0.06	0.81
	Gutta-Percha Point			
	Obturation			

Table 9. Mean and standard deviation of radiographic images obtained via digital radiography of Artefactual Images.

Phase of Treatment	Measurements	Percentages	Mean	Standard Deviation
Before		10	0.06	0.81
During	Woking length	3	0.02	0.24
	Gutta-Percha Point			
	Obturation			

4.5. Applying Chi-square Method

The data collected was recorded and analysed by utilizing Statistical package for social sciences (SPSS 20.0). Groups of data were analysed by using statistical tests i.e., chi-square, a p-value of >0.05 is calculated for conventional method of radiographic analysis whereas p-value for digital radiographic technique is calculated to be >0.001.

Table 10. variables of conventional and digital radiographic calculations.

Variables	Mean ± *SD*	p-Value
Conventional Method	0.50 ±5.67	>0.05
Digital Radiographs	0.57±6.97	>0.001

4.6. Discussion

Over the past few decades, studies have been performed on the difference of these two radiograph techniques. The present study is also reflecting on these parameters. Taghiloo, et al. [19] proved that digital radiography has wide range of advantages in the modern dentistry. However, conventional which is traditional kind has also uncountable pros. This study has also performed in the shadow of these techniques. In this study, results showed digital radiography image has higher diagnostic value than conventional, but the difference between both techniques was not significant. Therefore, our results are consistent with previous findings where [19] used the chi-square method to approach the statistics of results same as performed in this study. Similar to this study, [20] used the same comparative technique to detect the caries that found in the molars during the endodontic treatment. However, the digital radiographs have high approach than conventional.

5. Conclusion

From this research it is concluded the digital radiography have certain defining aspects of benefit that further proves its efficacy over conventional form of radiography. These added benefits as described by the study are generally on the basis of image clarity and presence of lesser artefacts for the digital means. Hence, it is proved by this study that digital radiography has better efficacy then conventional radiography.

Similarly, the digital method of radiographs defined the results procedure that have been used in the root canal therapy which have a prior efficacy over conventional form of radiographs. Furthermore, these benefits have been described by the study are generally on the basis of image clarity and the presence of less artefacts for the digital means. To conclude, the digital radiograph technique has better and cleared vision for the procedure despite of conventional ones.

6.1. Future Recommendations

In the future, we intend to implement different deep learning networks and their variants. Similarly, we will consider different resources-constrained devices to reduce computation and due promising results of sequential learning [21] in computer vision, we will investigate those algorithms for radiography.

References:

1. Javed, F., S. Habib, and R. Ghafoor, *Surgical endodontics under the microscope: principles and practice.* Dental Update, 2022. **49**(5): p. 416-422.
2. Sameye, M.R., et al., *Comparison of digital radiography, conventional film and self-developing film for working length determination.* Iranian Endodontic Journal, 2018. **13**(3): p. 381.
3. Mousavi, S.A., et al., *Comparative evaluation of root canal working length determination with three methods: conventional radiography, digital radiography and raypex6 apex locator: an experimental study.* Journal of Dental Materials and Techniques, 2021. **10**(2): p. 87-93.
4. Farida, A., et al., *A comparison between conventional and digital radiography in root canal working length determination.* Indian Journal of Dental Research, 2013. **24**(2): p. 229.
5. Shenoy, A., *Failure of Endodontic Therapy and Retreatment Options.* Endodontics: Principles and Practice E-book, 2016: p. 151.
6. Arslan, H., et al., *Effect of the simultaneous working length control during root canal preparation on postoperative pain.* Journal of endodontics, 2017. **43**(9): p. 1422-1427.
7. Ullah, F.U.M., et al., *AI-Assisted Edge Vision for Violence Detection in IoT-Based Industrial Surveillance Networks.* IEEE Transactions on Industrial Informatics, 2021. **18**(8): p. 5359-5370.
8. Ullah, F.U.M., et al., *An intelligent system for complex violence pattern analysis and detection.* International Journal of Intelligent Systems, 2021.
9. Ullah, F.U.M., et al., *A Comprehensive Review on Vision-based Violence Detection in Surveillance Videos.* ACM Computing Surveys, 2022.
10. Tuncer, A.K. and M. Gerek, *Effect of working length measurement by electronic apex locator or digital radiography on postoperative pain: a randomized clinical trial.* Journal of endodontics, 2014. **40**(1): p. 38-41.
11. Bartkoski, D.A., et al., *Analysis of a novel X-ray lens for converging beam radiotherapy.* Scientific reports, 2021. **11**(1): p. 1-12.
12. Biber, P., et al. *3D modeling of indoor environments by a mobile robot with a laser scanner and panoramic camera*. in *2004 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)(IEEE Cat. No. 04CH37566)*. 2004. IEEE.
13. Ravi, V., et al., *Direct digital radiography versus conventional radiography–assessment of visibility of file length placed in the root canal: An in vitro study.* Journal of pharmacy & bioallied sciences, 2012. **4**(Suppl 2): p. S285.
14. Khalaf, M.E., et al., *Clinical extension of proximal carious lesions compared to bitewing radiographs using photostimulable phosphor plates (PSP).* Journal of Dentistry, 2022. **122**: p. 104145.
15. Seymour, I., et al., *Advanced solid state nano-electrochemical sensors and system for agri 4.0 applications.* Sensors, 2021. **21**(9): p. 3149.
16. Xu, T., et al., *Artificial intelligence assisted identification of therapy history from periapical films for dental root canal.* Displays, 2022. **71**: p. 102119.
17. Messias, A., et al., *Acrylic customized X-ray positioning stent for prospective bone level analysis in long-term clinical implant studies.* Open Journal of Radiology, 2013. **3**(03): p. 136.
18. White, S.C. and M.J. Pharoah, *White and Pharoah's Oral Radiology: Principles and Interpretation*. 2018: Elsevier Health Sciences.
19. Taghiloo, H., et al., *Comparison of the Accuracy of Digital Radiography with Conventional Radiography and Visual Examination in the Detection of Permanent Teeth Interproximal Caries.* Pesquisa Brasileira em Odontopediatria e Clínica Integrada, 2019. **19**.

20. Schmitd, L.B., et al., *Comparison of radiographic measurements obtained with conventional an indirect digital imaging during endontic treatment.* Journal of Applied Oral Science, 2008. **16**: p. 167-170.
21. Ullah, F.U.M., et al., *Diving Deep into Short-Term Electricity Load Forecasting: Comparative Analysis and a Novel Framework.* Mathematics, 2021. **9**(6): p. 611.